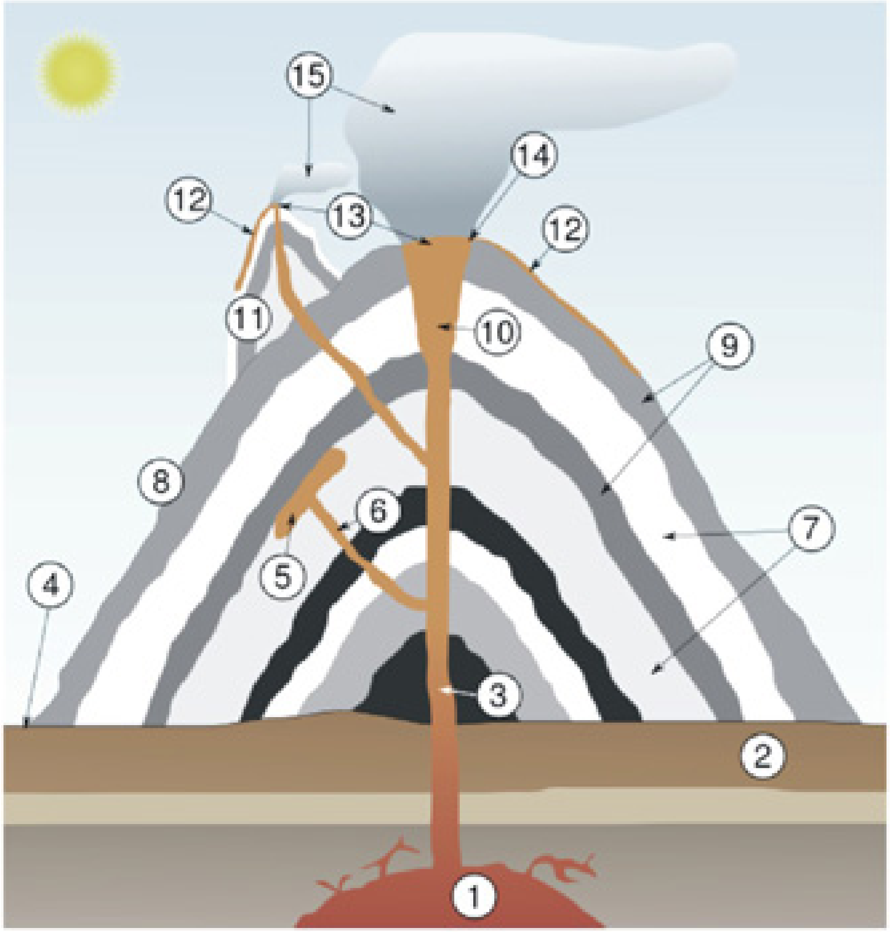
Encyclopedia of Volcanos

Eric Wood



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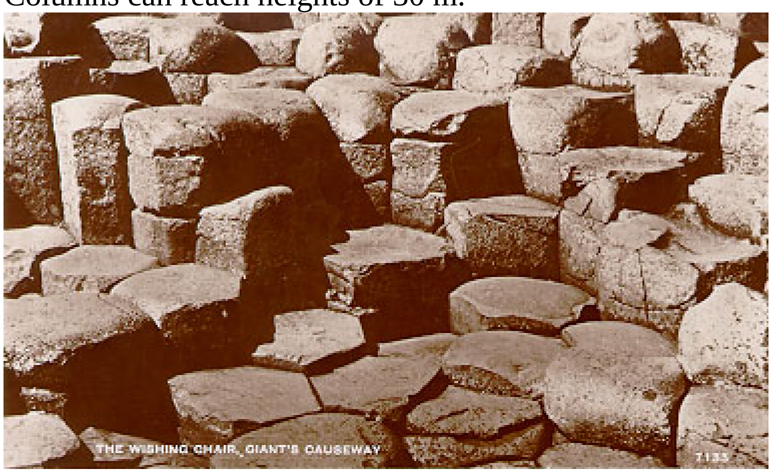
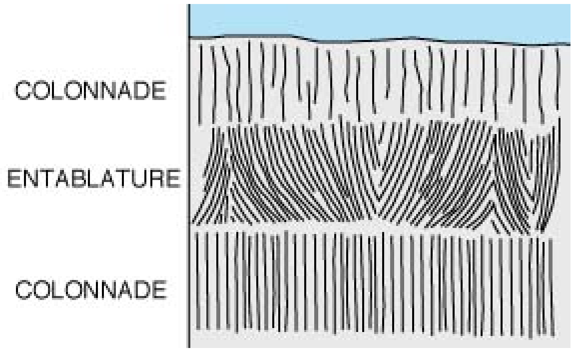
Columnar Jointing

Columnar jointing forms in lava flows, sills, dikes, ignimbrites (ashflow tuffs), and shallow intrusions of all compositions. Most columns are straight with parallel sides and diameters from a few centimeters to 3 m. Some columns are curved and vary in width. Columns can reach heights of 30 m.

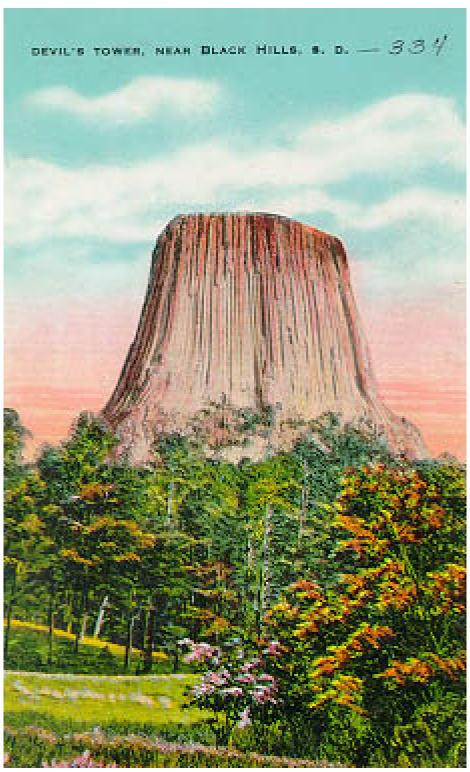


Most columns tend to have 5 or 6 sides but have as few as 3 and as many as 7 sides.

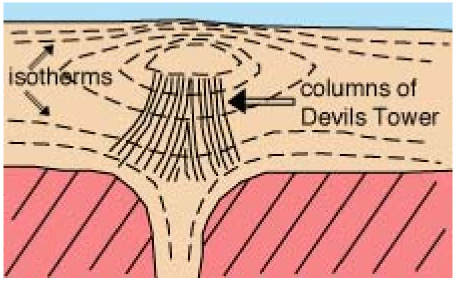
The columns may form sets. Straight, regular columns are called colonnade. Irregular, fractures columns are called entablature. From Spry (1962).



The columns form due to stress as the lava cools (Mallet, 1875; Iddings, 1886, 1909; Spry, 1962). The lava contracts as it cools, forming cracks. Once the crack develops it continues to grow. The growth is perpendicular to the surface of the flow. Entablature is probably the result of cooling caused by fresh lava being covered by water. The flood basalts probably damned rivers. When the rivers returned the water seeped down the cracks in the cooling lava and caused rapid cooling from the surface downward (Long and Wood, 1986). The division of colonnade and entablature is the result of slow cooling from the base upward and rapid cooling from the top downward.



1931 postcard of Devils Tower, Wyoming, a shallow intrusion that formed columnar jointing as it cooled.

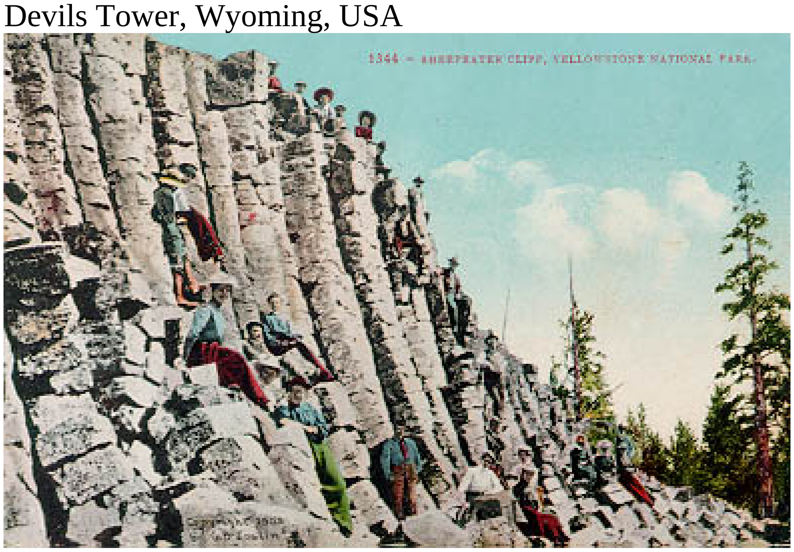


Possible mechanism for the formation of columnar jointing at Devils Tower. Isotherms are layers with the same temperature. Joints formed perpendicular to the isotherms as the rock cooled. From Spry (1962).

Old Models for the Formation of Columnar Jointing:

In 1804, Watts suggested that “molten magma solidified around a series of isolated centres to form large plastic balls, which when pressed together gave the typical hexagonal symmetry” (Spry, 1962). In 1916, Sosman proposed that the columns are the results of a system of hexagonal convection cells. Sosmans model was based on experiments of wax or oil in a flat dish. Critics noted that lava flows do not gain heat from their bases but actually lose heat from the top surface. Furthermore, the shape of the convection cells did not resemble hexagonal columns.

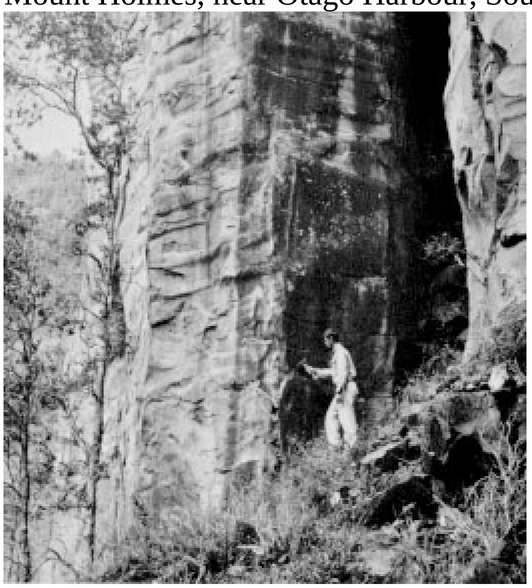
Classic examples:

- Giants Causeway, County Antrim, Northern Ireland
- Fingals Cave, Staffa Island, Scotland
- Columbia River flood basalts of Oregon, Washington, and Idaho, USA
- Devils Postpile, California, USA
- Devils Tower, Wyoming, USA
- 

  Columnar jointing in Sheepeater Cliff, Yellowstone National Park.

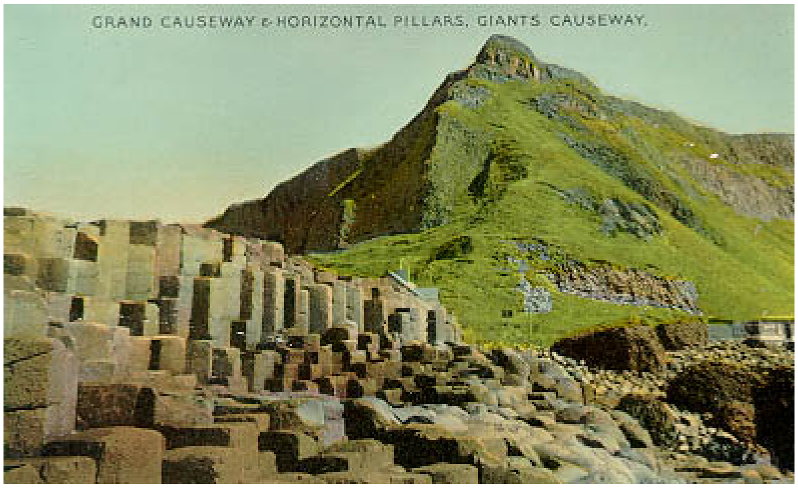
Lesser known examples:

- Rosette in the volcanic neck at Rock and Spindle, St. Andrews, Scotland

- Massif Central, France (described by Baron Leopold van Buch)
- Moraine Mountain trail, Lake Louise and Banff, Alberta, Canada
- Makuopuhi Crater, Kilauea, Hawaii, USA
- Craters of the Moon, Idaho, USA
- Dunsmuir, California, USA
- Bishop Tuff ignimbrite, California, USA
- Orange Mountains, New Jersey, USA
- San Anton, Morelos, Mexico
- Cerro Galan ignimbrite, near Antofagasta de la Sierra, Argentina
- Intrusion at Rosslyn Bay, Bluff Point National Park, Queensland, Australia
- Millstream Falls National Park, Queensland, Australia
- The Organ Pipes, in the valley of Jacksons Creek, near Bulla, New South Wales, Australia
- Barfold Gorge, along the Campaspe River, New South Wales, Australia
- Don Heads, Doctors Rocks, and Burnie, Tasmania, Australia
- Shag Head Rock, Avon-Heathcote estuary, Lyttelton volcano, South Island, New Zealand
- Quail Island, South Island, New Zealand
- Mount Bradley, Lyttelton volcano, South Island, New Zealand
- Mount Holmes, near Otago Harbour, South Island, New Zealand
- 
  Large columnar joints that developed in a cooling lava pond in Mokaopuhi Crater, East Rift Zone, Kilauea. The columns were exposed by a younger episode of collapse of the pit crater. An even younger eruption has buried these spectacular columns.
  Nan Madol, the Federated States of Micronesia

Cool Facts about Columns:

There are more than 40,000 columns at Giants Causeway. German composer Felix Mendelssohn based his famous 1830 “Hebrides Overture” on the sound of the waves filling and draining Fingals Cave. The similarity of the shape of the columns to those of quartz crystals was once used to support the theory (called Neptunism) that volcanic rocks precipitated from water.



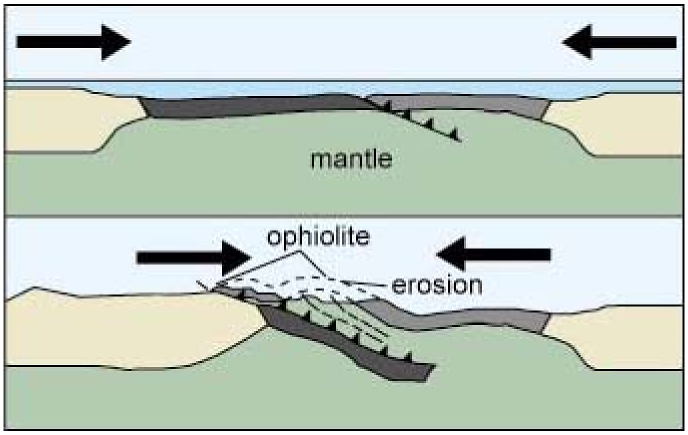
Postcard of the Grand Causeway & Horizontal Pillars at Giants Causeway.

Postcard of Fingals Cave.

Irish Folklore for the Origin of Giants Causeway and Fingals Cave: Finn Mac Cool, an Irish Giant, want to fight his Scottish counterpart, Finn Gall. Mac Cool drove the columns in place, one at a time, until the causeway reached Scotland

(Fingals Cave). Mac Cool was so tired from the hard work that he returned home to rest. Finn Gall followed the causeway to Ireland. He found Mac Cool sleeping and Mac Cools wife, a very shrewd women, told Finn Gall that this was her baby sleeping. Finn Gall grew alarmed, thinking this giant babys father must be of incredible size and that he would surely lose any fight. Finn gall fled back to Scotland. As he did, he destroyed the causeway. Only the two ends of the causeway survive to this day

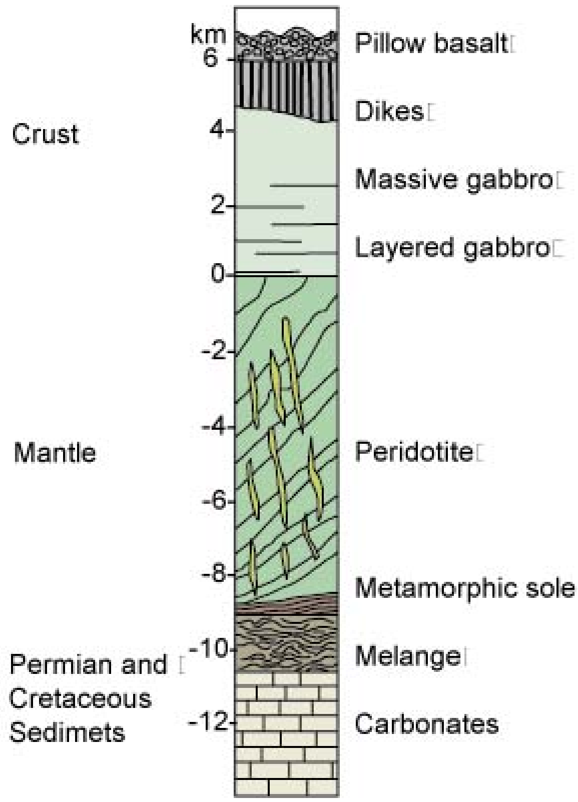
Ophiolites



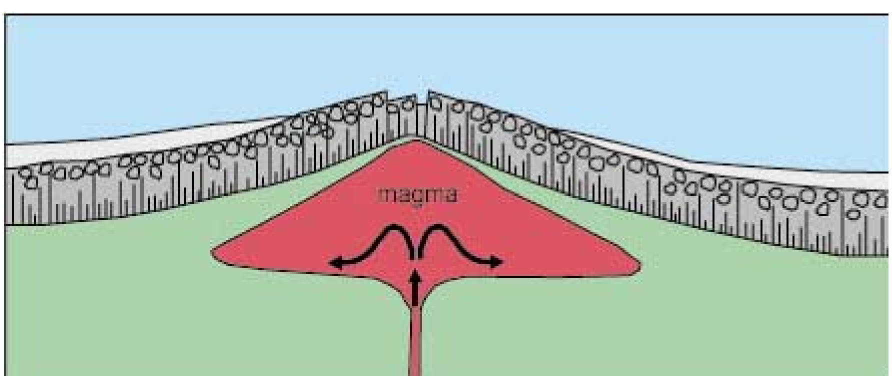
Ophiolites are pieces of oceanic plate that have been thrusted (obducted) onto the edge of continental plates. They provide models for processes at mid-ocean ridges.

Ophiolites are an assemblage of mafic and ultramafic lavas and hypabyssal rocks found in association with sedimentary rocks like greywackes and cherts. They are found in areas that have complex structure. Cross-sections simplified from R.C. Coleman, 1981, Journal of Geophysical Research, v. 86, p. 2497-2508.

Ophiolites have been found in Cyprus, New Guinea, Newfoundland, California, and Oman. The Samail ophiolite in southeastern Oman has probably been studied in the greatest detail. The rocks probably formed in the Cretaceous not far from the what is now the Persian Gulf. The rocks were later thrust (pushed uphill at a low angle) westward onto the Arabian shield.



Ophiolites are characterized by a classic sequence of rocks. This sequence is well exposed at the Samail ophiolite. The base of the sequence is sedimentary rocks of the Arabian shield, not part of the ophiolite, on which the oceanic plate was pushed. From base to top the ophiolite is made of: peridotite, layered gabbro, massive gabbro, dikes, and volcanic rocks. At Samail this entire sequence is 15 km thick. The basal peridotite is made of a rock called harzburgite (made mostly of the minerals olivine and enstatite). Within the peridotite are many dikes of gabbro and dunite. The peridotite is deformed. The peridotite is overlain by dunite (an intrusive igneous rock made mostly of the mineral olivine) that grades upward to gabbro (an intrusive igneous rock made mostly of plagioclase and clinopyroxene - augite). The sequence is capped by dikes and volcanic rocks (pillow basalts that erupted on the ocean floor). Sequence of rocks simplified from R.C. Coleman (1981).



From a tectonic perspective, the peridotite is depleted mantle that was under the magma chamber at the mid-ocean ridge crest. The gabbro layer is related, in some way, to the crystallization of the magma chamber (probably with repeated injections of magma).

Volocano Bomb Pictures

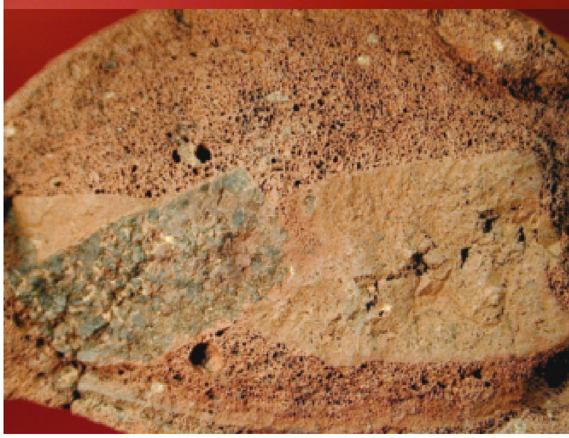
By far the greatest numbers of bombs produced during a volcanic eruption are simply irregular in shape. They are generally very vesicular and lumpy and are called scoria or cinders. The photographs that follow are of volcanic bombs that have a somewhat streamlined shape and were generally ejected during the final stages of the volcanic eruption.

Bread Crust Bombs

Bread crust bombs are created when the bomb cools, producing a hard crust that insulates the inside keeping it hot and full of dissolved gases. The gases continue to expand and break the crust that has already formed. Occasionally the molten interior squeezes out (see "pie filling" bomb) or if the gas expansion is violent, the bomb explodes (see explosion bomb).

CORE BOMBS

A core of basaltic scoria.

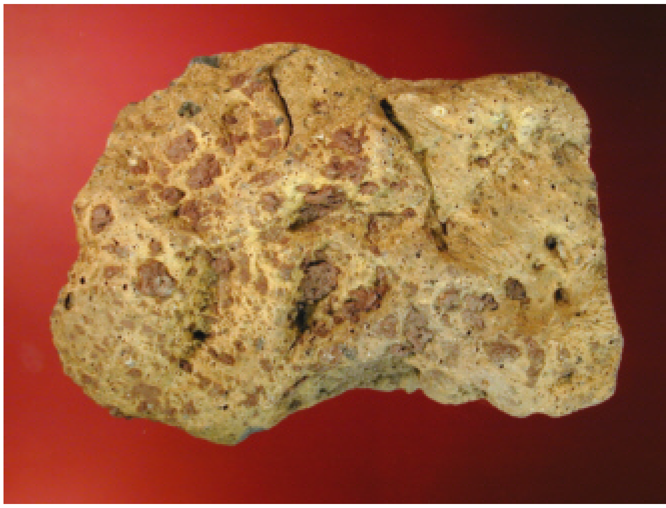



(Bottom picture pair) A core of basalt and a coarse grained gabbro.

As the name implies, core bombs have formed around a distinct core of solid material. The core can be any kind of a rock that is stable enough to withstand the conditions associated with the volcanic eruption. Commonly the core of core bombs is an older fragment of the volcano, e.g., a piece of basalt. In other cases, it is a piece of country rock ripped up by the ascending molten mass. Occasionally the core can be carried up from great depths and represent the lower crust or even the upper mantle.

The top photo shows a core of basaltic scoria, perhaps a remnant of a former eruption that was caught up in a more recent emission of molten ejecta. The bomb also shows a delicate flange of basalt on the left that formed as a result of its flight through the air.

COW PIE BOMBS OR COW PAT BOMBS


A cow pie or cow pat bomb is so named because of its resemblance to the cow droppings one would encounter while walking across a cow pasture. Actually the bomb was very plastic when it formed and was capable of flowing after it hit the ground. The implication is that the bomb was not cooled by a long flight time or was very hot when ejected. In addition to its plastic flow, cow pie bombs were also sticky enough to hold (weld) pieces of cinder to its cooling crust. This particular cow pie bomb is also a slag bomb

Another fine example of a cow pie bomb is shown here. The photo on the left is the "top" side of the bomb and the photo on the right is the "bottom". In either case, it is obvious that the bomb was very fluid after it fell on the side of the volcano and flowed downslope becoming encrusted with cinders, both from below and those falling from above. Cow pie bombs are relatively rare.

Explosion Bomb

The above picture shows a bomb that has had a minor explosion of rapidly expanding gas. After the bomb was ejected from the volcanic vent, it created a hard crust or shell that insulated the still plastic interior. Within this material, volcanic gas was still expanding. This gas produced a bubble that burst leaving this crater in the side of the bomb.

These photos are of different perspectives of the same explosion bomb. Here the expanding gases were more violent, blasting the bomb apart.


Another explosion bomb about 4 inches across.

FUSIFORM BOMBS

These are the "classic" types of bombs referred to in textbooks. They are typically very streamlined, often with elongate "ears" stretching beyond the central bulge. Often, the bomb and the ears are part of a much larger ribbon bomb in which the delicate ribbons separate as the fluid mass flies through the air or break off on impact.

This fusiform bomb has become welded to volcanic cinder and scoria, an indication that the volcanic ejecta remains hot and plastic after it comes to rest along the flanks of the volcano.

 The heat associated with volcanic ejecta is also demonstrated in this image of a fusiform bomb that has welded to cinder and has also become deformed by plastic flow.

SQUEEZE OUT BOMB After the bomb formed a hard crust the inside continued to expand. This expansion was not explosive but was able to crack the newly formed crust and allow some of its plastic interior to extrude outward. (See also the Tear Drop Bomb below.)

RIBBON BOMB



Ribbon Bombs, as the name implies are long thin bands of lava ejected from the volcanic vent. These very plastic bombs can be ejected directly or can form as long streamers pulled off of larger bombs as they fly through the air. Regardless of their mode of formation, they are usually very fragile and break upon impact.

Another ribbon bomb about 6 inches in length showing three distinct inclusions reminiscent of peas in a pod.

ROTATION BOMB

 This fusiform bomb probably had elongate ears that may have stretched into streamers as it was ejected from the volcano. It also achieved some rotation either from the force of the ejection or by the aerodynamics of its flight. What ever the reason, the bomb displays at definite twist.

SLAG BOMBS

Slag bombs have the appearance of smelter slag in that they are very vesicular (porous) and have a very fine grained, almost glassy, exterior. They are, however, bombs in that they were ejected from the volcanic vent and have taken on a streamlined shape.

TEARDROP BOMB

Teardrop bombs have the classic shape of a teardrop or raindrop. They are asymmetrical fusiform bombs that are elongate in one direction away from the central bulge. This teardrop bomb also displays the Squeeze Out effect in that the solid crust was breached and the still plastic interior expanded outwards.

Types of Volcanoes

Shield Volcanoes

Shield volcanoes are the largest volcanoes on Earth that actually look like volcanoes (i.e. not counting flood basalt flows). The Hawaiian shield volcanoes are the most famous examples. Shield volcanoes are almost exclusively basalt, a type of lava that is very fluid when erupted. For this reason these volcanoes are not steep (you can't pile up a fluid that easily runs downhill). Eruptions at shield volcanoes are only explosive if water somehow gets into the vent, otherwise they are characterized by low-explosivity fountaining that forms cinder cones and spatter cones at the vent, however, 90% of the volcano is lava rather than pyroclastic material. Shield volcanoes are the result of high magma supply rates; the lava is hot and little-changed since the time it was generated. Shield volcanoes are the common product of hotspot volcanism but they can also be found along subduction-related volcanic arcs or all by themselves. Examples of shield volcanoes are Kilauea and Mauna Loa (and their Hawaiian friends), Fernandina (and its Galápagos friends), Karthala, Erta Ale, Tolbachik, Masaya, and many others.

Here are 4 of the volcanoes that comprise the big island of Hawai'i. They are Mauna Kea (MK), Mauna Loa (ML), Hualalai (H), and Kohala (K). The photo was taken from near the summit of East Maui volcano (EM). These are the largest volcanoes on Earth.

This is a vertical air photo of the summit caldera of Mauna Loa volcano (North is to the left). Notice that the caldera is composed of numerous smaller "cookie-cutter" collapses which have coalesced to form the main caldera. Notice also that many of the lava flows (dark and light are 'a'a and pahoehoe, respectively) have been truncated by the caldera margin. This is an indication that they erupted from the volcano summit when the caldera was full. Collapse since then has produced the present caldera. In this manner of collapsing and filling, calderas come and go throughout the active lifetime of a basaltic volcano.

Strato Volcanoes

Strato Volcanoes comprise the largest percentage (~60%) of the Earth's individual volcanoes and most are characterized by eruptions of andesite and dacite - lavas that are cooler and more viscous than basalt. These more viscous lavas allow gas pressures to build up to high levels (they are effective "plugs" in the plumbing), therefore these volcanoes often suffer explosive eruptions. Strato volcanoes are usually about half-half lava and pyroclastic material, and the layering of these products gives them their other common name of composite volcanoes. The lava at strato volcanoes occasionally forms 'a'a, but more commonly it barely flows at all, preferring to pile up in the vent to form volcanic domes. Some strato volcanoes are just a collection of domes piled up on each other. Strato volcanoes are commonly found along subduction-related volcanic arcs, and the magma supply rates to strato volcanoes are lower. This is the cause of the cooler and differentiated magma compositions and the reason for the usually long repose periods between eruptions. Examples of strato volcanoes include Mt. St. Helens, Mt. Rainier, Pinatubo, Mt. Fuji, Merapi, Galeras, Cotopaxi, and super plenty others.

Although they are not as explosive as large silicic caldera complexes, strato volcanoes have caused by far the most casualties of any type of volcano. This is for many reasons. First is that there are so many more strato volcanoes than any of the other types. This means that there will also be lots of people who end up living on the flanks of these volcanoes. Additionally, strato volcanoes are steep piles of ash, lava, and domes that are often rained heavily on, shaken by earthquakes, or oversteepened by intruding blobs of magma (or all of these). This makes the likelihood of landslides, avalanches, and mudflows all very high. Occasionally as well, entire flanks of strato volcanoes collapse, in a process that has been termed "sector collapse". Of course the most famous example of this is Mt. St. Helens, the north flank of which failed during the first stages of the big 1980 eruption. Mt. St. Helens was certainly not the only volcano to have suffered an eruption such as this, however. Two other recent examples are Bezymianny (Kamchatka) in 1956, and Unzen (Japan) in 1792. The 1792 Unzen sector collapse dumped a flank of the volcano into a shallow inland sea, generating devastating tsunami that killed almost 15,000 people along the nearby coastlines.

Another very common and deadly hazard at most strato volcanoes is called a Lahar. Lahar is an Indonesian word for a mudflow, and most geologists use the term to mean a mudflow on an active volcano. Sometimes the word is reserved only for mudflows that are directly associated with an ongoing eruption (which are therefore usually hot), but that starts to make things confusing. It is probably simplest to just call any mudflow on a volcano a lahar. Lahars are so dangerous because they move quickly, and often times a small eruption or relatively small rainstorm can generate a huge lahar. The most recent huge volcanic disaster occurred at a Colombian volcano called Nevado del Ruiz in 1985. This disaster has been well-documented by numerous post-eruption studies. Nevado del Ruiz is a very tall volcano, and even though it lies only slightly above the equator it has a permanent snow and ice field on its summit. On November 13, 1985 a relatively small eruption occurred at the summit. Even though only a little bit of ash fell and only small pyroclastic flows were produced, they were able to melt and destabilize a good deal of the summit ice cap. The ice cap had already been weakened and fractured by a few months of pre-cursor seismic activity. The melted snow and ice, along with chunks of ice, surged down gullies that started high on the slopes, picking up water, water-saturated sediments, rocks, and vegetation along the way. The eruption occurred just after 9:00 pm, and about 2 and a half hours later lahars managed to travel the approximately 50 km down river valleys to the town of Armero. The lahar entered Armero at 11:30 pm as a wall of muddy water nearly 40 meters high, and roared into the city, producing an eventual thickness of 2-5 meters of mud. Somewhere around 23,000 people were almost instantly killed. The path of destruction almost exactly matches similar disasters that occurred in 1595 and 1845. It also almost exactly covered the highest lahar-designated area on the volcanic hazard map that had been prepared prior to the 1985 eruption. Unfortunately that map had not yet been distributed by the time of the 1985 eruption.

Another place that is starting to get really tired of lahars is Pinatubo, in the Philippines. The 1991 Pinatubo eruption was the second largest this century (after Katmai in 1912), and deposited a huge volume of relatively loose pyroclastic material on already-steep and gullied slopes. Additionally, the rainfall in the Philippines is very high. The combination of all this unconsolidated material and heavy rainfall has generated probably hundreds of lahars, some of which have been enormous. Timely evacuation meant that only a couple hundred people were killed directly by the 1991 eruption. Many times that many have been killed or injured by lahars since the 1991 eruption. These lahars will continue to be a problem for decades after the big eruption.

Rhyolite Caldera Complexes

Rhyolite caldera complexes are the most explosive of Earth's volcanoes but often don't even look like volcanoes. They are usually so explosive when they erupt that they end up collapsing in on themselves rather than building any tall structure (George Walker has termed such structures "inverse volcanoes"). The collapsed depressions are large calderas, and they indicate that the magma chambers associated with the eruptions are huge. In fact, layers of ash (either ash falls or ash flows) often extend over thousands of square kilometers in all directions from these calderas. Fortunately we haven't had to live through one of these since 83 AD when Taupo erupted. Many rhyolite caldera complexes, however, are the scenes of small-scale eruptions during the long reposes between big explosive events. The vents for these smaller eruptions sometimes follow the ring faults of the main caldera but most often they don't. The origin of these rhyolite complexes is still not well-understood. Many folks think that Yellowstone, for example, is associated with a hotspot. However, a hotspot origin for most other rhyolite calderas doesn't work; they occur in subduction-related arcs. Examples of rhyolite caldera complexes include Yellowstone, La Primavera, Rabaul, Taupo, Toba, and others.

This is an outcrop in the Los Chocoyos ignimbrite, the product of one of the most powerful eruptions known...

Volcanic Mineral Deposits

Can your knowledge of volcanic rocks make you rich? Yes, if you combine it with knowledge of mineral deposits and global economic factors. Volcanoes directly or indirectly produce or host deposits of aluminum, diamonds, gold, nickel, lead, zinc, and copper. We use most of these materials everyday and, over the course of a lifetime, consume some of them (via the products we buy and use) in great amounts. This page provides a basic overview of the mineral deposits hosted in volcanic rocks. Photo shows alluvial diamonds that were eroded from the Argyle pipe.

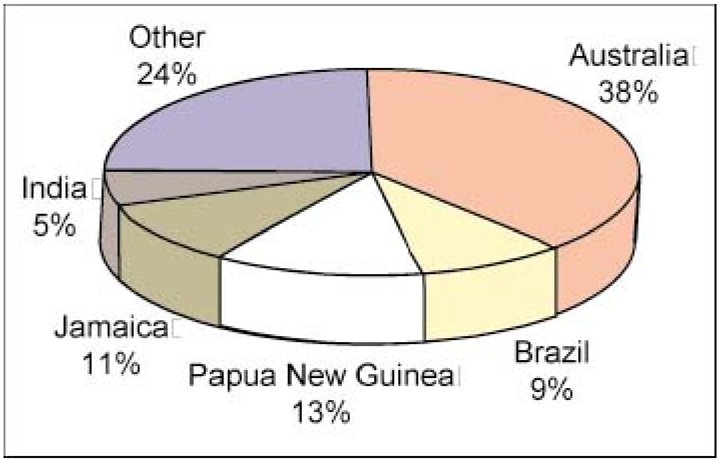
Bauxite

Aluminum ore, called bauxite, is most commonly formed in deeply weathered rocks. In some locations, deeply weather volcanic rocks, usually basalt, form bauxite deposits. This sample of bauxite ore is from Western Australia.

Uses for Aluminum

Aluminum has a wide range of common uses. It is lightweight, strong (especially with alloys), and conducts heat well. Many kitchen items (pots and pans, foil, dishes) are made of aluminum. Most materials used for transportation use large amounts of aluminum: cars, trucks, boats, aircraft, and aircraft engines. Road signs and high-voltage power lines are also made mostly of aluminum.

World Supply of Aluminum

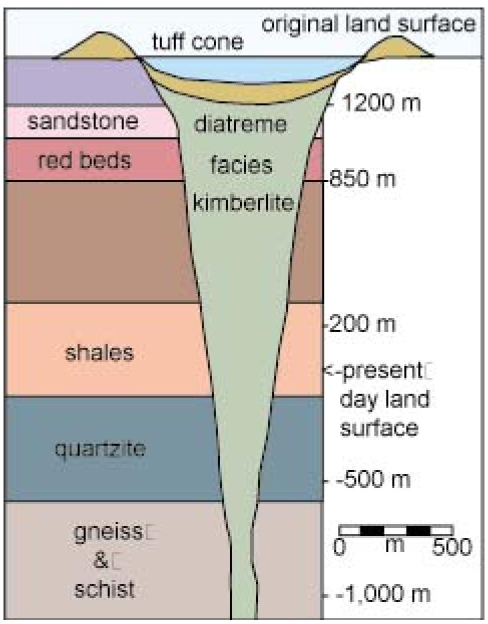


About 110 million tonnes of aluminum was produced in 1994. Australia produces most of the world's aluminum. Diagram from ITAM Bauxite by the Minerals Council of Australia

Diamonds

Diamonds are crystalline carbon and the hardest known substance. This photo shows diamonds from the Argyle Mine in northern Western Australia.
Photo of a courtesy of Argyle Diamond Mine.

Diamonds are brought to the surface from the mantle in a rare type of magma called kimberlite and erupted at a rare type of volcanic vent called a diatreme or pipe. Kimberlite is a gas-rich, potassic ultramafic igneous rock that contains the minerals olivine, phlogopite, diopside, serpentine, calcite, and minor amounts of apatite, magnetite, chromite, garnet, diamond, and other upper mantle minerals. Upper mantle xenoliths are found in some kimberlite and provide clues to the magma's origin. The source depth for kimberlite magmas is estimated at 200 km, more than twice as deep as the source region for most magmas. At a depth of 200 km the pressure is 60,000 times greater than the surface and the temperature is about 1500 C. Kimberlite magmas are rich in carbon dioxide and water which brings the magma quickly and violently to the surface. Most kimberlites occur as multiple intrusive events. Kimberlite was named for the rock associated with diamonds in Kimberley, South Africa.



Kimberlite magmas form "pipes" as they erupt. A tuff cone is at the surface and formed by base-surge deposits. In the subsurface, a funnel-shaped body narrows to a depth of hundreds of meters. The pipe (also called a diatreme) is filled with kimberlite, with or without diamonds (only 1 in 5 of the pipes at Kimberley contain diamonds). Simplified from Hawthorne (1975).

Just how many diamonds are needed to make aa pipe economical? Some South African mines operate at 25 carats of diamond per 100 cubic meters of rock or about 2 grams of diamonds per 100 tons of rock. Because diamond has a specific gravity of 3.5 grams per cubic centimeter, 1 cubic centimeter of diamond weighs 16 carats. Picture a giant 100-ton ore truck full of kimberlite - that truck contains only half of a cubic centimeter of diamonds! Only about 35% of those diamonds are gem quality.

Macles diamonds from the Argyle pipe, Western Australia.

Uses for Diamonds

Most diamonds are used in drill bits and diamond tools. A small number are used for glass cutters and surgical instruments. Only the finest are used as gems.

World Supply of Diamonds

Australia is currently the world's largest producer of diamonds. Most of these diamonds are low quality and used for industrial purposes. Most of the diamonds are from the Argyle diamond pipe in northern Western Australia. The pipe at Argyle is made of lamproite, not kimberlite. The mine produced 27.8 million carats (1 ct = 200 mg; 5 carats = 1 gram) of low grade diamonds in 1993-1994. Because of the high rate of production at Argyle, mining operations will end within the next few years.

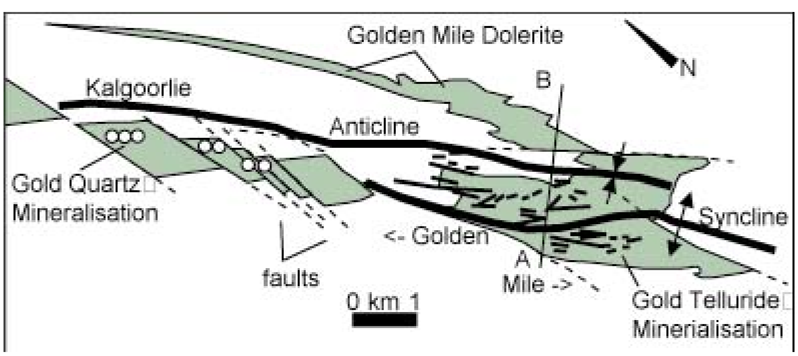
The mines at Kimberley, South Africa have produced a total of more than 200 million carats since the 1870s. About half of South Africa?s diamonds are gem quality.

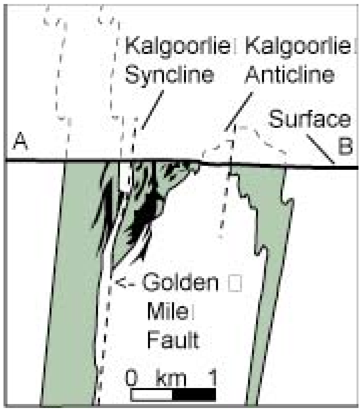
Gold

Gold forms in close association with volcanoes or is hosted in volcanic rocks. Three environments/styles are most common: gold in greenstone belts, gold in porphyry deposits, and gold in epithermal deposits. Photo shows gold jewelry recovered from the ash deposits of the 79 A.D. eruption of Vesuvius.

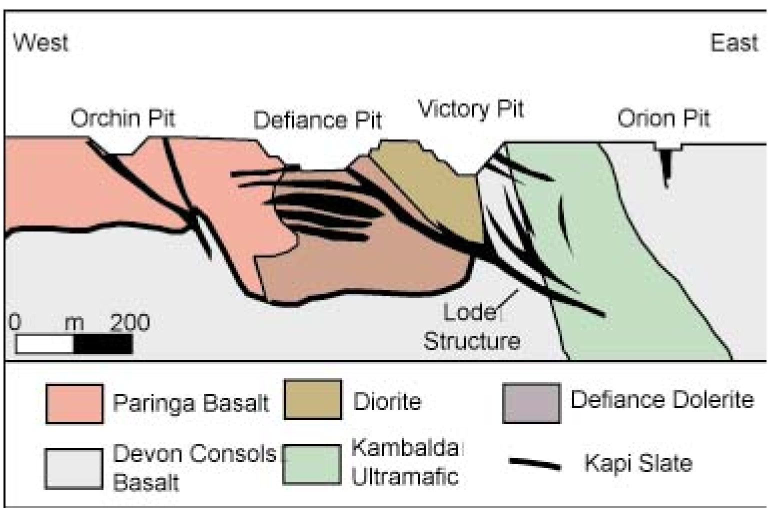
Gold in Greenstone Belts

Gold is found in Archean (rocks older than 2.5 billion years) greenstone belts in Australia, southern Africa, and Canada. Greenstone belts are volcanic-sedimentary sequences, which include ultramafic rocks, dolerite, basalt, chert, sandstone, shale, tuff, banded iron-formation and other rock types. These rocks are very complex, having undergone metamorphism, folding, faulting, and shearing. Gold is most commonly found along the edges of greenstone belts and associated with structural features. Intensely altered and fractured basalt is a common host rock. The gold is though to be mobilized by hydrothermal solutions during regional metamorphism. The solutions probably contain only a few parts-per billion gold but great volumes of solution can precipitate their gold in a small zone with favorable chemical conditions. The deposit itself is usually a quartz vein that carries the gold or adjacent altered rock.



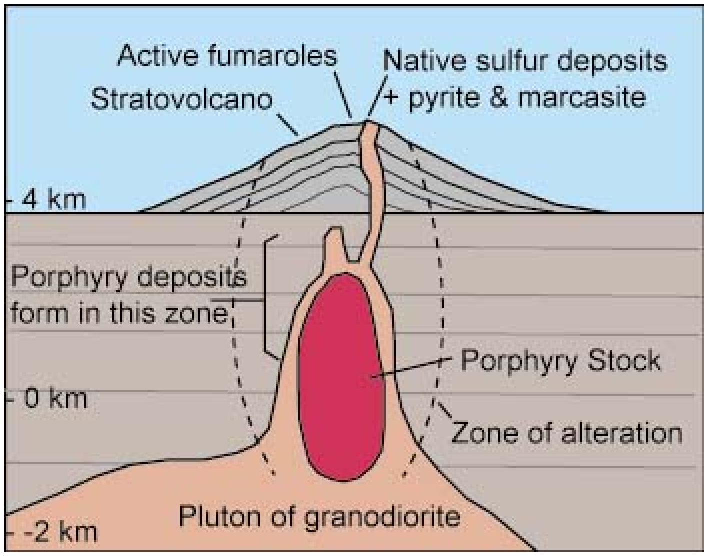


A classic example of gold hosted in greenstone is the Golden Mile in Kalgoorlie, Western Australia. The top diagram is a simple map that shows folds, faults, rock type, and mineralization. The bottom diagram is a cross-section of the deposit. Dolerite refers to dike rocks with plagioclase crystals in pyroxene crystals. By 1993, 40 million ounces of gold has been mined from the Golden Mile. Diagram from ITAM Gold by the Minerals Council of Australia.



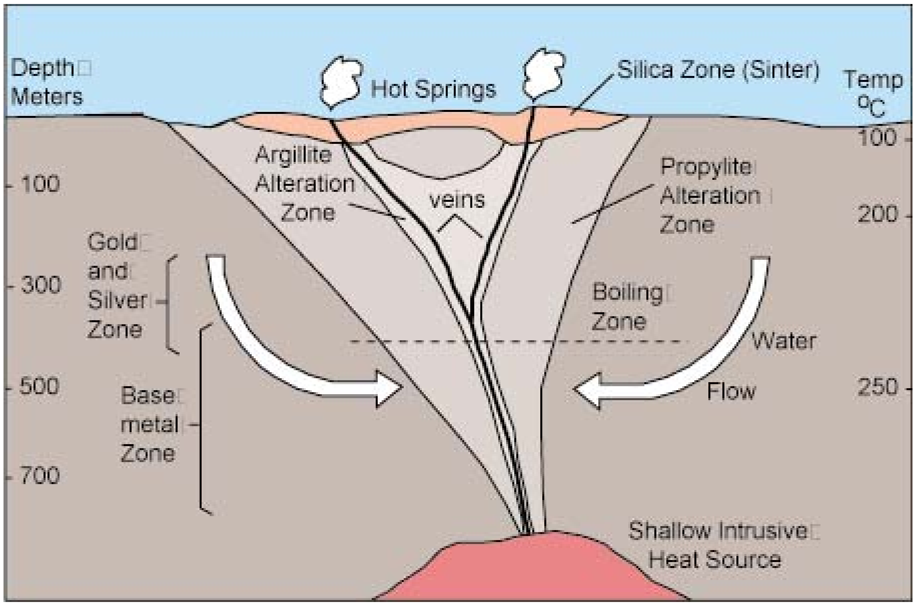
Another example of gold hosted in greenstone is the St. Ives deposit near Kambalda, Western Australia. Three mines have produced more than 2.1 million ounces of gold from 1980-1993. Another 5.4 million ounces of gold remains in the deposits. The gold is found in altered rocks in all parts of the stratigraphic sequence. Diagram from ITAM Gold by the Minerals Council of Australia.

Gold in Porphyry Deposits



Gold and copper are found in ore bodies associated with porphry. Porphry is a general term applied to igneous rocks of any composition that contain conspicuous phenocrysts (crystals) in a fine-grained groundmass. The term is from a Greek word for purple dye and was first applied to a purple-red rock with phenocrysts of alkali feldspar that was quarried in Egypt. Diagram from ITAM Copper by the Minerals Council of Australia. This type of deposit forms beneath stratovolcanoes and is associated with subduction zones. Erosion strips off overlying rocks to expose the mineralization. Gold and copper are found in sulfide minerals disseminated throughout the large volumes of intrusive rock (strictly speaking, this ore is associated with volcanic systems, usually not the volcanoes themselves). This requires large amounts of rock to be mined, often in open pits. The deposits are commonly 3-8 km across and copper may be less than 1% of the rock. Porphyry deposits are zoned in alteration (potassic ® sericitic ® argillic ® propylitic) and mineralization.

Gold in Epithermal Deposits



Epithermal refers to mineral deposits that form in association with hot waters. The deposits form within 1 km of the surface and water temperatures are about 50-200 degrees C. Shallow bodies of magma supply heat. The rising hot water carries dissolved gold and other elements. The water boils about 300 m below the surface and hydrogen sulfide gas escapes. This causes the gold to precipitate. The boiling zone is the target for mineral exploration. Veins commonly host the economic minerals. Diagram from ITAM Gold by the Minerals Council of Australia.

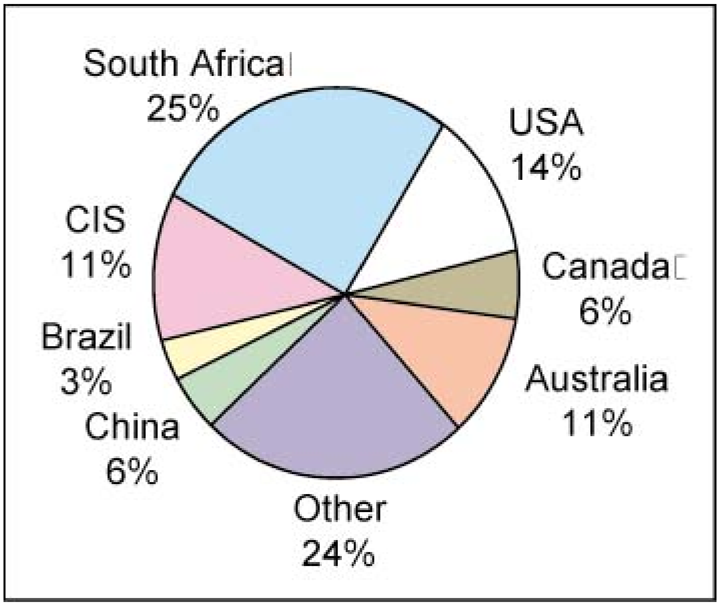
Lihir Island in Papua

New Guinea is an epithermal deposit discovered in 1982. The island is made of three volcanoes including Luise caldera, where the deposit formed. The rocks are trachybasalt lava flows, breccia, and tuffs.The mineralized rocks are highly altered. Most of the ore is in breccia thought to have been a boiling zone for rising fluids. The deposit formed between 350,000 and 100,000 years ago. It is estimated that the deposit contains 21.3 million ounces proven and probably another 42 million ounces as a geological resource. Most of the gold is fine particles in pyrite (FeS) grains. Hot springs and fumaroles are still active on the caldera floor.

Uses for Gold

Gold is rare, durable, chemically inert, and beautiful. These qualities make it useful for monetary exchange and investment, jewelry, and art.Gold?s high electrical conductivity, malleability, and ductility make it useful as an industrial metal. Gold is alloyed with silver, copper, nickel, palladium, zinc, and titanium to increase its tensile strength. Note: for gold, 1 carat = 1/24 part. Pure gold is 24 carat.

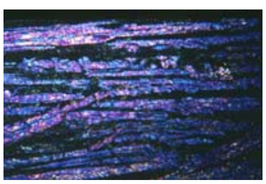
World Supply of Gold



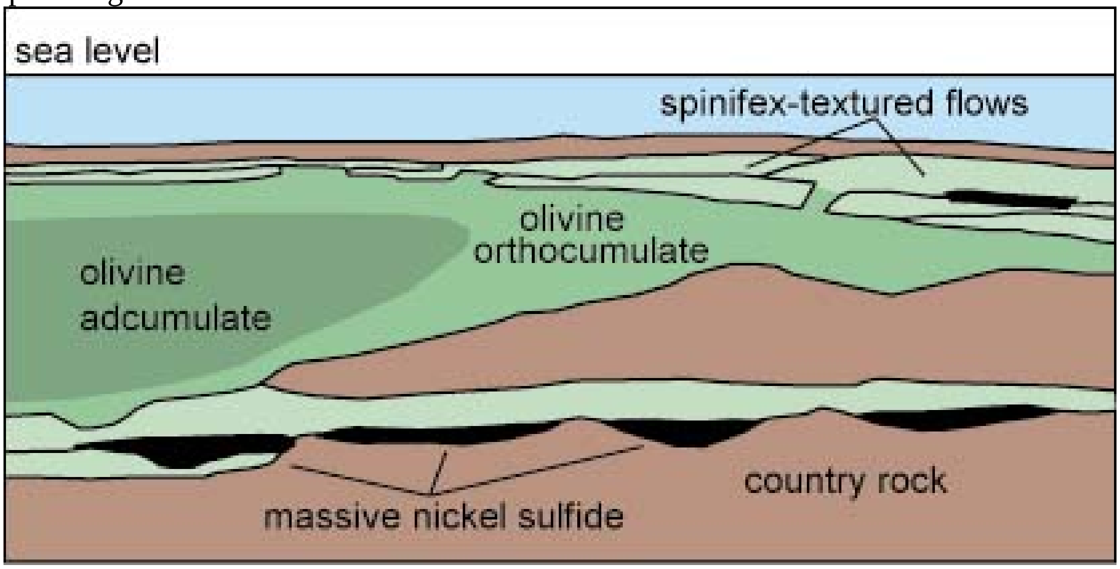
Pie diagram of major gold producers. In 1994, 2,296 tonnes of gold was produced. South Africa is the largest producer, followed by the USA, Australia, and the CIS (former Soviet Union).

Nickel

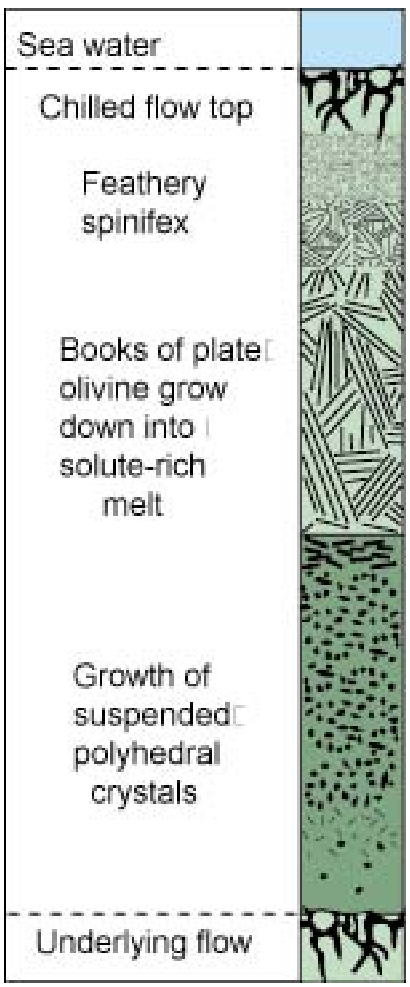
Deposits of nickel sulfides are mined from greenstone belts in many ancient volcanic terranes. The ore is associated with ultramafic lava flows called komatiites. Komatiites have more than 18 weight % magnesium oxide (MgO) and large amounts of the mineral olivine. Komatiites are derived from melting in the mantle.



Komatiites have a unique texture called spinifex. The texture is an intergrowth of long, skeletal crystals of olivine and/or pyroxene. The texture is named for its resemblance to spinifex grass in Australia.



Cross-section of a typical komatiite lava flow. Simplified from Hill and others, 1989.



Cross-section of igneous lithologies and associated massive nickel sulfides in a komatiite lava flow. Simplified from Hill and others, 1989.

Core in komatiite lava with adcumulate texture.
The Sudbury District in Canada is the world's largest producer of nickel.

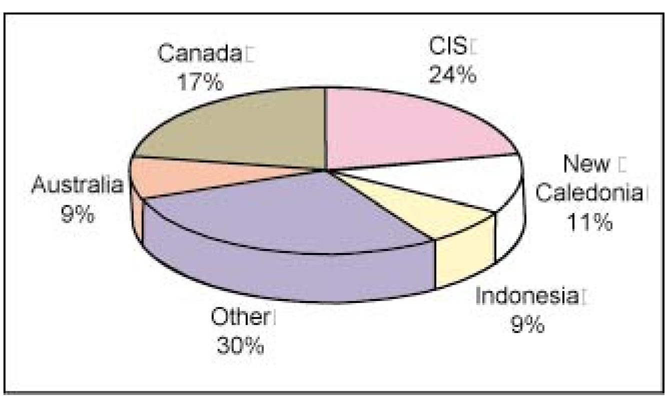
Another major nickel producer is in Western Australia and includes the Kambalda and MurrinMurrin deposits. MurrinMurrin consists of five deposits with a total of 11.9 million tonnes at 1.01% Ni and 0.07% Co.

In 1993, a large deposit of nickel-, copper-, and cobalt-sulfides (~150 million tons) was discovered at Voisey Bay on the northeast coast of Labrador, Canada. This deposit formed in magma chambers that fed large basaltic eruptions.

Uses for Nickel:

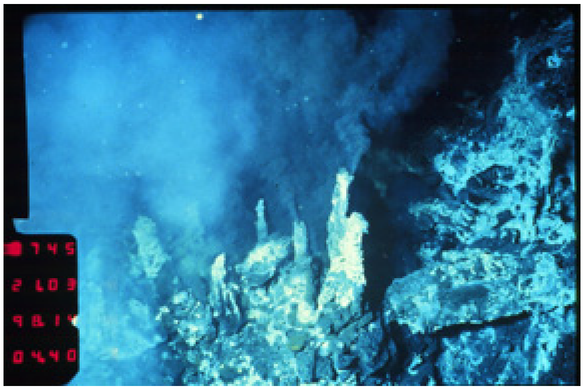
Nickel is commonly alloyed with other metals to provide resistance to corrosion and heat, and to add strength and hardness. These alloys are used for industrial and consumer goods. Most of the nickel produced is used to make stainless steel. Stainless steel contains about 8% nickel. Monel metal, a highly corrosion-resistant alloy, contains 67% nickel and is usedin ship building, food-processing equipment and in hospitals. Nickel is used by the military for armor plate. Nickel is used in alkaline batteries, dyes, insecticides and as a catalyst. Nickel is commonly used in coins.

World Supply of Nickel



In 1994, about 875,000 tonnes of nickel was produced worldwide. Major producers are the Commonwealth of Independent States (former Soviet Union), Canada, New Caledonia, Indonesia, and Australia. Diagram from ITAM Nickel by the Minerals Council of Australia.

Base Metals



Zinc-Copper volcanogenic massive sulfide (VMS) deposits have been observed as they form at mid-ocean ridges. Chimneys formed at the ridges have as much as 29 weight % zinc and 6 weight % copper in sulfide minerals (pyrrhotite, pyrite, sphalerite, and chalcopyrite). The minerals are dissolved in fluids at temperatures as high as 380 C flowing at 1-5 m/sec.

The minerals precipitate as the hot solution comes in contact with cold sea water. Woods Hole Oceanographic Institution and members of the Adventure dive (Principle Investigators: D. Fornari, R. Haymon, K. Von Damm, M. Perfit, M. Lilley, and R. Lutz).

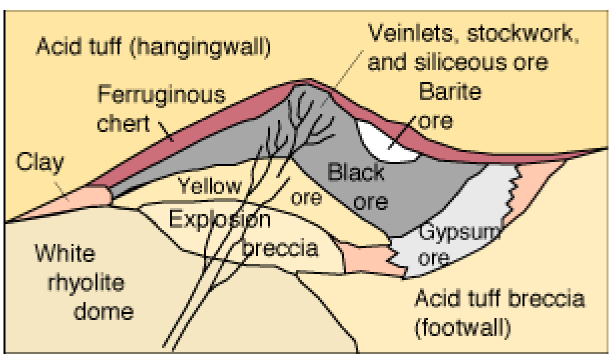
Photo 37. Pyrite stringers in silicified tuff.

Lead, zinc, and cooper are found in VMS deposits. The deposits form in deep ocean water by the precipitation of sulfide minerals released by submarine volcanoes.

Volcanic fluids and hot seawater move through the volcanic rocks and leach metals. The deposits are associated with lava flows, breccia, water-deposited tuffs, cherts, sulfates, and limestones. VMS deposits are usually associated with quartz, anhydrite, gypsum, and barite. This photo shows pyrite in silicified tuff from a VMS deposit in eastern Java, Indonesia. The sample contains 0.55 ppm gold.
Photo by Steve Mattox.

There are three types of VMS deposits:

	Zinc-Copper	Lead-Zinc-Copper	Copper-Pyrite	
Host rock	basalt to rhyolite	rhyolite	basalt or ultramafic lava	
Age	Archean	Proterozoic-Paleozoic	Mesozoic	
Ore minerals	sp, ch, py	ga, sp, py, some ch	ch, py	
Associated metals	gold, silver	silver, some gold	gold	
Famous Occurrences	greenstones of Canada, Australia	Sudbury and Bathurst Canada	Kuroko, Japan	Cyprus
Setting	spreading centers	back-arc basins	spreading centers	
Minerals:	sp = sphalerite	ch = chalcopyrite	py = pyrite	and ga = galena.



Kuroko-style VMS deposits are found in dacite-rhyolite domes that erupted in the deep water of back-arc (behind the main volcanic arc) basins. Kuroko deposits are zoned from copper-rich near the center, to zinc-rich, to lead-rich at the outer edges of the deposit. The fluids that form Kuroko deposits have twice the salinity of average ocean water and temperatures of 250-300 C. This cross-section of a typical Kuroko deposit is from Sato (1974) and Franklin and others (1981). Modern-day VMS deposits of the Kuroko-style have been observed as they form in the back-arc basin of the Okinawa Trough (Halbach and others, 1989).

The deposit at Bathurst in Canada is an example of lead-zinc-copper VMS. Hydrothermal solutions associated with Keweenawan flood basalts have produced copper deposits in the Lake Superior area. Between 1845 and 1968, over 13 billion pounds of copper and 16 million ounces of silver were produced from the Keweenawan district.

The porphry (not VMS) mine at El Abra in Chile will produce 500 million pounds of copper annually.

Uses for Copper, Lead, and Zinc

Copper was used as long ago as 8000 BC for tools, weapons, and ornaments. The discovery of bronze (copper and tin alloy) about 3500 BC marked the onset of the Bronze Age. Romans used lead for the plumbing and sewage systems. In Modern times, the electrical conductivity, ductility, and resistance to corrosion of copper, lead, and zinc, make them very useful in alloys. Copper is used for electrical applications (50%), general and industrial engineering applications (20%), building and construction (15%), transportation (11%) and other applications. Lead is used in storage batteries, paints, dyes, explosives, insecticides, and rubber products.

Zinc is used in galvanized steel, protective coatings for steel, and die casting. Zinc compounds are used for luminous dials, cosmetics, plastics, rubber products, soaps, and inks.

World Supply of Copper

In 1991, 9,167,000 tons of copper was produced. Chile (19.8%), USA (17.8 %), and the CIS (9.8%) are the main producers. USA, Japan, and the CIS are the main consumers.

Current Volcanic Activity

Third highest Fumarole and ice cavern

Headwall of Fourpeaked Glacier, surface rilling, vapor plume

Fourpeaked Volcano, Alaska Peninsula, USA

A large steam explosion near the summit of Fourpeaked volcano occurred on Sunday, September 17 beginning at approximately 12:00 noon AKDT (2000 UTC, September 18). Fourpeaked volcano is not known to have erupted historically and the age of the ast eruption is not known. Geological investigations have been limited and ice covers much of the area. Because of this, the rang f sizes and styles of past eruptions are not well-constrained. However, the composition of the volcano indicates that eruptions o ourpeaked can be explosive, possibly producing plumes that reach in excess of 10 km (33,000 ft) above sea level and local ashfa

Latest SI/USGS reports.

VOLCANO:	YEAR OF MOST RECENT SIGNIFICANT ERUPTION	DATE OF MOST RECENT ACTIVITY REPORT:	LOCATION and WEB CAM (if available)
Cleveland, Chuginadak Island, Alaska AVO raised the Alert Level for Cleveland from Advisory to Watch on 28 October based on pilot reports of an ash plume. Satellite imagery confirmed the presence of a plume drifting ENE at an altitude estimated at 6.1 km (20,000 ft) a.s.l. A pilot reported that the altitude of the plume was in excess of 9.1 km (30,000 ft) a.s.l. On 30 October, the Alert Level was lowered back to Advisory because of no further evidence of activity. Sources: Alaska Volcano Observatory - "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	October 31, 2006	52.82N, 169.95W
Mayon, Philippines PHIVOLCS announced the lowering of the Alert status for Mayon from Alert Level 2 to Alert Level 1 on 25 October. The 7-km Extended Danger Zone (EDZ) on the SE flank remained in effect. Sources: Philippine Institute of Volcanology and Seismology - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	October 31, 2006	13.3N, 123.7E
Bulusan, Philippines	1995	October 31,	12.770N,

PHIVOLCS reported that during 25-26 October, a lahar from Bulusan deposited sediments 15 cm (6 in) thick along a tributary leading to the Gulang-gulang River. According to news articles, the lahar mobilized boulders as large as trucks and caused at least 96 people to evacuate. During 30-31 October, ash explosions generated a light gray ash-and-steam plume that rose to 2.3 km (7,400 ft) a.s.l. and drifted NNE. Later field inspection revealed ashfall (trace to 1 mm) in the N sectors of the volcano, including areas in the municipalities of Casiguran and Gubat. Source: Philippine Institute of Volcanology and Seismology - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."		2006	124.05E
Colima, Mexico Based on reports from the Mexico City MWO and satellite imagery, the Washington VAAC reported that an eruption plume from Colima on 29 October reached an altitude of 6.1 km (20,000 ft) a.s.l. and drifted S. Sources: Washington Volcanic Ash Advisory Center - "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005, ongoing	October 31, 2006	19.51N, 103.62W WEB CAM
Karymsky, Kamchatka, Russia Seismic activity increased at Karymsky during 21-27 October, with 350-550 shallow earthquakes occurring daily. Explosions produced	2005, ongoing	October 31, 2006	54.0N, 159.5E

ash plumes that may have reached altitudes of 2.5-5.0 km (8,200-16,400 ft) a.s.l. and drifted E, NE, and SE. Staff from the Institute of Volcanology and Seismology (IVS) observed a series of ash bursts that produced plumes to 2.0 km (6,600 ft) a.s.l. on 25 October. A thermal anomaly in the crater was detected on satellite imagery during 19-24 October. Sources: Kamchatkan Volcanic Eruption Response Team (KVERT) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Kilauea, Hawai'i, USA The summit of Kilauea continued to slowly inflate S of Halema'uma'u caldera during 25-31 October. Incandescence was intermittently but strongly visible from the East Pond and January vents, and occasionally dimly visible from South Wall complex and Drainhole vent in Pu'u 'O'o's crater. Lava from the Campout and PKK systems continued to flow off of a lava delta into the ocean at the East Lae'apuki and East Ka'ili'ili entries. On 25 October, two separate break-out lava flows were visible on Pulama pali. The upper flow at about 320 m (1,050 ft) elevation consisted of 'a'a and pahoehoe and the lower flow at 114 m (375 ft) was solely pahoehoe. Sources: US Geological Survey Hawaiian Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005, ongoing	October 31, 2006	19.452N, 155.292W WEB CAM

Langila, New Britain, Papua New Guinea During 23-31 October, eruptive activity at Langila's Crater 2 consisted of continuous emissions of gray-to-brown ash plumes accompanied by sub-forceful gray ash plumes. Pilots reported plumes to an altitude of 2.4 km (8,000 ft) a.s.l. that drifted NE. Explosions of incandescent lava fragments were visible during 23-30 October. Based on satellite imagery, the Darwin VAAC reported that on 31 October a small ash plume rose to an altitude of 4.6 km (15,000 ft) a.s.l. and drifted NNE. Sources: Herman Patia, Rabaul Volcano Observatory, Darwin Volcanic Ash Advisory Centre - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2004	October 31, 2006	5.52S, 148.42E
Rabaul, Papua New Guinea Based on satellite imagery, the Darwin VAAC reported that a small ash-and-steam plume from Rabaul reached an altitude of 3.0 km (10,000 ft) a.s.l. and drifted NW on 26, 27, and 28 October. The RVO reported that mild eruptions during 29-30 October produced thick, gray ash plumes that drifted N and NW. Fine ashfall was reported from Namanula, including surrounding areas downwind, and E Rabaul town. Seismicity was at background levels and the rate of ground deformation was low. Sources: Herman Patia, Rabaul Volcano Observatory, Darwin Volcanic Ash Advisory Centre -	2004	October 31, 2006	4.27S, 152.20E

"Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Sakura-Jima, Kyushu, Japan Based on information from JMA, the Tokyo VAAC reported that on 25 and 27 October, ash plumes from Sakura-jima reached altitudes of 2.1-2.4 km (7,000-8,000 ft) a.s.l. Plumes drifted SW and NE, respectively. Source: Tokyo Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	October 31, 2006	31.58N 130.67E WEB CAM
Santa Maria, Guatemala According to the Washington VAAC, minor emissions from Santa Mar s Santiaguito lava-dome complex on 26, 27, and 30 October were visible on satellite imagery. The small plumes of gas and light ash drifted predominantly W. Source: Washington Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005, ongoing	October 31, 2006	14.8N, 91.5W
Semeru, Java, Indonesia Based on a pilot report, the Darwin VAAC reported that on 25 and 26 October, an eruption plume from Semeru reached 7.6 km (25,000 ft) a.s.l. and drifted W. On 30 October, ash-and-steam emissions were detected on satellite imagery.	2005	October 31, 2006	8.1S, 112.9E

Source: Darwin VAAC - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Soufriere Hills, Montserrat, West Indies During 20-27 October, lava-dome growth at Soufri Hills continued and was concentrated on the NE part of the edifice. Rockfalls and small pyroclastic flows originating from the active lobe traveled down the NE flank. Several small stubby spine-like structures were observed on the SE summit region of the dome. Based on information from the MVO, satellite imagery, and the Piarco MWO, the Washington VAAC reported that continuous ash and gas emissions during 25-31 October produced plumes that drifted NW and W. Plumes reached altitudes of 2.1 km (7,000 ft) a.s.l. A hotspot was detected on satellite imagery during 25-27 October and 29 October. Sources: Montserrat Volcano Observatory, Washington Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2006, ongoing	October 31, 2006	16.7N, 62.2W
Mount St. Helens, USA During 25-31 October, the lava dome at Mount St. Helens continued to grow and produce small rockfalls. On 29 October, a M 3.2 earthquake was accompanied by a rockfall that produced a small plume. The plume filled the crater to just above the rim	2006, ongoing	October 31, 2006	46.2N, 122.2W WEB CAM

and quickly dissipated. Source: US Geological Survey Cascades Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Sulu Range, New Britain Island, Papua New Guinea The RVO reported that during 28 September-24 October, seismic activity in the Sulu Range declined. Vapor plumes that were emitted from the Silanga Hotsprings were visible about 20 km NE from Bialla. A moderately strong sulfur smell from the Silanga and Talopu hot springs continued to be reported. Source:Herman Patia, Rabaul Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	The Sulu Range has not been active in historical times.	October 31, 2006	5.50S, 150.942E
Suwanose-Jima Ryukyu Islands, Japan Based on information from JMA, the Tokyo VAAC reported that on 27 and 28 October, ash plumes from Suwanose-jima reached altitudes of 1.8 km (6,000 ft) a.s.l. Plumes drifted E on 28 October. Source: Tokyo Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	October 31, 2006	29.53N, 129.72E
Tungurahua, Ecuador	2006, ongoing	October 31, 2006	1.467S, 78.44W

IG reported that during 25-30 October emissions from Tungurahua produced plumes consisting of steam, gas, and moderate ash that reached altitudes of 7-8 km (23,000-26,000 ft) a.s.l. and drifted W, SW, NW, and NE. Ashfall was reported from several towns downwind of the plumes including Penipe (8 km SW), Bilbao (8 km W), Cotalo (13 km NM), and Banos (8 km NNE). On 28 October, incandescent blocks were expelled from the summit and rolled about 500 m down the W and E flanks. The next day, a lahar traveled NNW down the Mandur drainage and muddy water swelled in the Vazcun drainage. Source:Instituto Geofisico-Escuela Politecnica Nacional, Washington Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Ubinas, Peru Based on pilot reports, the Buenos Aires VAAC reported continuous emissions from Ubinas on 25, 27-28, and 30-31 October. The plumes rose to 5.5-8.5 km (18,000-28,000 ft) a.s.l. and drifted N, NW, SW, and W. Sources: Buenos Aires Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1969	October 31, 2006	16.355S, 70.903W
Arenal, Costa Rica In September, activity originating from Arenal's Crater C consisted of gas emissions, sporadic Strombolian	2006, ongoing	October 24, 2006	10.46N, 84.70W

eruptions, lava flows traveling N, and occasional avalanches from lava-flow fronts. Blocks from the lava-flow fronts traveled N, NE, and NW, periodically reaching vegetation where they produced small fires. Volcanic activity was at relatively low levels, however, with few eruptions occurring and a small amount of pyroclastic material ejected. Eruptions produced ash plumes that rose about 2.2 km (7,100 ft) a.s.l. Ash and acid rain fell on the NE and SE flanks. Small avalanches of volcanic material traveled down several ravines. Crater D showed only fumarolic activity. Source: Observatorio Vulcanologico y Sismologico de Costa Rica-Universidad Nacional (OVISICORI-UNA) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Barren Island, Andaman Islands, India Based on pilot observations, the Darwin VAAC reported that ash-and-steam plumes from Barren Island on 19 and 20 October reached altitudes of 1.5 km (5,000 ft) a.s.l. and drifted WNW. Source: Darwin Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2006	October 24, 2006	12.29N, 93.88E
Fourpeaked, Alaska Peninsula, USA The AVO reported that earthquake activity and gas emissions continued	unknown	October 24, 2006	58.770N, 153.672W

at Fourpeaked during 14-20 October. Steam-and-gas plumes rising from a location near the summit were visible on a recently installed web camera. Source: Alaska Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Metis Shoal, Tonga Islands Further information obtained regarding the floating pumice rafts between Tonga and Fiji indicated that the source was Metis Shoal. Mariners in the region were being informed of this activity in early September via "Rag of the Air" radio broadcasts from Fiji. The earliest report found to this point comes from a boat with callsign KB1LSY, noting that "thick pumice" slowed them for 30 minutes during the early morning hours of 28 August as they were approaching the northern islands of the Lau Group in Fiji, about 500 km NW of Metis Shoal. By 15 October yachts sailing between Tonga and Fiji reported no remaining pumice. (Original report - 9/26) Reports have been received of large pumice rafts in the Fiji Islands. On 16 September observers aboard the M/V National Geographic Endeavour noted almost continuous rows of pumice that day as they traveled about 90 km east-southeast to Vatoa Island, where the pumice was present on the beaches. Large rafts of pumice were also passing through the northern Lau Group around Naitauba Island on 19 September. The source of the pumice is unknown at this time.	n/a	October 24, 2006	19.18S, 174.87W

Sources: Sources: Encore II Crew, KB1LSY Crew, Bob McDavitt's Weathergram McDavitt's Pacific Weathergrams, David Cothran, M/V National Geographic Endeavour; David Forsythe, Naitauba Island, Fiji - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Poas, Costa Rica OVSICORI-UNA reported that during September, Laguna Caliente, a summit lake of Po?s, was mostly gray in color and produced gas columns that reached the crater rim. The level of the lake had dropped 5 cm with respect to August measurements and had a temperature of 46 degrees Celsius. On 25 October, a phreatic eruption produced a plume that drifted 12 km SW of the crater. Fumarolic activity from a pyroclastic cone on the floor of the crater produced gas plumes that drifted W and SW. New points of gas discharge were noted from the crater floor, the SE and NE crater walls, the N terrace, and the NE edge of the crater. Source: Observatorio Vulcanologico y Sismologico de Costa Rica-Universidad Nacional (OVSICORI-UNA) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1996	October 24, 2006	10.20N, 84.23W
Sangay, Ecuador Based on a pilot report, the Washington VAAC reported that on 21 October, emission plumes from Sangay reached altitudes of 6.7 km (22,000 ft) a.s.l.	2005	October 24, 2006	2.0S, 78.3W

Source: Washington Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Turrialba, Costa Rica Fumarolic activity and gas discharge in and to the W of Turrialba's central crater continued throughout September. New points of gas discharge, small landslides, and accelerated vegetation die-off were noted from various locations within the crater. Source: Observatorio Vulcanologico y Sismologico de Costa Rica-Universidad Nacional (OVSICORI-UNA) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1866	October 24, 2006	10.025N, 83.767W
San Miguel, El Salvador Servicio Nacional de Estudios Territoriales (SNET) reported on 10 October that an Alert Level for San Miguel was established as Green within 4 km from the center of the crater due to a slight increase in seismic activity. On 15 October, the Alert Level was increased to Yellow due to further increases in seismic activity, but then decreased to Green again the next day. Source: Servicio Nacional de Estudios Territoriales (SNET) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2004	October 17, 2006	13.431N, 88.272W

Piton de la Fournaise, Reunion Island, Indian Ocean The eruption of Piton de la Fournaise that began on 30 August continued within the Dolomieu Crater. A new cone about 20-25 m high was formed in the SE part of Dolomieu and lava flows up to 10 m thick filled up 75% of the crater floor. The E part of the crater was filled up to the rim where lava flowed over and down the flank for hundreds of meters. On 9 October, a new crater formed about 100 m SW of the first one. Source: Thomas Staudacher, Observatoire Volcanologique du Piton de la Fournaise via the Volcano Listserv - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2004	October 17, 2006	21.23S, 55.71E WEB CAM
Ruapehu, New Zealand A M 2.8 earthquake centered at Ruapehu was recorded on 4 October. Scientists visited the summit crater lake on 7 October and confirmed that a small hydrothermal eruption had occurred. The lake water level had risen 1 m since a previous measurement, and evidence suggested wave action up to 4-5 m above the surface of the lake. The lake temperature was 22.5C, up from 15C. Ruapehu remained at Volcanic Alert Level 1 (some signs of volcano unrest). Sources: US Geological Survey Hawaiian Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological	1997	October 10, 2006	39.3S, 175.6E WEB CAM

Survey's Volcano Hazards Program."			
Taal, Philippines PHIVOLCS reported ongoing seismic unrest at Taal on 26 September. During 25-26 September, 29 volcanic earthquakes occurred with five felt Modified Mercalli intensities of II to III. Epicenters were dispersed NE, N, and NW. Approximately five seismic events in a 24-hour period is typical during quiet periods. Source: Philippine Institute of Volcanology and Seismology - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1977	October 10, 2006	14.002N, 120.993E
Fuego, Guatemala INSIVUMEH reports noted that frequent explosions at Fuego during 14-29 September sent incandescent lava 75-100 m above the crater rim and generated hot avalanches SW towards the Taniluy? River. Source: Instituto Nacional de Sismologia, Vulcanologia, Meteorologia, e Hidrologia - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2006, ongoing	October 03, 2006	14.5N, 90.9W
Pacaya, Guatemala Lava flows have continued at Pacaya during 14-29 September, as reported by INSIVUMEH. The flows slowly advanced W towards Cerro Chino and NE towards Cerro Grande. White fumarolic emissions continued to rise from the MacKenney Cone.	2005	October 03, 2006	14.4N, 90.6W

Source: Instituto Nacional de Sismologia, Vulcanologia, Meteorologia, e Hidrologia (INSIVUMEH) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Dempo, Sumatra, Indonesia Increased seismicity at Dempo resulted in an elevation of the hazard status to Alert Level 2. Source: Center of Volcanology and Geological Hazard Mitigation (CVGHM) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1994	September 26, 2006	4.03S, 103.41E
Simbo, Solomon Islands Residents on Simbo Island reported feeling seven "earth tremors" on 21 September, and others in recent days. None of the events caused damage. The Solomon Islands Seismology Division does not have monitoring equipment on the island. Simbo is a small island in the Western Solomons with three truncated andesitic volcanic centers. The only known Potassium-Argon date suggests a Pliocene-to-Pleistocene age for the island, although the southern half of the island is thermally active. Fault-related fumarolic areas and hot springs are found near saltwater Lake Ove along the western coast and along the eastern coast near Mount Patukio, which has a steep-walled summit crater. Grover (1955) noted	1910 +/- 10 years	September 26, 2006	8.292S, 156.52E

native accounts of the explosive enlargement of the Ngusunu explosion crater along the SW coast of the island one to two generations prior to 1955, probably after a visit by Guppy in 1882. Press reports mentioned an eruption at Simbo in the early 1900s that forced the evacuation of villages beside Lake Ove, immediately adjacent to Ngusunu crater. Source: Solomon Star - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Raoul Island, New Zealand The Alert Level at Raoul Island was lowered to 0 (on a scale of 0-5) on 18 September due to a general decline in activity. Since April 2006, no significant earthquake activity had occurred within ~30 km of the island, the water in Green Lake dropped to the pre-eruption level, and on-going hydrothermal activity returned to normal. Source: New Zealand GeoNet Project - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1965	September 19, 2006	29.27S, 177.92W
Tengger Caldera, Java, Indonesia CVGHM reported that the Alert Level for Tengger Caldera was lowered one level to 2 (on a scale of 1-4) on 18 September due to decreased activity. Source:Center of Volcanology and Geological Hazard Mitigation	2004	September 19, 2006	7.942S, 112.950E

(CVGHM) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Etna, Sicily, Italy On 14 July, a fissure opened on the E flank of the SE Crater of Etna and produced a lava flow that traveled E to the Valle del Bove. Moderate strombolian activity from the E flank of the SE Crater produced a small amount of ashfall on Catania (~25 km SSE of the volcano). The lava flow reached a maximum distance of 3 km within the Valle del Bove and ceased on 24 July. On 26 July, strong explosions were heard from the rim of the NE crater. On 31 August, strombolian activity from the summit of the SE Crater produced lapilli and bombs that fell mainly in the crater. The ejecta filled the crater and overflowed on the E side on 5 September, forming lava falls that accumulated in a steep-sided circular depression on the middle part of the E flank. On 7 September, the sluggish a'a' flow breached the E rim and spread out on the E flank of the SE Crater and towards the Valle del Bove rim. Explosive activity at the SE Crater summit produced lava blocks that fell to the base of the cone. On 10 September, a rockfall from a wall that divided the SE Crater and the depression on the middle part of the E flank produced an ash plume that drifted W. Lava flows and strombolian activity from the summit of the SE Crater continued on 11 September.	2005	September 12, 2006	37.7N, 15.0E WEB CAM

Source: Istituto Nazionale di Geofisica e Vulcanologia Sezione di Catania - "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Talang, Sumatra, Indonesia CVGHM raised the Alert Level at Talang to 3 (on a scale of 1-4) on 9 September due to an increase in tremor. On 10 September, a brownish plume rose 250 m above the summit (~10,000 ft a.s.l.). Sources: Directorate of Volcanology and Geological Hazard Mitigation, Washington Post - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	September 12, 2006	1.0S, 100.7E
Manam, Papua New Guinea Based on satellite imagery, the Darwin VAAC reported that ash-and-steam plumes from Manam reached altitudes of 4.6 km (15,000 ft) a.s.l. and drifted W on 1 and 2 September. Steam plumes with possible ash were visible on satellite imagery below 3 km (10,000 ft) a.s.l. and drifted NE. Source: Darwin Volcanic Ash Advisory Centre - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	September 05, 2006	4.1S, 145.0E
Popocatepetl, Mexico According to the Washington VAAC, emissions of gas, steam, and possibly	2004	September 05, 2006	19.0N, 98.6W

ash from Popocat?petl were visible from the camera operated by CENEPRED during 4-5 September. The resulting eruption cloud drifted W and did not rise high above the summit. Incandescence was periodically observed at the summit. Sources: Washington Volcanic Ash Advisory Center- "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			WEB CAM (Select Tamano A or B)
Ulawun, New Britain, Papua New Guinea Based on satellite imagery, the Darwin VAAC reported that ash-and-steam plumes from Ulawun drifted SW and S on 30 August and 2 September, respectively. Sources: Darwin Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2003	September 05, 2006	5.04S, 151.3E
Dukono, Halmahera, Indonesia According to the Darwin VAAC, a diffuse ash plume from Dukono was visible on satellite imagery extending NNE on 23 August. Source: Darwin Volcanic Ash Advisory Center- "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	August 29, 2006	1.70N, 127.87E
Lascar, Chile Several small phreatic explosions	2002	August 29, 2006	23.57S, 67.73W

occurred at Lascar during May, July, and August. The explosions were separated in time by up to several weeks. The last observed explosion, lasting for about five minutes on 14 August, produced a plume that reached a height of 450 m above the crater (19,800 ft a.s.l.) and dispersed ESE. Source: Jorge Clavero-Chilean Geological Survey (Sernageomin) and Juan Cayupi-Chilean Emergency Office (ONEMI) via the Volcano Listserv - "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Oyama, Miyake-jima, Izu Islands, Japan The Tokyo VAAC reported that an eruption at Miyake-jima on 23 August generated plumes that reached altitudes of ~1.5 km (~5,000 ft) a.s.l. and drifted SE. Ash was not identified on satellite imagery. Source: Tokyo Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2004	August 29, 2006	34.08N, 139.53E
Augustine, Cook Inlet, Alaska USA AVO reduced the Concern Color Code at Augustine from Yellow to Green on 9 August. Seismic, satellite, and visual data indicated a decrease in activity to background levels. No changes were seen at the summit during the previous several months. AVO warned that the lava dome and	2005	August 15, 2006	59.363N, 153.43W WEB CAM

surrounding area were still unstable despite the apparent cessation of lava-dome growth. Rockfalls and avalanches were still occurring, especially on the N flank, and may continue for several weeks or months. Sources: Alaska Volcano Observatory - "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Karangetang, Siau Island, Indonesia During 7-13 August, lava flows from Karangetang advanced E toward the Batu Awang river. Incandescent rockfalls originating from lava flow fronts were also observed. The Alert Level remained at 3. Source:Center of Volcanology and Geological Hazard Mitigation (CVGHM) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	August 15, 2006	2.78N, 125.48E
Merapi, Java, Indonesia Based on pilot reports, the Darwin VAAC reported that eruption plumes from Merapi on 2 and 3 August reached altitudes of ~6.1 km (~20,000 ft) a.s.l. and drifted W. According to CVGHM, during 2-4 August rockfalls traveled 1 km SE toward the Gendol river and gas plumes reached a maximum of 400 m above the summit (10,900 ft a.s.l.). On 3 August, the Alert Level was lowered to 2 (on a scale of 1-4). Sources: Center of Volcanology and Geological Hazard Mitigation	2006	August 08, 2006	7.54S, 110.44E

(CVGHM), Darwin Volcanic Ash Advisory Center - "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Canlaon, Philippines Based on interpretations of seismic data, an explosion at Canlaon that lasted more than 10 minutes occurred on 23 July. An ash column was not observed due to cloud cover. Trace deposits of ash fell up to 9 km ENE of the crater in the neighborhoods of Pula, Malaiba, and Lumapao. On 24 July, PHIVOLCS reported a total of 16 volcanic earthquakes, 3 short-duration tremors, and 2 earthquakes indicating small explosions. Ash was not observed. Source: Philippine Institute of Volcanology and Seismology - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2003	July 25, 2006	10.4N, 123.1E
Galeras, Colombia On 17 July, INGEOMINAS (Instituto Colombiano de Geolog?a y Miner?a) reported that after the 12 July eruption of Galeras, seismic activity decreased considerably. Observations of the dome and secondary craters in the W sector post-12 July, showed small physical changes. Gas plumes with little steam content were observed without associated seismic activity. Galeras remained at Alert Level 3 (changes in the behavior of volcanic activity have been noted). Sources: Instituto Colombiano de	2005	July 25, 2006	1.22N, 77.37W

Geologia y Mineria - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Shiveluch, Kamchatka, Russia Eruption plumes from Shiveluch that were visible on satellite imagery on 19 July reached a maximum altitude of 5.2 km (17,000 ft) a.s.l. and drifted SE. Ash was not visible on satellite imagery. A thermal anomaly over the dome was visible on 17 and 18 July. Sources: Kamchatkan Volcanic Eruption Response Team, Tokyo Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005, ongoing	July 25, 2006	56.65N, 161.36E WEB CAM
Bamus, New Britain Island, Papua New Guinea RVO reported that white vapor emissions from Bamus were observed during 1000-1130 on 12 July. The emissions were forceful and slightly gray in color at 1110. The vapor plume drifted SSE. Source: Herman Patia, Rabaul Volcanological Observatory - "Reports provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1886 (+/- 8 years)	July 25, 2006	5.20S, 151.23E
Lopevi, Central Islands, Vanuatu Based on pilot reports, the Wellington VAAC reported that an eruption plume from Lopevi on 5 July reached an unknown altitude and smoke-and-ash plumes on 8 and 9 July reached	2003	July 11, 2006	16.507S, 168.346E

altitudes of 3.7 km (12,000 ft) a.s.l. and drifted E and SE, respectively. Sources: Wellington VAAC - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Batu Tara, Lesser Sunda Islands, Indonesia Based on a pilot report, the Darwin VAAC reported that an ash cloud from Batu Tara reached an altitude of 1.5 km (5,000 ft) a.s.l. and drifted NW. Ash was not identified on satellite imagery. Source: Darwin Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1852	July 04, 2006	7.792S, 123.579E
Anatahan, Mariana Islands According to the Washington VAAC, a pilot reported that on 26 June an ash cloud from Anatahan reached altitudes of 3 km (10,000 ft) a.s.l. and drifted W. Source: Washington Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1920	June 27, 2006	16.35N, 145.67E
Bagana, Bougainville Island, Papua New Guinea An ash-and-steam plume from Bagana was visible on satellite imagery on 18 June drifting SW. The height of the plume was not reported.	2005, ongoing	June 20, 2006	6.14S, 155.19E

Source: Darwin Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Tongariro Volcanic Centre, New Zealand According to GeoNet on 14 June, seismic activity at Ngauruhoe (the youngest cone of the Tongariro complex) remained elevated. The Alert Level remained at 1. Source: GeoNet Space Centre - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	June 20, 2006	39.13S, 175.642E
Heard Island, Southern Indian Ocean, Australia From 11 March to 2 June, MODVOLC (a MODIS thermal alert system) detected approximately 10 alerts from or near the summit of Big Ben on Heard Island. The area of the thermal anomaly was 1 to 2 pixels in size (1 pixel=1 km). Source: Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts Team - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2004	June 13, 2006	53.106S, 73.513E
Karthala, Comoros Islands, Indian Ocean According to news articles, eruptive activity at Karthala that occurred on 28 May had ceased. No seismic	2005	June 06, 2006	11.75N, 43.38E

activity was detected during 31 May to 1 June. Sources: Reuters, AFP - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Aoba, Ambae Island, Vanuatu According to news reports, on 28 May aerial observations by scientists from the Department of Geology and Mines revealed that Lake Voui of Aoba volcano had changed from blue to red in color. Aoba remains at an Alert level 2, which means the crater area is restricted. Sources: Commision of Volcanic Lakes (CVL), The Age News - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1995	May 30, 2006	15.40S, 167.83E
Kelut, Java, Indonesia Based on a pilot report, the Darwin VAAC reported that on 18 May an ash plume from Kelut reached a height of 5.5 km (18,000 ft) a.s.l. The report was not verified by ground observations. Source: Darwin Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1990	May 23, 2006	7.9S, 112.3E
Bezymianny, Kamchatka, Russia Following an explosive eruption at	2005	May 16, 2006	55.98N, 160.58E

Bezymianny on 9 May, seismicity was at background levels on 10 May. In addition, fumarolic plumes were observed and lava flows probably extended from the lava dome. On 11 May the Concern Color Code at Bezymianny was reduced from Orange to Yellow. On 12 May, seismicity remained at background levels and gas-and-steam plumes were visible. Source: Kamchatkan Volcanic Eruption Response Team - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			WEB CAM
San Cristobal, Nicaragua Phreatomagmatic eruptions began at San Cristobal on 21 April. Seismic tremor increased at the volcano that same day around 1300. Small explosions produced gas-and-ash plumes during 21-23 April that deposited small amounts of ash in nearby towns. Source: Instituto Nicaraguense de Estudios Territoriales (INETER) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	May 02, 2006	12.7N, 87.0W WEB CAM
Veniaminof, Alaska Peninsula, USA During 7-14 April, seismicity at Veniaminof remained at low levels, but above background. Views of the volcano were obscured by clouds during the report period, and AVO received no information about ash clouds or activity at the volcano. The Concern Color Code remained at	2004	April 18, 2006	56.17N, 159.38W WEB CAM

Yellow. Sources: Alaska Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Ol Doinyo Lengai, Tanzania, Africa On Frederick Belton's Ol Doinyo Lengai website, a bush pilot reported that a lava flow and lava fountains were emitted on the 30th, but there were no ash emissions. A steam plume was visible that may have been mistakenly described as ash in news reports. According to an observer in Tanzania, on 4 April a very large lava flow was visible on the volcano's W flank. The lava flow was over 1 km long and had traveled down the flank of the volcano and into a gorge. There were no signs that the flow was still hot. Photographs revealed that another lava flow may have traveled W of the volcano on 3 or 4 April. On 7 or 8 April, active lava was contained within a new lava lake. Contrary to news reports, a local tour operator stated that there were no evacuations from villages near the volcano. The eruption began at Ol Doinyo Lengai around 30 March, forcing villagers living near the volcano to evacuate. An article stated that, "Eyewitnesses said they heard a rumbling noise before the volcano began discharging ash and lava, prompting local residents to flee the area in their hundreds. District officials estimated that about 3,000 people from Nayobi, Magadini, Engaruka, Malambo, Ngaresero, Gelai Bomba, and Kitumbeine	2004	April 11, 2006	2.751S, 35.902E

villages left their homes within a few hours of the eruption..." There were reports of polluted water sources and destroyed vegetation, but no reports of deaths or injuries. Sources: Frederick Belton's Ol Doinyo Lengai website, Guardian News, Associated Press - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Santa Ana, El Salvador During 24-31 March, activity at Santa Ana decreased to low levels in comparison to the previous 4 months of moderate activity. During the report period, seismicity was at relatively low levels, steam plumes occasionally rose ~200 m above the volcano (or 8,400 ft a.s.l.), and the daily sulfur-dioxide flux was between 500 and 1,000 metric tons. The Alert Level remained at red, the highest level, within 5 km of the volcano's summit crater. Sources: Servicio Nacional de Estudios Territoriales (SNET)- "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	April 04, 2006	13.9N, 89.6W
Akan, Hokkaido, Japan A very small eruption occurred at Me-Akan (also called Meakan-dake, which means Meakan Peak) of the Akan volcanic complex on 21 March. Tremor began around 0628, the eruption apparently began around 0637, and an alert was issued by JMA at 0643. The eruption occurred from	1998	March 21, 2006	43.384N, 144.013E

the volcano's NE flank. Ash was deposited on snow as far as 10 km SE of the volcano. The volcano is in a remote area and no populated areas were threatened. Me-Akan last erupted in 1998. Sources: Gunma University, Reuters - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Atka, Aluetian Islands, United States AVO decreased the Concern Color Code at Korovin volcano in the Atka volcanic center from Yellow to Green (the lowest level) on 8 March. After raising the Concern Color Code on 22 February in response to increased seismicity, the rate of micro-earthquakes stabilized and then declined. During 1-8 March, seismicity was near background levels and no unusual activity was seen on satellite imagery or by observers. Source: Alaska Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1998	March 14, 2006	52.381N, 174.154W
Ebeko, Kuril Islands, Russia KVERT reported that no significant changes in activity at Ebeko had been seen on satellite imagery or via ground observations for several months, so the Concern Color Code was reduced from Yellow to Green, the lowest level. A weak scent of hydrogen sulfide and chlorine gas was sometimes noted in the town of Severo-Kurilsk, ~7 km from the	1991	February 28, 2006	50.68N, 156.02E

volcano. Ebeko is not seismically monitored. According to KVERT, it is likely that activity will stay at low levels and an explosive eruption is not imminent in the next weeks. Source: Kamchatkan Volcanic Eruption Response Team - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Guagua Pichincha, Ecuador On 5 February, beginning around 1300, three small gas emissions occurred at Guagua Pichincha. IG reported that this phreatic activity was associated with accumulated rainfall that was heated by magmatic material from the previous eruptive period, and was not related to renewed volcanic activity. After the emissions, a series of seismic signals associated with rockfalls and long-period earthquakes were recorded. The signals were related to degassing that commonly occurs after emissions. Cloudy conditions prevented observations of the volcano. IG recommended that people should not visit Guagua Pichincha's crater since emissions or explosions can occur at any time. Source: Instituto Geofisico-Escuela Politecnica Nacional - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2004	February 14, 2006	0.17S, 78.6W
Garbuna Group, New Britain, Papua New Guinea During 1-15 January, the two vents at	Unknown	January 31, 2006	5.45S, 150.03E

the summit of Garbuna emitted small-to-moderate volumes of gas. There were no other unusual observations. Seismicity was low and dominated by occasional low-frequency earthquakes. Sources: Darwin Volcanic Ash Advisory Center - - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Planchon-Peteroa, Chile The Buenos Aires VAAC reported that based on SIGMETs, increased fumarolic activity occurred at Planchon-Peteroa and Cerro Azul beginning on 26 January. Servicio Nacional de Geolog?a y Mineria clarified that intense fumarolic activity only occurred at Planchon-Petero around 25 January. Increased fumarolic activity is normal during the summer when snow melts in the crater and more steam is produced. Sources: Servicio Nacional de Geologia y Mineria, Buenos Aires Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1998, ongoing	January 31, 2006	35.240S, 70.570W
Mount Martin, Alaska USA Increased seismicity occurred at Martin during 8 January until at least 15 January. About 300 earthquakes were recorded during 2 days, in contrast to the background rate of ~25 earthquakes per month since the seismic network was installed in 1996. AVO increased the Concern	1953	January 17, 2006	58.172N, 155.361W

Color Code to Yellow. AVO reported that swarms of earthquakes of this nature are common at volcanoes such as Martin, and do not suggest that eruptive activity is imminent. Satellite data showed nothing unusual, although steaming is frequently observed at the volcano.			
Spurr, Southwestern Alaska, USA Seismicity remained above background levels at Spurr during 30 December to 6 January. Clear satellite and web camera views of the volcano showed no unusual activity. Spurr remained at Concern Color Code Yellow. Source: Alaska Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1992	January 10, 2006	61.299N, 152.251W WEB CAM
Soputan, Sulawesi, Indonesia A phreatic eruption began at Soputan on 26 December around 1230 following heavy rain that contacted lava at the volcano's summit. On 27 December at 0400, a Strombolian eruption began that lasted ~50 minutes. Incandescent volcanic material was ejected ~35 m, and avalanches of volcanic material traveled as far as 750 m E. Around 0640 the avalanches became larger, as pyroclastic avalanches occurred from the edge of the lava. The avalanches extended 200 m E, and booming noises were heard as far as 5 km from the summit. The Darwin VAAC reported that an ash plume reached a height of ~5.8 km (~19,000 ft) a.s.l. and drifted SE.	2005	December 27, 2005	1.11N, 124E

As of 28 December, eruptive activity continued at Soputan, producing ash plumes to a height of ~1 km above the volcano (or 9,100 ft a.s.l.). Strombolian eruptions continued, ejecting incandescent volcanic material up to 200 m above the summit (or 6,500 ft a.s.l.). Pyroclastic avalanches traveled ~500 m E and SW. This was the fourth event at Soputan in 2005, with previous activity on 14 and 20 April, and on 12 September. The Alert Level remained at 2, since the volcano is about 11 km from the nearest settlement. Visitors are prohibited from climbing Soputan's summit and camping around Kawah Masem. Sources: Directorate of Volcanology and Geological Hazard Mitigation, Darwin Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Tanaga, Aleutian Islands, USA AVO reported on 25 November that for several weeks seismicity beneath young volcanic vents on Tanaga Island decreased significantly from levels recorded in early October. Satellite images of the island showed no anomalous temperatures or evidence of ash emissions. AVO reported that based on the decrease in earthquake counts and frequency of tremor episodes, the likelihood of an eruption had diminished. Therefore, AVO downgraded the Concern Color Code from Yellow to Green. Source: Alaska Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism	2004	November 29, 2005	51.88N, 178.15W

Program and the US Geological Survey's Volcano Hazards Program."			
San Cristobal, Nicaragua There was an increase in seismicity at San Crist?bal beginning on 19 November. Increased tremor was interpreted as being related to gas and ash emissions. Ash fell W of the volcano and near the town of Chinandega, ~15 km SW of the volcano. The amount of tremor decreased later. Source: Instituto Nicaraguense de Estudios Territoriales (INETER) - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1998	November 22, 2005	12.7N, 87.0W
Avachinsky, Kamchatka, Russia KVERT reported on 8 November that the number and energy of shallow earthquakes below Avachinsky increased during the previous month. A weak thermal anomaly near the volcano's summit was visible on satellite imagery on 7 November. KVERT reported that based on these changes the possibility of sudden ash explosions at Avachinsky had increased, so the Concern Color Code was raised from Green to Yellow on 8 November. Source: Kamchatkan Volcanic Eruption Response Team - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	November 22, 2005	53.25N, 158.83E
Reventador, Ecuador During 7-13 November, the number	2005	November 22, 2005	0.07S, 77.67W

of earthquakes at Reventador increased slightly in comparison to the previous week. Small explosions produced ash plumes that rose to a height of ~4.6 km (15,000 ft) a.s.l. Sources: Instituto Geofisico-Escuela Poltecnica Nacional, Washington Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Montagu Island, South Sandwich Islands A partly cloudy ASTER satellite image from 3 November appeared to indicate that large-scale effusive activity from the summit of Montagu Island (Mt. Belinda) had ceased. The image showed that the 3.5-km-long lava flow noted in previous reports (observed entering the sea in an image from 23 September 2005) had extended the shoreline on the N side of island. The new land extended approximately 500 m from the previous shoreline, and was ~400 m wide, equating to a total area of 0.2 square kilometers. Source: Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts Team and John Smellie of the British Antarctic Survey - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005, ongoing	November 15, 2005	58.42S, 26.33W
Nyiragongo, Democratic Republic of the Congo On 13 November, a plume that may	2005	November 15, 2005	1.52S, 29.25E

have contained some ash was emitted from Nyiragongo and seen on satellite imagery. Source: Toulouse Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Katmai, Alaska, USA Strong winds in the Katmai area picked up loose ash deposited during the 1912 eruption and carried it E over Kodiak Island. AVO recorded a large area of resuspended ash on satellite imagery. The National Weather Service estimated that the top of the plume was at 1.5 km (5,000 ft) a.s.l. Katmai remained at Concern Color Code Green. Source: Alaska Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1912	November 08, 2005	58.28N, 154.96W
Kliuchevskoi, Kamchatka, Russia Seismic activity at Kliuchevskoi was at background levels during the previous 3 weeks and no activity was observed on satellite imagery. Since there were no indications that an eruption was imminent at Kliuchevskoi, KVERT reduced the Concern Color Code from Yellow to Green on 4 November. Source: Kamchatkan Volcanic Eruption Response Team - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological	2005, ongoing	November 08, 2005	56.06N, 160.64E WEB CAM

Survey's Volcano Hazards Program."			
Sierra Negra, Galapagos Islands According to IG, an eruption began at Sierra Negra on the S end of Isabela Island on 22 October at 1730 when an explosion was heard by many people in the town of Villamil, 20 km SE of the volcano. The eruption was preceded by a seismic event on 22 October at 1438, and by earthquakes on 19 October and 2 weeks earlier. The Washington VAAC recorded an ash cloud on satellite imagery at 1745 at a height of ~15.2 km (50,000 ft) a.s.l. moving SW, and a very large hotspot. The ash cloud may have reached a height of 20 km (65,600 ft) a.s.l. Extensive lava fountains were seen rising to heights of 200-300 m along a segment of the Sierra Negra rim. Incandescent lava flowed several kilometers down the outer NW flank of the volcano's edifice and tourists reported seeing two lava flows descending the N flank. The exact orientation of flows on the volcano's flanks was not clear from early reports. Scientists did not see active lava flows in this area or evidence of flows entering the sea during an overflight on 23 October. During a visit to Sierra Negra on 23 October, scientists saw that the eruption originated from four adjacent craters aligned along a 500-m-long fracture at the base of the inner wall of the volcano's caldera in the NE sector. Lava traveled from four principal vents southwards with exceptional force, volume, and speed downslope in several main channels. Based on observations, the main lava river traveled nearly 20 m/sec as it left its source vents. Two vents	2005	November 01, 2005	0.83S, 91.17W

mainly supplied lava to the many lava rivers flowing southward over the northern caldera bench and then down onto the caldera floor. The feeding fracture apparently extended westward along the inner wall, but then climbed up onto the caldera rim itself where its trace was not obvious. However, small vents with fountaining and incandescent lava were observed on the rim along this general fracture system, implying that the active fracture extended for about 2 km W of the main vents. By 23 October around 1530, the lava formed one large flow that was 1-1.5 km wide and had progressed ~7 km southeastward along the base of the eastern interior wall of the caldera, then westward along the southern wall reaching a point almost halfway across the caldera. The volume of lava ejected at this time was estimated at 25 million cubic meters. On 26 October, there were reports that lava was no longer emitted from one of the four principal vents. No populated areas on the island were threatened by the eruption. Sources:Instituto Geofisico-Escuela Politecnica Nacional - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Nyamuragira, Democratic Republic of Congo Beginning on 23 October, GVO recorded heightened seismic activity along the East African Rift and around the Virunga volcanoes when a	2004	November 01, 2005	1.4S, 29.2E

swarm of long-period earthquakes occurred N of Nyamuragira. More than 140 events were recorded at a station 19 km E of the volcano. On 27 October at 1500, another swarm of long-period earthquakes began beneath the same area. More than 300 events were recorded until at least 28 October. At 2010, a M 4.5 tectonic earthquake occurred N of Lake Tanganika, which was followed by several aftershocks. GVO noted that this activity reinforces the likelihood of an eruption in the near future, but volcanic activity would not pose a threat to inhabited areas. The Alert Level for the nearby city of Goma remained at Yellow. Source: Goma Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Dabbahu, Ethiopia *Volcanic activity at Erta Ale discussed in the 5-11 October 2005 Weekly Volcanic Activity Report actually occurred at Dabbahu. The correct report is below.* A team of scientists visited the Da'Ure locality immediately adjacent to the NE flank of the Quaternary Dabbahu (or Boina) felsic complex on 4 and 5 October after receiving reports of volcanic activity there on 26 September. People in the area noted that on 26 September at about 1300 a very strong earthquake shook the area, and was followed by a dark column of "smoke" that rose high into the atmosphere and spread out to form a cloud, which darkened the area for 3 days and 3 nights. The scientists determined that a minor explosive	2004	October 18, 2005	12.6N, 40.48E

eruption occurred from two semi-circular vents, producing ashfall that was ~5 cm thick near the vent. Ash deposits extended more than 500 m from the vent. Boulders emitted during the eruption were as large as 3 m and were deposited as far as 20 meters away. The scientists noted intense degassing from the vents, the scent of sulfur dioxide, and the sound of boiling water in the vents. As of about 10 October, the Addis Ababa University Geophysical Observatory reported that seismic activity in the area was continuing. Sources: Gezahegn Yirgu, Department of Earth Sciences, Addis Ababa University - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Erebus, Ross Island, Antarctica According to the Mt. Erebus activity log, several "small- to medium-sized" eruptions occurred during 12-18 October, with a "very large" eruption occurring on 14 October. The eruption sizes were based on comparisons of seismic data for known Erebus eruptions. Source: Mount Erebus Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	October 18, 2005	77.53S, 167.17E
Mount Michael, Saunders Island, South Sandwich Islands The first MODVOLC alerts at Mount Michael since May 2003 recently	2003	October 18, 2005	57.78S, 26.45W

began, indicating an increased level of activity in the island's summit crater (and presumed lava lake). The alerts occurred on 3, 5, and 6 October. Sources: Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts Team and John Smellie of the British Antarctic Survey - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Stromboli, Italy A plume emitted from Stromboli that may have contained ash was visible on satellite imagery on 14 October at a height around 1.8-2.4 km (6,000-8,000 ft) a.s.l. The plume extended ~10 km NW of the volcano. Source: Toulouse Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2005	October 18, 2005	38.79N, 15.21E WEB CAM
Cayambe, Ecuador A cluster of earthquakes that had been recorded at Cayambe since 16 September, with about 300 small earthquakes occurring during 16-18 September, decreased in number significantly after 19 September. During 19-25 September, an average of 5.3 earthquakes occurred daily. Source: Instituto Geofisico-Escuela Politecnica Nacional - "Report provided courtesy of the Smithsonian's Global Volcanism	1786	October 04, 2005	0.029 N 77.986 W

Program and the US Geological Survey's Volcano Hazards Program."			
Cotopaxi, Ecuador During 29 August to 4 September, the number of long-period and hybrid earthquakes at Cotopaxi decreased slightly, and the number of volcano-tectonic earthquakes increased, in comparison to the previous week. No changes in deformation were recorded, and no surficial changes were seen at the volcano. Source: Instituto Geofisico-Escuela Politecnica Nacional - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1940	September 13, 2005	00.677S, 78.436W
Chiginagak, Alaska AVO reported that a 400-m-wide "melt-water lake" formed in the snow-and-ice filled summit crater of Chiginagak sometime after the previous observation in August 2004. Earlier this summer, the southern crater rim of Chiginagak was breached, allowing a portion of the lake to drain. The resulting lahar left a deposit on a glacier draining the crater to the S and caused flooding of 1-2 m above normal at Indecision Creek. The breach in the crater rim and the ensuing lahar probably occurred in July 2005; there were reports from a nearby lodge at this time of strong sulfur smells and cloudy, yellowish water in the Indecision Creek drainage. There were no indications that an eruption is imminent or that this event is necessarily precursory to an eruption. Chiginagak is not seismically	1998	August 30, 2005	57.13N, 157.00W

monitored, so AVO did not assign it a Concern Color Code. Source: Alaska Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."			
Mauna Loa, Hawai'i, USA HVO reported on 21 August that extension across Mauna Loa's summit had resumed over the previous few weeks after pausing for much of July. Seismicity remained at low levels at the volcano. Source: US Geological Survey Hawaiian Volcano Observatory - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	1984	August 23, 2005	19.5N, 155.6W WEB CAM
Pago, New Britain, Papua New Guinea Pago was quiet during 15-21 August, with only steam emissions occurring from the upper vents of the fissure system. Seismicity was at low levels. Source: Rabaul Volcano Observatory via the Darwin Volcanic Ash Advisory Center - "Report provided courtesy of the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program."	2003	August 23, 2005	

- Most diamonds are used to make abrasives and drill bits.
- California has diamonds.
- Diamonds fall in two age groups: 3.3 billion years and 1.6-1.0 billion years. The magmas that carry them to the surface can be much younger.
- The first diamond found in South Africa weighed 21 carats!
- Mining for diamonds in one pipe at Kimberley went to a depth of 3,500 feet below the surface.
- Gold particles have formed from volcanic gases at Mount Erebus.
- The average person will use about 350 kg of zinc, 350 kg of lead and 650 kg of copper during a lifetime.
- Our term for copper is based on the Latin name for the island of Cyprus-cuprum. Mining is no longer economically important on the island.
- Armalcolite ((Mg, Fe)Ti2O5), a mineral named in honor of the Apollo 11 astronauts Armstrong, Aldrin, and Collins and first identified in lunar samples, has been found in the rocks at the Argyle diamond pipe. The mineral probably formed in metasomatised mantle peridotite.
- Mining in Australia uses only 0.02% of the land, less than all the hotel car parks in the country.

Volcanic and Geologic Terms

'A'a: Hawaiian word used to describe a lava flow whose surface is broken into rough angular fragments. Click here to view a photo of **'a'a**.

Accessory: A mineral whose presence in a rock is not essential to the proper classification of the rock.

Accidental: Pyroclastic rocks that are formed from fragments of non-volcanic rocks or from volcanic rocks not related to the erupting volcano.

Accretionary Lava Ball: A rounded mass, ranging in diameter from a few centimeters to several meters, [carried] on the surface of a lava flow (e.g., 'a'a) or on cinder-cone slopes [and formed] by the molding of viscous lava around a core of already solidified lava.

Acid: A descriptive term applied to igneous rocks with more than 60% silica (SiO2).

Active Volcano: A volcano that is erupting. Also, a volcano that is not presently erupting, but that has erupted within historical time and is considered likely to do so in the future.

Agglutinate: A pyroclastic deposit consisting of an accumulation of originally plastic ejecta and formed by the coherence of the fragments upon solidification.

Alkalic: Rocks which contain above average amounts of sodium and/or potassium for the group of rocks for which it belongs. For example, the basalts of the capping stage of Hawaiian volcanoes are alkalic. They contain more sodium and/or potassium than the shield-building basalts that make the bulk of the volcano.

Andesite: Volcanic rock (or lava) characteristically medium dark in color and containing 54 to 62 percent silica and moderate amounts of iron and magnesium.

Ash: Fine particles of pulverized rock blown from an explosion vent. Measuring less than 1/10 inch in diameter, ash may be either solid or molten when first erupted. By far the most common variety is vitric ash (glassy particles formed by gas bubbles bursting through liquid magma).

Ashfall (Airfall): Volcanic ash that has fallen through the air from an eruption cloud. A deposit so formed is usually well sorted and layered.

Ash Flow: A turbulent mixture of gas and rock fragments, most of which are ash-sized particles, ejected violently from a crater or fissure. The mass of pyroclastics is normally of very high temperature and moves rapidly down the slopes or even along a level surface.

Asthenosphere: The shell within the earth, some tens of kilometers below the surface and of undefined thickness, which is a shell of weakness where plastic movements take place to permit pressure adjustments.

Aquifer: A body of rock that contains significant quantities of water that can be tapped by wells or springs.

Avalanche: A large mass of material or mixtures of material falling or sliding rapidly under the force of gravity. Avalanches often are classified by their content, such as snow, ice, soil, or rock avalanches. A mixture of these materials is a debris avalanche.

Basalt: Volcanic rock (or lava) that characteristically is dark in color, contains 45% to 54% silica, and generally is rich in iron and magnesium.

Basement: The undifferentiated rocks that underlie the rocks of interest in an area.

Basic: A descriptive term applied to igneous rocks (basalt and gabbro) with silica (SiO2) between 44% and 52%.

Bench: The unstable, newly-formed front of a lava delta.

Blister: A swelling of the crust of a lava flow formed by the puffing-up of gas or vapor beneath the flow. Blisters are about 1 meter in diameter and hollow.

Block: Angular chunk of solid rock ejected during an eruption.

Bomb: Fragment of molten or semi-molten rock, 2 1/2 inches to many feet in diameter, which is blown out during an eruption. Because of their plastic condition, bombs are often modified in shape during their flight or upon impact.

Caldera: The Spanish word for cauldron, a basin-shaped volcanic depression; by definition, at least a mile in diameter. Such large depressions are typically formed by the subsidence of volcanoes. Crater Lake occupies the best-known caldera in the Cascades.

Capping Stage: Refers to a stage in the evolution of a typical Hawaiian volcano during which alkalic, basalt, and related rocks build a steeply, sloping cap on the main shield of the volcano. Eruptions are less frequent, but more explosive. The summit caldera may be buried.

Central Vent: A central vent is an opening at the Earth's surface of a volcanic conduit of cylindrical or pipe-like form.

Central Volcano: A volcano constructed by the ejection of debris and lava flows from a central point, forming a more or less symmetrical volcano.

Cinder Cone: A volcanic cone built entirely of loose fragmented material (pyroclastics.)

Cirque: A steep-walled horseshoe-shaped recess high on a mountain that is formed by glacial erosion.

Cleavage: The breaking of a mineral along crystallographic planes, that reflects a crystal structure.

Composite Volcano: A steep volcanic cone built by both lava flows and pyroclastic eruptions.

Compound Volcano: A volcano that consists of a complex of two or more vents, or a volcano that has an associated volcanic dome, either in its crater or on its flanks. Examples are Vesuvius and Mont Pelee.

Compression Waves: Earthquake waves that move like a slinky. As the wave moves to the left, for example, it expands and compresses in the same direction as it moves. Usage of **compression waves**.

Conduit: A passage followed by magma in a volcano.

Continental Crust: Solid, outer layers of the earth, including the rocks of the continents. Usage of **continental crust**.

Continental Drift: The theory that horizontal movement of the earth's surface causes slow, relative movements of the continents toward or away from one another.

Country Rocks: The rock intruded by and surrounding an igneous intrusion.

Crater: A steep-sided, usually circular depression formed by either explosion or collapse at a volcanic vent.

Craton: A part of the earth's crust that has attained stability and has been little deformed for a prolonged period.

Curtain of Fire: A row of coalescing lava fountains along a fissure; a typical feature of a Hawaiian-type eruption.

Dacite: Volcanic rock (or lava) that characteristically is light in color and contains 62% to 69% silica and moderate a mounts of sodium and potassium.

Debris Avalanche: A rapid and unusually sudden sliding or flowage of unsorted masses of rock and other material. As applied to the major avalanche involved in the eruption of Mount St. Helens, a rapid mass movement that included fragmented cold and hot volcanic rock, water, snow, glacier ice, trees, and some hot pyroclastic material. Most of the May 18, 1980 deposits in the upper valley of the North Fork Toutle River and in the vicinity of Spirit Lake are from the debris avalanche.

Debris Flow: A mixture of water-saturated rock debris that flows downslope under the force of gravity (also called lahar or mudflow).

Detachment Plane: The surface along which a landslide disconnects from its original position.

Devonian: A period of time in the Paleozoic Era that covered the time span between 400 and 345 million years.

Diatreme: A breccia filled volcanic pipe that was formed by a gaseous explosion.

Dike: A sheetlike body of igneous rock that cuts across layering or contacts in the rock into which it intrudes.

Dome: A steep-sided mass of viscous (doughy) lava extruded from a volcanic vent (often circular in plane view) and spiny, rounded, or flat on top. Its surface is often rough and blocky as a result of fragmentation of the cooler, outer crust during growth of the dome.

Dormant Volcano: Literally, "sleeping." The term is used to describe a volcano which is presently inactive but which may erupt again. Most of the major Cascade volcanoes are believed to be dormant rather than extinct.

Drainage Basin: The area of land drained by a river system.

Echelon: Set of geologic features that are in an overlapping or a staggered arrangement (e.g., faults). Each is relatively short, but collectively they form a linear zone in which the strike of the individual features is oblique to that of the zone as a whole.

Ejecta: Material that is thrown out by a volcano, including pyroclastic material (tephra) and lava bombs.

Episode: An episode is a volcanic event that is distinguished by its duration or style.

Eruption: The process by which solid, liquid, and gaseous materials are ejected into the earth's atmosphere and onto the earth's surface by volcanic activity. Eruptions range from the quiet overflow of liquid rock to the tremendously violent expulsion of pyroclastics.

Eruption Cloud: The column of gases, ash, and larger rock fragments rising from a crater or other vent. If it is of sufficient volume and velocity, this gaseous column may reach many miles into the stratosphere, where high winds will carry it long distances.

Eruptive Vent: The opening through which volcanic material is emitted.

Evacuate: Temporarily move people away from possible danger.

Extinct Volcano: A volcano that is not presently erupting and is not likely to do so for a very long time in the future. Usage of **extinct**.

Extrusion: The emission of magmatic material at the earth's surface. Also, the structure or form produced by the process (e.g., a lava flow, volcanic dome, or certain pyroclastic rocks).

Fault: A crack or fracture in the earth's surface. Movement along the fault can cause earthquakes or--in the process of mountain-building--can release underlying magma and permit it to rise to the surface.

Fault Scarp A steep slope or cliff formed directly by movement along a fault and representing the exposed surface of the fault before modification by erosion and weathering.

Felsic: An igneous rock having abundant light-colored minerals.

Fire fountain: See also: lava fountain

Fissures: Elongated fractures or cracks on the slopes of a volcano. Fissure eruptions typically produce liquid flows, but pyroclastics may also be ejected.

Flank Eruption: An eruption from the side of a volcano (in contrast to a summit eruption.)

Fluvial: Produced by the action of of flowing water.

Formation: A body of rock identified by lithic characteristics and stratigraphic position and is mappable at the earth's surface or traceable in the subsurface.

Fracture: The manner of breaking due to intense folding or faulting.

Fumarole: A vent or opening through which issue steam, hydrogen sulfide, or other gases. The craters of many dormant volcanoes contain active fumaroles.

Geothermal Energy: Energy derived from the internal heat of the earth.

Geothermal Power: Power generated by using the heat energy of the earth.

Graben: An elongate crustal block that is relatively depressed (downdropped) between two fault systems.

Guyot: A type of seamount that has a platform top. Named for a nineteenth-century Swiss-American geologist.

Hardness: The resistance of a mineral to scratching.

Harmonic Tremor: A continuous release of seismic energy typically associated with the underground movement of magma. It contrasts distinctly with the sudden release and rapid decrease of seismic energy associated with the more common type of earthquake caused by slippage along a fault.

Heat transfer: Movement of heat from one place to another.

Heterolithologic: Material is made up of a heterogeneous mix of different rock types. Instead of being composed on one rock type, it is composed of fragments of many different rocks.

Holocene: The time period from 10,000 years ago to the present. Also, the rocks and deposits of that age.

Horizontal Blast: An explosive eruption in which the resultant cloud of hot ash and other material moves laterally rather than upward.

Horst: A block of the earth's crust, generally long compared to its width, that has been uplifted along faults relative to the rocks on either side.

Hot Spot: A volcanic center, 60 to 120 miles (100 to 200 km) across and persistent for at least a few tens of million of years, that is thought to be the surface expression of a persistent rising plume of hot mantle material. Hot spots are not linked to arcs and may not be associated with ocean ridges.

Hot-spot Volcanoes: Volcanoes related to a persistent heat source in the mantle.

Hyaloclastite: A deposit formed by the flowing or intrusion of lava or magma into water, ice, or water-saturated sediment and its consequent granulation or shattering into small angular fragments.

Hydrothermal Reservoir: An underground zone of porous rock containing hot water.

Hypabyssal: A shallow intrusion of magma or the resulting solidified rock.

Hypocenter: The place on a buried fault where an earthquake occurs. Usage of **hypocenter**.

Ignimbrite: The rock formed by the widespread deposition and consolidation of ash flows and Nuees Ardentes. The term was originally applied only to densely welded deposits but now includes non-welded deposits.

Intensity: A measure of the effects of an earthquake at a particular place. Intensity depends not only on the magnitude of the earthquake, but also on the distance from the epicenter and the local geology.

Intermediate: A descriptive term applied to igneous rocks that are transitional between basic and acidic with silica (SiO_2) between 54% and 65%.

Intrusion: The process of emplacement of magma in pre-existing rock. Also, the term refers to igneous rock mass so formed within the surrounding rock.

Joint: A surface of fracture in a rock.

Juvenile: Pyroclastic material derived directly from magma reaching the surface.

Kipuka: An area surrounded by a lava flow.

Laccolith: A body of igneous rocks with a flat bottom and domed top. It is parallel to the layers above and below it.

Lahar: A torrential flow of water-saturated volcanic debris down the slope of a volcano in response to gravity. A type of mudflow. Usage of **lahar**. For a larger discussion on **lahars**, click here.

Landsat: A series of unmanned satellites orbiting at about 706 km (438 miles) above the surface of the earth. The satellites carry cameras similar to video cameras and take images or pictures showing features as small as 30 m or 80 m wide, depending on which camera is used. Usage of **Landsat**.

Lapilli: Literally, "little stones." Round to angular rock fragments, measuring 1/10 inch to 2 1/2 inches in diameter, which may be ejected in either a solid or molten state.

Lava: Magma which has reached the surface through a volcanic eruption. The term is most commonly applied to streams of liquid rock that flow from a crater or fissure. It also refers to cooled and solidified rock.

Lava Dome: Mass of lava, created by many individual flows, that has built a dome-shaped pile of lava.

Lava Flow: An outpouring of lava onto the land surface from a vent or fissure. Also, a solidified tongue like or sheet-like body formed by outpouring lava.

Lava Fountain: A rhythmic vertical fountainlike eruption of lava.

Lava Lake (Pond): A lake of molten lava, usually basaltic, contained in a vent, crater, or broad depression of a shield volcano.

Lava Shields: A shield volcano made of basaltic lava.

Lava Tube: A tunnel formed when the surface of a lava flow cools and solidifies while the still-molten interior flows through and drains away.

Limu O Pele (Pele Seaweed): Delicate, translucent sheets of spatter filled with tiny glass bubbles.

Lithic: Of or pertaining to stone.

Lithosphere: The rigid crust and uppermost mantle of the earth. Thickness is on the order of 60 miles (100 km). Stronger than the underlying asthenosphere.

Luster: The reflection of light from the surface of a mineral.

Maar: A volcanic crater that is produced by an explosion in an area of low relief, is generally more or less circular, and often contains a lake, pond, or marsh.

Mafic: An igneous composed chiefly of one or more dark-colored minerals.

Magma: Molten rock beneath the surface of the earth.

Magma Chamber: The subterranean cavity containing the gas-rich liquid magma which feeds a volcano.

Magmatic: Pertaining to magma.

Magnitude: A numerical expression of the amount of energy released by an earthquake, determined by measuring earthquake waves on standardized recording instruments (seismographs.) The number scale for magnitudes is logarithmic rather than arithmetic. Therefore, deflections on a seismograph for a magnitude 5 earthquake, for example, are 10 times greater than those for a magnitude 4 earthquake, 100 times greater than for a magnitude 3 earthquake, and so on.

Mantle: The zone of the earth below the crust and above the core.

Matrix: The solid matter in which a fossil or crystal is embedded. Also, a binding substance (e.g., cement in concrete).

Miocene: An epoch in Earth's history from about 24 to 5 million years ago. Also refers to the rocks that formed in that epoch.

Moho: Also called the Mohorovicic discontinuity. The surface or discontinuity that separates the crust from the mantle. The Moho is at a depth of 5-10 km beneath the ocean floor and about 35 km below the continents (but down to 60 km below mountains). Named for Andrija Mohorovicic, a Croatian seismologist.

Monogenetic: A volcano built by a single eruption.

Mudflow: A flowage of water-saturated earth material possessing a high degree of fluidity during movement. A less-saturated flowing mass is often called a debris flow. A mudflow originating on the flank of a volcano is properly called a lahar.

Myth: A fictional story to explain the origin of some person, place, or thing. Usage of **myth**.

Nuees Ardentes: A French term applied to a highly heated mass of gas-charged ash which is expelled with explosive force and moves hurricane speed down the mountainside. Usage of **Nuees Ardentes**

Obsidian: A black or dark-colored volcanic glass, usually composed of rhyolite.

Oceanic Crust: The earth's crust where it underlies oceans. Usage of **oceanic crust**.

Pahoehoe: A Hawaiian term for lava with a smooth, billowy, or ropy surface. Click here to view a photo of pahoehoe.

Pali: Hawaiian word for steep hills or cliffs.

Pele Hair: A natural spun glass formed by blowing-out during quiet fountaining of fluid lava, cascading lava falls, or turbulent flows, sometimes in association with pele tears. A single strand, with a diameter of less than half a millimeter, may be as long as two meters.

Pele Tears: Small, solidified drops of volcanic glass behind which trail pendants of Pele hair. They may be tear-shaped, spherical, or nearly cylindrical.

Peralkaline: Igneous rocks in which the molecular proportion of aluminum oxide is less than that of sodium and potassium oxides combined.

Phenocryst: A conspicuous, usually large, crystal embedded in porphyritic igneous rock.

Phreatic Eruption (Explosion): An explosive volcanic eruption caused when water and heated volcanic rocks interact to produce a violent expulsion of steam and pulverized rocks. Magma is not involved.

Phreatomagmatic: An explosive volcanic eruption that results from the interaction of surface or subsurface water and magma.

Pillow lava: Interconnected, sack-like bodies of lava formed underwater.

Pipe: A vertical conduit through the Earth's crust below a volcano, through which magmatic materials have passed. Commonly filled with volcanic breccia and fragments of older rock.

Pit Crater: A crater formed by sinking in of the surface, not primarily a vent for lava.

Plastic: Capable of being molded into any form, which is retained.

Plate Tectonics: The theory that the earth's crust is broken into about 10 fragments (plates,) which move in relation to one another, shifting continents, forming new ocean crust, and stimulating volcanic eruptions.

Pleistocene: A epoch in Earth history from about 2-5 million years to 10,000 years ago. Also refers to the rocks and sediment deposited in that epoch.

Plinian Eruption: An explosive eruption in which a steady, turbulent stream of fragmented magma and magmatic gases is released at a high velocity from a vent. Large volumes of tephra and tall eruption columns are characteristic.

Plug: Solidified lava that fills the conduit of a volcano. It is usually more resistant to erosion than the material making up the surrounding cone, and may remain standing as a solitary pinnacle when the rest of the original structure has eroded away.

Plug Dome: The steep-sided, rounded mound formed when viscous lava wells up into a crater and is too stiff to flow away. It piles up as a dome-shaped mass, often completely filling the vent from which it emerged.

Pluton: A large igneous intrusion formed at great depth in the crust.

Polygenetic: Originating in various ways or from various sources.

Precambrian: All geologic time from the beginning of Earth history to 570 million years ago. Also refers to the rocks that formed in that epoch.

Pumice: Light-colored, frothy volcanic rock, usually of dacite or rhyolite composition, formed by the expansion of gas in erupting lava. Commonly seen as lumps or fragments of pea-size and larger, but can also occur abundantly as ash-sized particles. Usage of **pumice**.

Pyroclastic: Pertaining to fragmented (clastic) rock material formed by a volcanic explosion or ejection from a volcanic vent.

Pyroclastic Flow: Lateral flowage of a turbulent mixture of hot gases and unsorted pyroclastic material (volcanic fragments, crystals, ash, pumice, and glass shards) that can move at high speed (50 to 100 miles an hour.) The term also can refer to the deposit so formed.

Quaternary: The period of Earth's history from about 2 million years ago to the present; also, the rocks and deposits of that age.

Relief: The vertical difference between the summit of a mountain and the adjacent valley or plain.

Renewed Volcanism State: Refers to a state in the evolution of a typical Hawaiian volcano during which --after a long period of quiescence--lava and tephra erupt intermittently. Erosion and reef building continue.

Repose: The interval of time between volcanic eruptions.

Rhyodacite: An extrusive rock intermediate in composition between dacite and rhyolite.

Rhyolite: Volcanic rock (or lava) that characteristically is light in color, contains 69% silica or more, and is rich in potassium and sodium.

Ridge, Oceanic: A major submarine mountain range.

Rift System: The oceanic ridges formed where tectonic plates are separating and a new crust is being created; also, their on-land counterparts such as the East African Rift.

Rift Zone: A zone of volcanic features associated with underlying dikes. The location of the rift is marked by cracks, faults, and vents.

Ring of Fire: The regions of mountain-building earthquakes and volcanoes which surround the Pacific Ocean.

Scoria: A bomb-size (> 64 mm) pyroclast that is irregular in form and generally very vesicular. It is usually heavier, darker, and more crystalline than pumice.

Seafloor Spreading: The mechanism by which new seafloor crust is created at oceanic ridges and slowly spreads away as plates are separating.

Seamount: A submarine volcano.

Seismograph: An instrument that records seismic waves; that is, vibrations of the earth.

Seismologist: Scientists who study earthquake waves and what they tell us about the inside of the Earth. Usage of **seismologist**.

Seismometer: An instrument that measures motion of the ground caused by earthquake waves. Usage of **seismometer**.

Shearing: The motion of surfaces sliding past one another.

Shear Waves: Earthquake waves that move up and down as the wave itself moves. For example, to the left. Usage of **shear waves**.

Shield Volcano: A gently sloping volcano in the shape of a flattened dome and built almost exclusively of lava flows.

Shoshonite: A trachyandesite composed of olivine and augite phenocrysts in a groundmass of labradorite with alkali feldspar rims, olivine, augite, a small amount of leucite, and some dark-colored glass. Its name is derived from the Shoshone River, Wyoming and given by Iddings in 1895.

Silica: A chemical combination of silicon and oxygen.

Sill: A tabular body of intrusive igneous rock, parallel to the layering of the rocks into which it intrudes.

Skylight: An opening formed by a collapse in the roof of a lava tube.

Solfatara: A type of fumarole, the gases of which are characteristically sulfurous.

Spatter Cone: A low, steep-sided cone of spatter built up on a fissure or vent. It is usually of basaltic material.

Spatter Rampart: A ridge of congealed pyroclastic material (usually basaltic) built up on a fissure or vent.

Specific Gravity: The density of a mineral divided by the density of water.

Spines: Horn-like projections formed upon a lava dome.

Stalactite: A cone shaped deposit of minerals hanging from the roof of a cavern.

Stratigraphic: The study of rock strata, especially of their distribution, deposition, and age.

Stratovolcano: A volcano composed of both lava flows and pyroclastic material.

Streak: The color of a mineral in the powdered form.

Strike-Slip Fault: A nearly vertical fault with side-slipping displacement.

Strombolian Eruption: A type of volcanic eruption characterized by jetting of clots or fountains of fluid basaltic lava from a central crater.

Subduction Zone: The zone of convergence of two tectonic plates, one of which usually overrides the other.

Surge: A ring-shaped cloud of gas and suspended solid debris that moves radially outward at high velocity as a density flow from the base of a vertical eruption column accompanying a volcanic eruption or crater formation.

Talus: A slope formed a the base of a steeper slope, made of fallen and disintegrated materials.

Tephra: Materials of all types and sizes that are erupted from a crater or volcanic vent and deposited from the air.

Tephrochronology: The collection, preparation, petrographic description, and approximate dating of tephra.

Tilt: The angle between the slope of a part of a volcano and some reference. The reference may be the slope of the volcano at some previous time.

Trachyandesite: An extrusive rock intermediate in composition between trachyte and andesite.

Trachybasalt: An extrusive rock intermediate in composition between trachyte and basalt.

Trachyte: A group of fine-grained, generally porphyritic, extrusive igneous rocks having alkali feldspar and minor mafic minerals as the main components, and possibly a small amount of sodic plagioclase.

Tremor: Low amplitude, continuous earthquake activity often associated with magma movement.

Tsunami: A great sea wave produced by a submarine earthquake, volcanic eruption, or large landslide.

Tuff: Rock formed of pyroclastic material.

Tuff Cone: A type of volcanic cone formed by the interaction of basaltic magma and water. Smaller and steeper than a tuff ring.

Tuff Ring: A wide, low-rimmed, well-bedded accumulation of hyalo-clastic debris built around a volcanic vent located in a lake, coastal zone, marsh, or area of abundant ground water.

Tumulus: A doming or small mound on the crest of a lava flow caused by pressure due to the difference in the rate of flow between the cooler crust and the more fluid lava below.

Ultramafic: Igneous rocks made mostly of the mafic minerals hypersthene, augite, and/or olivine.

Unconformity: A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic sucession, such as an interruption in continuity of a depositional sequence of sedimentary rocks or a break between eroded igneous rocks and younger sedimentary strata. It results from a change that caused deposition to cease for a considerable time, and it normally implies uplift and erosion with loss of the previous formed record.

Vent: The opening at the earth's surface through which volcanic materials issue forth. Usage of **vent**.

Vesicle: A small air pocket or cavity formed in volcanic rock during solidification.

Viscosity: A measure of resistance to flow in a liquid (water has low viscosity while honey has a higher viscosity.)

Volcano: A vent in the surface of the Earth through which magma and associated gases and ash erupt; also, the form or structure (usually conical) that is produced by the ejected material.

Volcanic Arc: A generally curved linear belt of volcanoes above a subduction zone, and the volcanic and plutonic rocks formed there.

Volcanic Complex: A persistent volcanic vent area that has built a complex combination of volcanic landforms.

Volcanic Cone: A mound of loose material that was ejected ballistically.

Volcanic Neck: A massive pillar of rock more resistant to erosion than the lavas and pyroclastic rocks of a volcanic cone.

Vulcan: Roman god of fire and the forge after whom volcanoes are named.

Vulcanian: A type of eruption consisting of the explosive ejection of incandescent fragments of new viscous lava, usually on the form of blocks.

Water Table: The surface between where the pore space in rock is filled with water and where the the pore space in rock is filled with air.

Xenocrysts: A crystal that resembles a phenocryst in igneous rock, but is a foreign to the body of rock in which it occurs.