Physical geology

Unit 4.

Valcanoes.

Volcano, vent in the crust of Earth or another planet or satellite, from which issue eruptions of molten rock, hot rock fragments, and hot gases. They can cause disastrous loss of life and property, especially in densely populated regions of the world. Sometimes beginning with an accumulation of gas-rich magma (molten underground rock) in reservoirs near Earth's surface, they can be preceded by emissions of steam and gas from small vents in the ground. Swarms of small earthquakes, which may be caused by a rising plug of dense, viscous magma oscillating against a sheath of more-permeable magma, may also signal volcanic eruptions, especially explosive ones. In some cases, magma rises in conduits to the surface as a thin and fluid lava, either flowing out continuously or shooting straight up in glowing fountains or curtains. In other cases, entrapped gases tear the magma into shreds and hurl viscous clots of lava into the air. In more violent eruptions, the magma conduit is cored out by an explosive blast, and solid fragments are ejected in a great cloud of ash-laden gas that rises tens of thousands of metres into the air. One feared phenomenon accompanying some explosive eruptions is the *nuée ardente*, or pyroclastic flow, a fluidized mixture of hot gas and incandescent particles that sweeps down a volcano's flanks, incinerating everything in its path. Great destruction also can result when ash collects on a high snowfield or glacier, melting large quantities of ice into a flood that can rush down a volcano's slopes as an unstoppable mudflow.

Volcanoes are closely associated with plate tectonic activity. Most volcanoes, such as those of Japan and Iceland, occur on the margins of the enormous solid rocky plates that make up Earth's surface. Other volcanoes, such as those of the Hawaiian Islands, occur in the middle of a plate, providing important evidence as to the direction and rate of plate motion.

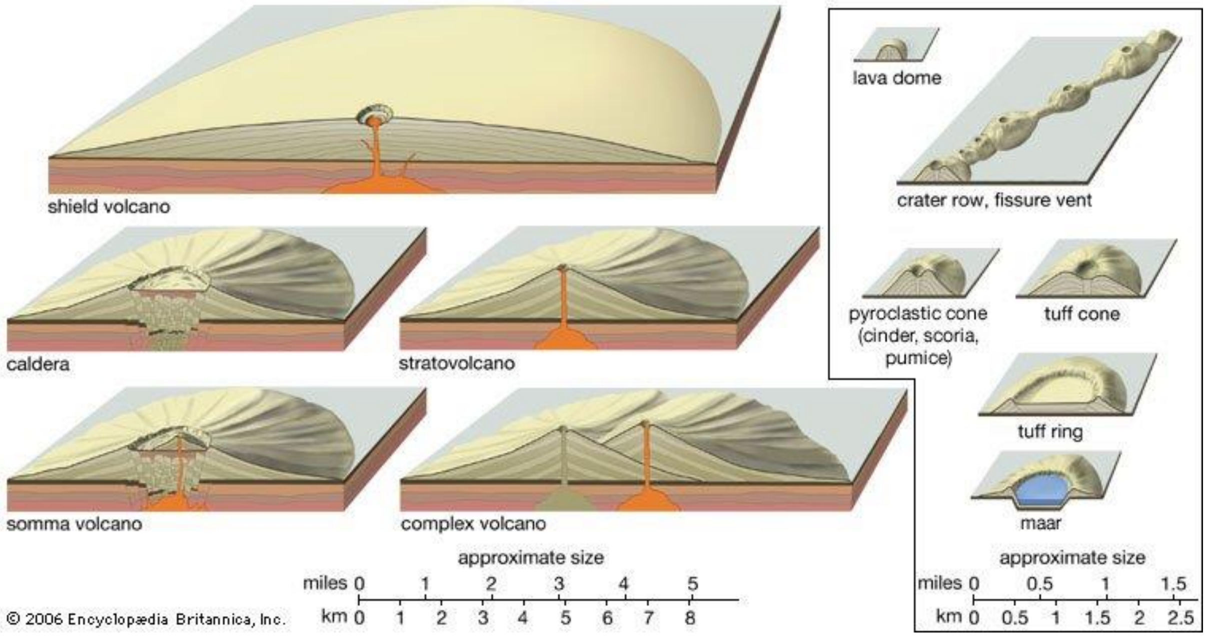
Lava.

The list of hazards associated with volcanic eruptions is long and varied: lava flows, explosions, toxic gas clouds, ash falls, pyroclastic flows, avalanches, tsunamis, and mudflows. In addition to these immediatedangers, volcanic activity produces secondary effects such as property damage, crop loss, and perhaps changes to weather and climate. The root zone of volcanoes is found some 70 to 200 km (40 to 120 miles) below the surface of Earth. There, in Earth's upper mantle, temperatures are high enough to melt rock and form magma. At these depths, magma is generally less dense than the solid rocks surrounding and overlying it, and so it rises toward the surface by the buoyant force of gravity. In some cases, as in the undersea zones where the tectonic plates of Earth's crust are separating, magma may move directly up to the surface through fissures that reach as deep as the mantle. In other cases, it collects in large underground reservoirs known as magma chambers before erupting to the surface. Molten rock that reaches the surface is called lava.

Most magma formed by partial melting of the mantle is basaltic in composition, but, as it ascends, it assimilates silica, sodium, and potassium from the surrounding host rocks. Volcanic rocks found where magma erupts to the surface are classified into four major types, or "clans"—basalt, andesite, dacite, and rhyolite. These rocks are ranked, as can be seen in the table, mainly by their silica content, which ranges from approximately 50 percent for basalt to approximately 75 percent for rhyolite. As silica content increases, rock types generally become more viscous.

Types of volcanoes.

The common mental image of a volcano is that of a steep symmetrical cone sweeping upward in a concave curve to a sharp summit peak. Mount Fuji in Japan is the archetype of this image, but in reality only a few volcanoes attain this ideal shape. Each of the more than 1,500 potentially active volcanoes or volcanic areas around the world has a distinct form, though most can be generalized into nine categories (*see* table). These categories are described below in order of their numerical importance.



volcanic landforms

The landforms shown at left and right are vertically exaggerated, and those shown at right are out of scale to those shown at left. In reality a cinder cone would be approximately one-tenth the size of a stratovolcano.

Stratovolcanoes.

Stratovolcanoes such as Mayon Volcano in the Philippines, Mount Momotombo in Nicaragua, and Ol Doinyo Lengai in Tanzania are steep cones built by both pyroclastic and lava-flow eruptions. The cone-shaped form slopes up gradually and becomes steeper (up to 35°) toward the summit, which generally contains a crater. Stratovolcanoes are composed of volcanic rock types that vary from basalt to rhyolite, but their composition is generally andesite. They may erupt many thousands of times over life spans of millions of years. A typical eruption begins with ash explosions and ends with extrusion of thick, viscous lava flows. The alternating layers (strata) of ash and lava are not continuous, blanketlike deposits; rather, they are overlapping lobes or tongues of ash and lava. For this reason many geologists refer to stratovolcanoes as composite volcanoes.

Shield valcanoes

Structures of this type are large dome-shaped mountains built of lava flows. Their name derives from their similarity in shape to a warrior's shield lying face up. Shield volcanoes are usually composed of basalt. Small shield volcanoes may form rapidly from almost continuous eruptions, but the larger shields are formed over a span of about 1 million years by hundreds of thousands of effusive eruptions of fluid lavas from their summits and rift zones. The slopes of shield volcanoes are gentle, seldom exceeding 6°. The summits, which are nearly flat, are generally indented by cliff-walled craters or calderas. The Hawaiian volcano Mauna Loa is a typical shield volcano. Its elongate shape records a long history of fluid lava flows not only from its summit but from its two persistent rift zones.

Submarine volcanoes.

These structures occur in various forms, but many are cone-shaped seamounts. Some ancient island volcanoes were eroded flat or covered with a coral cap at sea level before they sank below the sea surface as they and the crust supporting them cooled and became denser. These flat-topped seamounts are called guyots. Most of the active submarine volcanoes that are known occur at shallow depths beneath the sea. They are recognized because their explosive eruptions can be detected and located by hydrophones. Active submarine volcanoes at depths of a few thousand metres are probably common, particularly along oceanic spreading centres, but the water pressure at these depths reduces explosive boiling, and so the eruptions are difficult to detect. One exception to this is the submarine volcano Lōʻihi, a seamount whose summit caldera is 1 km (0.6 mile) below sea level and 30 km (19 miles) southeast of the island of Hawaii. Although eruptions of this youngest volcano of the Hawaiian chain have not been directly observed, seismographs detected swarms of earthquakes at shallow depths beneath the summit of Lōʻihi in 1971–72, 1975, and 1996. Observers in a submersible research vessel from the University of Hawaii dove to Lōʻihi as the 1996 earthquakes waned, and they discovered a new collapse crater at the summit and fine white “dust” that greatly reduced visibility but saw no red lava or erupting vents. A submarine eruption has not yet been directly observed in progress.

Calderas.

Most calderas—large circular or oval depressions more than 1 km (0.6 mile) in diameter—have been formed by inward collapse of landforms after large amounts of magma have been expelled from underground. Many are surrounded by steep cliffs, and some are filled with lakes. The terms *crater* and *caldera* are often used synonymously, but calderas are larger than craters. A crater can occur inside a caldera, as at Taal Lake in the Philippines, but not the reverse. Calderas are often associated with large eruptions (those producing volumes of 10 cubic km [2.4 cubic miles] or more) of dacitic or rhyolitic magma that form pyroclastic plateaus.

Complex valcanoes

Such structures are mixed landforms. In most cases, they occur because of changes either in eruptive habit or in location of the principal vent area. A stratovolcano may form a large explosion crater that later becomes filled by a lava dome, or several new cones and craters may develop on a caldera's rim. One stratovolcano may have multiple summits when individual cones overlap one another. The Three Sisters volcanic complex in Oregon is an example of a complex volcano with three summits.

Pyroclastic cones

Pyroclastic cones (also called cinder cones or scoria cones) such as Cerro Negro in Nicaragua are relatively small, steep (about 30°) volcanic landforms built of loose pyroclastic fragments, most of which are cinder-sized. The fragments cool sufficiently during their flight through the air so that they do not weld together when they strike one another. Generally, the crater from which the cinder fragments were ejected is located in the centre of the cone. In areas with strong prevailing winds, however, the crater may be upwind of the cone. The rock type involved in pyroclastic cones is generally basalt or basaltic andesite, and the eruption type is either the moderately

Valcanic products

Lava, gas, and other hazards

The list of hazards associated with volcanic eruptions is long and varied: lava flows, explosions, toxic gas clouds, ash falls, pyroclastic flows, avalanches, tsunamis, and mudflows. In addition to these immediate dangers, volcanic activity produces secondary effects such as property damage, crop loss, and perhaps changes to weather and climate. These hazards and long-term effects are described in this section.explosive Vulcanian or the gentler Hawaiian, which produces high lava fountains.

Lava flow.

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Pyroclastic flows.

Pyroclastic flows are the most dangerous and destructive aspect of explosive volcanism. Variously called *nuées ardentes* ("glowing clouds"), glowing avalanches, or ash flows, they occur in many sizes and types, but their common characteristic is a fluidized emulsion of volcanic particles, eruption gases, and entrapped air, resulting in a flow of sufficiently low viscosity to be very mobile and of sufficiently high density to hug the ground surface. A pyroclastic flow can pour over the lip of an erupting vent, or it may form when an ash column becomes too dense to continue rising and falls back to the ground. In major caldera collapses associated with explosive volcanoes (*see below* Calderas), huge pyroclastic flows may issue from the ring fractures as the caldera block subsides.

Pyroclastic flows can move at speeds up to 160 km (100 miles) per hour and have temperatures ranging from 100 to 700 °C (212 to 1,300 °F). They sweep away and incinerate nearly everything in their path. Smaller pyroclastic flows are often confined to valleys. Large pyroclastic flows may spread out as a blanket deposit across many hundreds or even thousands of square kilometres around a major caldera collapse. During the past two million years, the area around Yellowstone National Park in the western United States has undergone three major caldera collapses involving pyroclastic eruptions of 280 to 2,500 cubic km (67 to 600 cubic miles) of ash flows and ash falls.

Gas clouds.

Even beyond the limit of explosive destruction, the hot, ash-laden gas clouds associated with an explosive eruption can scorch vegetation and kill animals and people by suffocation. Gas clouds emitted from fumaroles (volcanic gas vents) or from the sudden overturn of a crater lake may contain suffocating or poisonous gases such as carbon dioxide, carbon monoxide, hydrogen sulfide, and sulfur dioxide. At Lake Nyos, a crater lake in Cameroon, West Africa, more than 1,700 people were killed by a sudden release of carbon dioxide in August 1986. Scientists theorize that carbon dioxide of volcanic origin had been seeping into the lake, perhaps for centuries, and had accumulated in its deep layers. It is thought that some disturbance, such as a large landslide into the lake, could have triggered the outburst of gas, creating an effervescence that stirred the lake and started the degassing.

Ash falls.

Ash falls from continued explosive jetting of fine volcanic particles into high ash clouds generally do not cause any direct fatalities. However, where the ash accumulates more than a few centimetres, collapsing roofs and failure of crops are major secondary hazards. Crop failure can occur over large areas downwind from major ash eruptions, and widespread famine and disease may result, especially in poorly developed countries. In the long run, however, the decomposition of nutrient-rich volcanic fallout is responsible for some of the world's best soils.

Causes of Valcanism.

The radioactive substances inside the earth keep generating a lot of heat through decomposition and chemical reactions. As a result the material in the earth's interior is in constant flux. This molten, semi-molten and sometimes gaseous material appears on earth at the first available opportunity. This opportunity is provided by weak zones along the earth's surface. The earthquakes, for instance, may expose fault zones through which magma may escape. Because of high pressure in the earth's interior, the magma and gases escape with great velocity as the pressure is released through eruptions.

Styles of volcanic eruption.

Scientists realized long ago that no two volcanoes erupt the same. Some, like Mount St. Helens, burst violently and send ash and gas high into the air. Others, like Kilauea in Hawaii, ooze red hot lava which runs like maple syrup down the slope of the volcano. Many factors control how a volcano will erupt.

Effusive eruptions – magma rises through the surface and flows out of the volcano as a viscous liquid called lava.

Explosive eruptions – magma is torn apart as it rises and reaches the surface in pieces known as pyroclasts.

cience of volcanology.

Types of eruption.

Many types of eruptions can occur at each of New Zealand's volcanoes - the eruption type can vary minute to minute. The style of eruption depends on a number of factors, including the magma chemistry and content, temperature, viscosity (how runny the magma is), volume and how much water and gas is in it, the presence of groundwater, and the plumbing of the volcano. For information on volcanic hazards which can be produced by our volcanoes,

Hydrothermal

An eruption driven by the heat in a hydrothermal systems. Hydrothermal eruptions pulverise surrounding rocks and can produce ash, but do not include magma. These are typically very small eruptions

Phreatic eruption

An eruption driven by the heat from magma interacting with water. The water can be from groundwater, hydrothermal systems, surface runoff, a lake or the sea. Phreatic eruptions pulverise surrounding rocks and can produce ash, but do not include new magma.

Phreatomagmatic eruption

An eruption resulting from the interaction of new magma or lava with water and can be very explosive. The water can be from groundwater, hydrothermal systems, surface runoff, a lake or the sea.

Strombolian and Hawaiian eruptions

These are the least violent types of explosive eruptions. Hawaiian eruptions have fire fountains and lava flows, whereas Strombolian eruptions have explosions causing a shower of lava fragments.

Vulcanian eruptions
Vulcanian eruptions are small to moderate explosive eruptions, lasting seconds to minutes. Ash columns can be up to 20 km in height, and lava blocks and bombs may be ejected from the vent.

Subplinian and Plinian eruptions
Eruptions with a high rate of magma discharge, sustained for minutes to hours. They form a tall, convective eruption column of a mixture of gas and rock particles, and can cause wide dispersion of ash. Subplinian eruption columns are up to 20 km high, and are relatively unsteady, whereas Plinian eruptions have 20 to 35 km tall columns which may collapse to form pyroclastic density currents (PDC's). Very rare Ultraplinian eruptions are even larger and have a higher magma discharge rate than Plinian eruptions.

Prediction of Volcanic eruption

Volcanologists attempt to forecast volcanic eruptions, but this has proven to be nearly as difficult as predicting an earthquake. Many pieces of evidence can mean that a volcano is about to erupt, but the time and magnitude of the eruption are difficult to pin down. This evidence includes the history of previous volcanic activity, earthquakes, slope deformation, and gas emissions.

History of Volcanic Activity

A volcano's history, how long since its last eruption and the time span between its previous eruptions, is a good first step to predicting eruptions. If the volcano is considered **active**, it is currently erupting or shows signs of erupting soon. A **dormant** volcano means there is no current activity, but it has erupted recently. Finally, an **extinct** volcano means their is no activity and will probably not erupt again. Active and dormant volcanoes are heavily monitored, especially in populated areas.

Earthquakes

Moving magma shakes the ground, so the number and size of **earthquakes** increases before an eruption. A volcano that is about to erupt may produce a sequence of earthquakes. Scientists use seismographs that record the length and strength of each earthquake to try to determine if an eruption is imminent. Magma and gas can push the volcano's slope upward. Most ground deformation is subtle and can only be detected by tiltmeters, which are instruments that measure the angle of the slope of a volcano. But ground swelling may sometimes create huge changes in the shape of a volcano. Mount St. Helens grew a bulge on its north side before its 1980 eruption. Ground swelling may also increase rockfalls and landslides.

Gas Emissions

Gases may be able to escape a volcano before magma reaches the surface. Scientists measure gas emissions in vents on or around the volcano. Gases, such as sulfur dioxide (SO_2), carbon dioxide (CO_2), hydrochloric acid (HCl), and even water vapor (H_2O) can be measured at the site or, in some cases, from a distance using satellites. The amounts of gases and their ratios are calculated to help predict eruptions.

Remote Monitoring

Some gases can be monitored using satellite technology. Satellites also monitor temperature readings and deformation. As technology improves, scientists are better able to detect changes in a volcano accurately and safely.Since volcanologists are usually uncertain about an eruption, officials may not know whether to require an evacuation. If people are evacuated and the eruption doesn't happen, the people will be displeased and less likely to evacuate the next time there is a threat of an eruption. The costs of disrupting business are great. However, scientists continue to work to improve the accuracy of their predictions.

<u>Volcanic landforms</u>

<u>Craters</u>: Craters form as the result of explosive eruptive activity at a volcanic vent where rock, magma, and other material is ejected leaving a conical void.

<u>Lava flows</u>: Lava can flow out of fissures and vents forming a variety of features depending on the composition and viscosity. Learn about the two types of basaltic lava flows: 'A'a and Pahoehoe.

Pillow lava: Pillow lava is commonly cited as the most abundant geologic landform on Earth's surface. As described above, pillows form at low, though imprecisely known, flow rates.

Domes: A dome is a curved formation or structure. ... Some natural domes develop when magma from deep within the Earth pushes up surface rock layers. This type of geologic dome can form as magma intrudes between two layers of sedimentary rock. The magma creates a dome or triangle shape as it pushes the other layers apart.

Columnar lava structures: Columnar jointing is a geological structure where sets of intersecting closely spaced fractures, referred to as joints, result in the formation of a regular array of polygonal prisms, or columns. Columnar jointing occurs in many types of igneous rocks and forms as the rock cools and contracts. Columnar jointing can occur in cooling lava flows and ashflow tuffs (ignimbrites), as well as in some shallow intrusions.[1] Columnar jointing also occurs rarely in sedimentary rocks if they have been heated by nearby hot magma.

Distribution of valcanoes

Approximately 1,550 subaerial volcanoes in the world today are thought to have erupted in the last 10,000 years, and thousands more volcanoes ring the seafloor. These active volcanoes mainly occur in curvilinear belts that define tectonic plate boundaries. Hundreds of millions of people live on the flanks of active volcanoes and could suffer the acute affects of even a moderate-sized eruption. Island arc nations such as Indonesia, the Philippines, and Japan host the largest populations within 100 km of an active volcano; Indonesia prompts further distinction as having the most explosive eruptions on record as well as the greatest number of eruption-related fatalities. The Volcanoes of the World database maintained by Smithsonian's Global Volcanism Program, documents more than 10,000 Holocene eruptions, yet only six eruptions account for more than half of the total quantified fatalities. The assembled data bring into relief large gaps in our understanding of the risks posed by volcanoes and the need for more research into volcanic hazards, risks, and timescales.

Volcanic activity is widespread over the earth, but tends to be concentrated in specific locations. Volcanoes are most likely to occur along the margins of **tectonic plates**, especially in subduction zones where oceanic plates dive under continental plates. As the oceanic plate subducts beneath the surface, intense heat and pressure melts the rock. Molten rock material, magma, can then ooze its way toward the surface where it accumulates at the surface to create a volcano. Volcanic activity can be found along the **Mid-ocean ridge system** as well. Here, oceanic plates are diverging and magma spreads across the ocean floor, ultimately being exposed at the surface. Crustal spreading long the ridge is partly responsible for the volcanic activity of Iceland. It is also thought that a "hot spot" lies beneath the island that contributes to volcanism.

Examples of Indian volcanoes

Barren Island: Barren Island is a confirmed active volcano in the South-Asia. It is located in the Andaman Sea. Its first and the last eruption occurred in the year 1787 and 2017 respectively. One can easily reach Barren Island from Port Blair, which is around 138 kilometres away, either by a seaplane or by a boat/ ship.

Location: Andaman Islands
Type: Stratovolcano, Active
Last Eruption: 2017

Narcodam Island: It is a small volcanic island, which covers around 6.8 square kilometers of area. It is situated in the Andaman Sea. Well, it’s a fairly remote island and has very poor connectivity and is hard to reach. Till now, there had been only eight visits.

Location: Andaman Islands
Type: Stratovolcano, Dormant
Last Eruption: Unknown

Deccan traps: They are located on the Deccan plateau, Maharashtra. They cover an area of around 500,000 square kilometers. Their formation resembles steps or stairs and are solodifies flood basalts. If you want to explore this place more, you can reach the destination via road.

Location: Maharashtra
Type: -
Last eruption: 2007

Baratang: Baratang Island or Ranchiwalas Island is an island in the Andaman Islands with an area of 242.6 square kilometers. It contains only mud volcanoes, which have erupted in the past. If you are one of those who want to visit this place, then you have to take a local bus or taxi which will drop you at Nilambur Jetty. From here, you have to take a boat ride which will last for about 15 minutes and take you to your desired location.

Location: Andaman Islands
Type: Mud Volcano
Last eruption: Active since 2003

Dhinodhar :Dhinodhar hill, located in Gujarat, is an inactive volcano. Its elevation is around 386 metres. This extinct volcano can be reached from Bhuj, Devpur- Vithon route or Nakhatrana- Virani route. The location is around 75 kilometres from Bhuj.

Location: Gujarat
Type: Extinct Volcano
Last eruption: Inactive Volcano

Dhosi hills: Dhosi Hills are a part of the Aravalli Mountain Range, that has formation of igneous rocks. It is located in the state of Haryana. Dhosi Hills is easily accessible by road.

Location: Haryana
Type: Extinct Volcano
Last eruption: 732 Ma BP (million years before present).

Tosham hills: Tosham hill volcano is an extinct volcano with an average elevation of 207 metres. The rock formation present is igneous rocks and it is part of the Aravalli Mountain Range. Tosham hill is absolutely safe and can be reached easily by road.

Location: Haryana
Type: Extinct Volcano
Last eruption: 732 Ma BP (million years before present)

Atmosphere

We live at the bottom of an invisible ocean called the atmosphere, a layer of gases surrounding our planet. Nitrogen and oxygen account for 99 percent of the gases in dry air, with argon, carbon dioxide, helium, neon,and other gases making up minute portions. Water vapor and dust are also part of Earth's atmosphere. Other planets and moons have very different atmospheres, and some have no atmospheres at all.The atmosphere is so spread out that we barely notice it, yet its weight is equal to a layer of water more than 10 meters (34 feet) deep covering the entire planet. The bottom 30 kilometers (19 miles) of the atmosphere contains about 98 percent of its mass. The atmosphere—air—is much thinner at high altitudes. There is no atmosphere in space. Scientists say many of the gases in our atmosphere were ejected into the air by early volcanoes. At that time, there would have been little or no free oxygen surrounding the Earth. Free oxygen consists of oxygen molecules not attached to another element, like carbon (to form carbon dioxide) or hydrogen (to form water).

Free oxygen may have been added to the atmosphere by primitive organisms, probably bacteria, during photosynthesis. Photosynthesis is the process a plant or other autotroph uses to make food and oxygen from carbon dioxide and water. Later, more complex forms of plant life added more oxygen to the atmosphere. The oxygen in today's atmosphere probably took millions of years to accumulate. The atmosphere acts as a gigantic filter, keeping out most ultraviolet radiation while letting in the sun's warming rays. Ultraviolet radiation is harmful to living things, and is what causes sunburns. Solar heat, on the other hand, is necessary for all life on Earth.Earth's atmosphere has a layered structure. From the ground toward the sky, the layers are the troposphere, stratosphere, mesosphere,thermosphere, and exosphere. Another layer, called the ionosphere,extends from the mesosphere to the exosphere. Beyond the exosphere is outer space. The boundaries between atmospheric layers are not clearly defined, and change depending on latitude and season.

The atmosphere is layered, corresponding with how the atmosphere's temperature changes with altitude. By understanding the way temperature changes with altitude, we can learn a lot about how the atmosphere works. While weather takes place in the lower atmosphere, interesting things, such as the beautiful aurora, happen higher in the atmosphere.

Air Temperature

Papers held up by rising air currents above a radiator demonstrate the important principle that warm air rises. Why does warm air rise .Gas molecules are able to move freely and if they are uncontained, as they are in the atmosphere, they can take up more or less space. When gas molecules are cool, they are sluggish and do not take up as much space. With the same number of molecules in less space, both air density and air pressure are higher. When gas molecules are warm, they move vigorously and take up more space. Air density and air pressure are lower. Warmer, lighter air is more buoyant than the cooler air above it, so it rises. The cooler air then sinks down, because it is denser than the air beneath it.

The property that changes most strikingly with altitude is air temperature. Unlike the change in pressure and density, which decrease with altitude, changes in air temperature are not regular. A change in temperature with distance is called a temperature gradient.

Vertical extent layers

The atmosphere is divided into layers based on how the temperature in that layer changes with altitude, the layer's temperature gradient. The temperature gradient of each layer is dierent. In some layers, temperature increases with altitude and in others it decreases. The temperature gradient in each layer is determined by the heat source of the layer . Most of the important processes of the atmosphere take place in the lowest two layers: the troposphere and the stratosphere.

Troposphere

The temperature of the troposphere is highest near the surface of the Earth and decreases with altitude. On average, the temperature gradient of the troposphere is 6.5°C per 1,000 m (3.6°F per 1,000 ft.) of altitude. What is the source of heat for the troposphere? Earth's surface is a major source of heat for the troposphere, although nearly all of that heat comes from the Sun. Rock, soil, and water on Earth absorb the Sun's light and radiate it back into the atmosphere as heat. The temperature is also higher near the surface because of the greater density of gases. The higher gravity causes the temperature to rise. Notice that in the troposphere warmer air is beneath cooler air. What do you think the consequence of this is? This condition is unstable. The warm air near the surface rises and cool air higher in the troposphere sinks. So air in the troposphere does a lot of mixing. This mixing causes the temperature gradient to vary with time and place. The rising and sinking of air in the troposphere means that all of the planet's weather takes place in the troposphere. Sometimes there is a temperature inversion, air temperature in the troposphere increases with altitude and warm air sits over cold air. Inversions are very stable and may last for several days or even weeks. Inversions form: Over land at night or in winter when the ground is cold. The cold ground cools the air that sits above it, making this low layer of air denser than the air above it.

Near the coast where cold seawater cools the air above it. When that denser air moves inland, it slides beneath the warmer air over the land. Since temperature inversions are stable, they often trap pollutants and produce unhealthy air conditions in cities .Smoke makes a temperature inversion visible. The smoke is trapped in cold dense air that lies beneath a cap of warmer air. At the top of the troposphere is a thin layer in which the temperature does not change with height. This means that the cooler, denser air of the troposphere is trapped beneath the warmer, less dense air of the stratosphere. Air from the troposphere and stratosphere rarely mix.

Stratosphere

Ash and gas from a large volcanic eruption may burst into the stratosphere, the layer above the troposphere. Once in the stratosphere, it remains suspended there for many years because there is so little mixing between the two layers. Pilots like to y in the lower portions of the stratosphere because there is little air turbulence. In the stratosphere, temperature increases with altitude. What is the heat source for the stratosphere? The direct heat source for the stratosphere is the Sun. Air in the stratosphere is stable because warmer, less dense air sits over cooler, denser air. As a result, there is little mixing of air within the layer. The ozone layer is found within the stratosphere between 15 to 30 km (9 to 19 miles) altitude. The thickness of the ozone layer varies by the season and also by latitude.

The ozone layer is extremely important because ozone gas in the stratosphere absorbs most of the Sun's harmful ultraviolet (UV) radiation. Because of this, the ozone layer protects life on Earth. High-energy UV light penetrates cells and damages DNA, leading to cell death (which we know as a bad sunburn). Organisms on Earth are not adapted to heavy UV exposure, which kills or damages them. Without the ozone layer to reect UVC and UVB radiation, most complex life on Earth would not survive long.

Mesosphere

Temperatures in the mesosphere decrease with altitude. Because there are few gas molecules in the mesosphere to absorb the Sun's radiation, the heat source is the stratosphere below. The mesosphere is extremely cold, especially at its top, about -90°C (-130°F). The air in the mesosphere has extremely low density: 99.9% of the mass of the atmosphere is below the mesosphere. As a result, air pressure is very low (Figure below). A person traveling through the mesosphere would experience severe burns from ultraviolet light since the ozone layer which provides UV protection is in the stratosphere below. There would be almost no oxygen for breathing. Stranger yet, an unprotected traveler's blood would boil at normal body temperature because the pressure is so low. layer which provides UV protection is in the stratosphere below. There would be almost no oxygen for breathing. Stranger yet, an unprotected traveler's blood would boil at normal body temperature because the pressure is so low.

Thermosphere and Beyond

The International Space Station (ISS) orbits within the upper part of the thermosphere, at about 320 to 380 km above the Earth. The density of molecules is so low in the thermosphere that one gas molecule can go about 1 km before it collides with another molecule. Since so little energy is transferred, the air feels very cold (Figure above). Within the thermosphere is the ionosphere. The ionosphere gets its name from the solar radiation that ionizes gas molecules to create a positively charged ion and one or more negatively charged electrons. The freed electrons travel within the ionosphere as electric currents. Because of the free ions, the ionosphere has many interesting characteristics. At night, radio waves bounce o the ionosphere and back to Earth. This is why you can often pick up an AM radio station far from its source at night. The Van Allen radiation belts are two doughnut-shaped zones of highly charged particles that are located beyond the atmosphere in the magnetosphere.

The particles originate in solar ares and y to Earth on the solar wind. Once trapped by Earth's magnetic eld, they follow along the eld's magnetic lines of force. These lines extend from above the equator to the North Pole and also to the South Pole then return to the equator.
When massive solar storms cause the Van Allen belts to become overloaded with particles, the result is the most spectacular feature of the ionosphere — the nighttime aurora (Figure below). The particles spiral along magnetic eld lines toward the poles. The charged particles energize oxygen and nitrogen gas molecules, causing them to light up. Each gas emits a particular color of light.

(a) Spectacular light displays are visible as the aurora borealis or northern lights in the Northern Hemisphere. (b) The aurora australis or southern lights encircles Antarctica. There is no real outer limit to the exosphere, the outermost layer of the atmosphere; the gas molecules nally become so scarce that at some point there are no more. Beyond the atmosphere is the solar wind. The solar wind is made of high-speed particles, mostly protons and electrons, traveling rapidly outward from the Sun.

Copomsition

The atmosphere is concentrated at the earth's surface and rapidly thins as you move upward, blending with space at roughly 100 miles above sea level. The atmosphere is actually very thin compared to the size of the earth, equivalent in thickness to a piece of paper laid over a beach ball. However, it is responsible for keeping our earth habitable and for producing weather.

The atmosphere is composed of a mix of several different gases in differing amounts. The permanent gases whose percentages do not change from day to day are nitrogen, oxygen and argon. Nitrogen accounts for 78% of the atmosphere, oxygen 21% and argon 0.9%. Gases like carbon dioxide, nitrous oxides, methane, and ozone are trace gases that account for about a tenth of one percent of the atmosphere. Water vapor is unique in that its concentration varies from 0-4% of the atmosphere depending on where you are and what time of the day it is. In the cold, dry artic regions water vapor usually accounts for less than 1% of the atmosphere, while in humid, tropical regions water vapor can account for almost 4% of the atmosphere. Water vapor content is very important in predicting weather.

Greenhouse gases whose percentages vary daily, seasonally, and annually have physical and chemical properties which make them interact with solar radiation and infrared light (heat) given off from the earth to affect the energy balance of the globe. This is why scientists are watching the observed increase in greenhouse gases like carbon dioxide and methane carefully, because even though they are small in amount, they can strongly affect the global energy balance and temperature over.

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Living things created much of the third atmosphere, the one that now exists on Earth. Cyanobacteria were responsible for the rise in the atmospheric concentration of oxygen beginning 2.3 billion years ago. These bacteria, algae, and other plants produce oxygen by photosynthesis. Although most of this oxygen is used in respiration (biological oxidation) or in the atmospheric oxidation of the carbon containing products, approximately 0.1 % of the organic matter is sequestered in sediments and that quantity of oxygen is added to the atmosphere. Over time, the excess oxygen has built up so that it is now makes up nearly 20% of the gases close to Earth.

Composition of Earth's Atmosphere	
Nitrogen	78.1%
Oxygen	20.9%
Argon	0.9 %
Carbon dioxide, Methane, Rare (inert) gases 0.1%	1%

Molecular nitrogen and molecular oxygen are the most common gases in today's atmosphere. Others are present in small concentrations.

Pressure

A key measure of gas-phase molecules is their **pressure**. For a gas in a container, the pressure of the gas is the force exerted by the gas particles hitting the surface of the container. There isn't really a container for our atmosphere so we need to think of pressure in a slightly different way.

1. All atoms and molecules in the Earth's atmosphere are held by the **gravitational force** of the planet. The force decreases by $1/(\text{distance})^2$ so the particles are held less tightly as the distance between them and the Earth (altitude) increases.

2. The **gas density**, that is the mass of gas particles in every liter of volume, decreases as the altitude increases.

3. The **weight** of a column of gas particles, that is the Earth's gravitational force acting on the mass of the gas particles, above any point must decrease as the altitude increases. This weight is **atmospheric pressure**

Temperature

Atmospheric temperature is a measure of temperature at different levels of the Earth's atmosphere. It is governed by many factors, including incoming solar radiation, humidity and altitude. When discussing surface air temperature, the annual atmospheric temperature range at any geographical location depends largely upon the type of biome, as measured by the Köppen climate classification

Temperature variation

Temperature varies greatly at different heights relative to the Earth's surface and this variation in temperature characterizes the four layers that exist in the atmosphere. These layers include: the Troposphere, Stratosphere, Mesosphere, and Thermosphere.

The troposphere is the lowest of the four layers, extending from the surface of the Earth to about 11 km (7 mi) into the atmosphere where the tropopause (the boundary between the troposphere stratosphere) is located. The width of the troposphere can vary depending on latitude, for example, the troposphere is thicker in the tropics (about 16 km or 10 mi) because the tropics are generally warmer, and thinner at the poles (about 8 km or 5 mi) because the poles are colder. Temperatures in the atmosphere decrease with height at an average rate of 6.5°C/km. Because the troposphere experiences its warmest temperatures closer to Earth's surface, there is great vertical movement of heat and water vapour, causing turbulence. This turbulence, in conjunction with the presence of water vapour, is the reason that weather occurs within the troposphere.[3][4]

Following the tropopause is the stratosphere. This layer extends from the tropopause to the stratopause which is located at an altitude of about 50 km (31 mi). Temperatures remain constant with height from the tropopause to an altitude of 20 km (12.5 mi), after which they start to increase with height. This happening is referred to as an inversion and It is because of this inversion that the stratosphere is not characterised as turbulent. The stratosphere receives its warmth from the sun and the ozone layer which absorbs ultraviolet radiation.

The next layer is called the mesosphere which extends from the stratopause to the mesopause, located at an altitude of 85 km (53 mi). Temperatures in the mesospere decrease with altitude and are in fact the coldest in the Earth's atmosphere[5] This decrease in temperature can be attributed to the diminishing radiation received from the Sun, after most of it has already been absorbed by the thermosphere.[3]

The fourth layer of the atmosphere is known as the thermosphere which extends from the mesopause to the 'top' of the collisional atmosphere. Some of the warmest temperatures can be found in the thermosphere, due to its reception of strong ionizing radiation at the level of the Van Allen radiation belt.

Temperature range

The variation in temperature that occurs from the highs of the day to the cool of nights is called diurnal temperature variation. Temperature ranges can also be based on periods of a month, or a year.

The size of ground-level atmospheric temperature ranges depends on several factors, such as:

- The average temperature
- The average humidity
- The regime of winds (intensity, duration, variation, temperature, etc.)
- The proximity to large bodies of water,
- The minimum temperature on calm, clear nights has been observed to occur not on the ground, but rather a few tens of centimeters above the ground.

Globle temperatureThe concept of a global temperature is commonly used in climatology, and denotes the average temperature of the Earth based on surface, near-surface or tropospheric measurements. These temperature records and measurements are typically acquired using the satellite or ground instrumental temperature measurements, then usually compiled using a database or computer model. Long-term global temperatures in paleoclimate are discerned using proxy data.

Wind

Wind is caused by a difference in pressure from one area to another area on the surface of the Earth. Air naturally moves from high to low pressure, and when it does so, it is called wind.

Generally, we can say that the cause of the wind is the uneven heating of the Earth’s surface by the Sun. The Earth’s surface is made of different land and water areas, and these varying surfaces absorb and reflect the Sun’s rays unevenly. Warm air rising yields a lower pressure on the Earth, because the air is not pressing down on the Earth’s surface, while descending cooler air produces a higher pressure.

But there are many other factors affecting wind direction. For example, the Earth is spinning, so air in the Northern Hemisphere is deflected to the right by what is known as the Coriolis force. This causes the air, or wind, to flow clockwise around a high-pressure system and counter-clockwise around a low-pressure system.

The closer these low- and high-pressure systems are together, the stronger the “pressure gradient,” and the stronger the winds. Vegetation also plays a role in how much sunlight is reflected or absorbed by the surface of the Earth. Furthermore, snow cover reflects a large amount of radiation back into space. As the air cools, it sinks and causes a pressure increase.

And wind can get even more complex. Some parts of the Earth, near the equator, receive direct sunlight all year long and have a consistently warmer climate. Other parts of the Earth, near the polar regions, receive indirect rays, so the climate is colder.

As the warm air from the tropics rises, colder air moves in to take the place of the rising warmer air. This movement of air also causes the wind to blow. It's a dynamic, complex mechanism, which is why weather forecasting is not quite a precise science.

Today we see windmills, used to make electricity, in operation in all parts of the United States, but especially along our coasts. Coastal regions tend to have fairly strong winds blowing in from ocean to land during the day and out from land to ocean during the night. The cause of this phenomenon is that land heats up and cools down faster than water, again creating a pressure gradient.

Diurnal Variation

Wind variations that tend to repeat on a daily basis are called diurnal patterns. Many of these occur as a pronounced maximum wind speed at the same time (often the afternoon) each day. There may also be an associated directional pattern. Diurnal patterns may vary over the course of the year with different seasonal conditions.

An example of a diurnal pattern is the onshore/offshore winds found at coastal sites, where the wind blows toward the land during the day and toward the sea at night. Diurnal patterns may vary by height above ground and elevation above sea level. For example, some sites may exhibit a daytime maximum near the ground (10 m) but a nighttime maximum near turbine height (50 m). Exposed ridge-crest locations frequently have a nighttime maximum and a daytime minimum, both at the ground and at turbine hub height. Some sites, such as offshore locations, do not exhibit significant diurnal variations.

Wind power generation is power generation that converts wind energy into electric energy. The wind generating set absorbs wind energy with a specially designed blade and converts wind energy to mechanical energy, which further drives the generator rotating and realizes conversion of wind energy to electric energy.

The commonly used wind power generation systems include the direct-driven wind power generating set and the double-fed wind power generating set; the direct-driven wind power generating set is connected to the grid through a full power converter, while the double-fed wind power generating set is connected to the grid through a double-fed converter.

Mountain

Mountain, landform that rises prominently above its surroundings, generally exhibiting steep slopes, a relatively confined summit area, and considerable local relief. Mountains generally are understood to be larger than hills, but the term has no standardized geological meaning. Very rarely do mountains occur individually. In most cases, they are found in elongated ranges or chains. When an array of such ranges is linked together, it constitutes a mountain belt. For a list of selected mountains of the world.

A mountain belt is many tens to hundreds of kilometres wide and hundreds to thousands of kilometres long. It stands above the surrounding surface, which may be a coastal plain, as along the western Andes in northern Chile, or a high plateau, as within and along the Plateau of Tibet in southwest China. Mountain ranges or chains extend tens to hundreds of kilometres in length. Individual mountains are connected by ridges and separated by valleys. Within many mountain belts are plateaus, which stand high but contain little relief. Thus, for example, the Andes constitute a mountain belt that borders the entire west coast of South America; within it are both individual ranges, such as the Cordillera Blanca in which lies Peru's highest peak, Huascarán, and the high plateau, the Altiplano, in southern Peru and western Bolivia.

Mountainous terrains have certain unifying characteristics. Such terrains have higher elevations than do surrounding areas. Moreover, high relief exists within mountain belts and ranges. Individual mountains, mountain ranges, and mountain belts that have been created by different tectonic processes, however, are often characterized by different features.

Types and Classification of mountains.

Mountains have always played a central role in human culture, but we've only recently come to understand how they form and develop. To this day, these magnificent landforms still hold many secrets. There are several ways to analyze and classify mountains depending on your scientific discipline. Here, we'll describe some of the more common classifications of mountains in detail.

Generally, mountains be classified as: fold mountains, block mountains, dome mountains, and volcanic mountains. Plateau mountains, uplifted passive margins, and hotspot mountains are also sometimes considered.

Fold mountains — the most common type, they form when two or more tectonic plates collide.

Block mountain or(fault –block)some rocks up and others down.

Dome mountains — formed as a result of hot magma pushing beneath the crust.

Volcanic mountains — also known by a simpler name: volcanoes.

Other types of mountains sometimes included in classifications are **plateau mountains**, **uplifted passive margins**, and **hotspot mountains**.

Fold mountains. Fold mountains are the most common and most massive types of mountains (on Earth, at least). Fold mountain chains can spread over thousands of kilometers — we're talking about the Himalayas, the Alps, the Rockies, the Andes — all the big boys. They're also relatively young (another reason they're so tall, as they haven't been thoroughly eroded), but that's "young" in geological terms — still tens of millions of years. In order to understand how fold mountains form and develop, we have to think about plate tectonics. The Earth's lithosphere is split into rigid plates which move independently of one another. There are seven major tectonic plates and several smaller ones all across the world.

When two plates collide, several things can happen. For instance, if one plate is denser than the other (oceanic plates are typically denser because of the type of rocks that make up the plate), a process called subduction will start: the heavier one will slowly glide beneath the lighter one. If they have relatively similar densities, then they will start to crumple up, driving movement upwards. Essentially, the tectonic plates are pushed, and since neither can slide beneath the other, they build up geological folds. To get a better idea of what this looks like, try to push two pieces of papers towards each other: some parts will rise up, representing the process of mountain formation.T

This process is called orogeny (giving birth to mountains) and it generally takes millions of years for it to complete. Many of today's fold mountains are still developing as the tectonic process unfolds. The process doesn't occur on tectonic edges — sometimes the mountain-generating fold process can take place well inside a tectonic plate.

Block mountains

While the previous category was all about folds, this one is all about faults: geological faults, that is. Let's revisit the previous idea for a moment. Let's say that while under pressure, some parts of a tectonic plate start to fold. As the pressure grows and grows, at one point the rock will simply break. Faults are those breaks: they're the planar fractures or discontinuities in volumes of rock. Their size can vary tremendously, from a few centimeters to mountain-sized.

Basically, when big blocks of rock are broken through faulting, some of them can get pushed up or down, thus resulting in block mountains. Higher blocks are called *horsts* and troughs are called *grabens.* Their size can also be impressive, though they're generally not as big as fold mountains because the process which generates them takes place on a smaller scale and involves less pressure. Still, the Sierra Nevada mountains (an example of block mountains), feature a block 650 km long and 80 km wide. Another good example is the Rhine Valley and the Vosges mountain in Europe. Rift valleys can also generate block mountains, as is the case in the Eastern African Rift.

Valcanoic mountains

Everyone knows something about volcanoes, though we rarely think about them as mountains (and truth be told, they aren't always mountains).

Volcanic mountains are created when magma deep beneath the surface starts to rise up. At one point, it erupts in the form of lava and then cools down, solidifying and piling on to create a mountain. Mount Fuji in Japan and Mount Rainier are classic examples of volcanic mountains — with Mount Rainier being one of the most dangerous volcanoes in the world. However, it's not necessary for the volcano to be active to be a volcanic mountain. Several types of volcanoes can generate mountains, with Stratovolcanoes typically creating the biggest ones. Despite the fact that Mount Everest is the tallest mountain above sea level, Mauna Kea is actually much taller than Everest at a total height over 10,000 meters. However, much of it is submerged, with only 4,205 meters rising above sea level.

Dome mountains

Dome mountains are also the result of magmatic activity, though they are not volcanic in nature. Sometimes, a lot of magma can accumulate beneath the ground and start to swell the surface. Occasionaly, this magma won't reach the surface but will still form a dome. As that magma cools down and solidifies, it is often tougher than other surrounding rocks and will eventually be exposed after millions of years of erosion. The mountain is this dome — a former accumulation of magma which cooled down and was exposed by erosion. Round Mountain is a relatively recently formed dome mountain. It represents a volcanic feature of the Canadian Northern Cordilleran Volcanic Province that formed in the past 1.6 million years. Black Dome Mountain is another popular example, which is also located in Canada.

Other types of mountains
As we mentioned above, there's no strict definition of mountain classifications, so other types are sometimes mentioned.

Plateau mountains
Plateau mountains aren't formed by something going up — they're formed by something going down. For instance, imagine a plateau that has a river on it. Year after year, that river carves out a part of the plateau, bit by bit. After some time, there might only be a small part of the original plateau left un-eroded, which basically becomes a mountain. This generally takes a very long time even by geological standards, taking up to billions of years. Some geologists group these mountains with dome mountains into a broader category called erosional mountains.

Uplifted passive margins
There's no geological model to fully explain how uplifted passive margins formed, but we do see them in the world. The Scandinavian Mountains, Eastern Greenland, the Brazilian Highlands or Australia's Great Dividing Range are such examples, owing their existence to some uplifting mechanism.

Hotspot mountains.

Although once thought to be identical to volcanic mountains, new research has shed some light on this belief. Hotspots are volcanic regions thought to be fed by a part of the underlying mantle which is significantly hotter than its surroundings. However, even though that hot area is fixed, the plates move around it — causing it to leave a hotspot trail of mountains.

<u>Mountain: The Origins of Mountains</u>

Mountains and mountain ranges have varied origins. Some are the erosional remnants of plateaus; others are cones built up by volcanoes, such as Mt. Rainier in Washington, or domes pushed up by intrusive igneous rock (see rock), such as the Black Hills of South Dakota and the Henry Mts., Utah. Fault-block mountains (see fault) are formed by the raising of huge blocks of the earth's surface relative to the neighboring blocks. The Basin and Range region of Nevada, Arizona, New Mexico, and Utah is one of the most extensive regions of fault-block mountains.

All the great mountain chains of the earth are either fold mountains or complex structures in whose formation folding, faulting, or igneous activity have taken part. The growth of folded or complex mountain ranges is preceded by the accumulation of vast thicknesses of marine sediments. It was first suggested in the late 1800s that these sediments accumulated in elongated troughs, or geosynclines, that were occupied by arms of the sea. While some of the sediment was derived from the interior of the continent, great quantities of sediment were apparently derived from regions now offshore from the continent. For examples, sedimentary rocks of the Appalachian Mts. formed in a vast geosyncline that extended from the Gulf states northeastward through the eastern states and New England, and into E Canada. It is now recognized that great thicknesses of sediment can occur wherever there is subsidence (lowering of the earth's crust).

The best modern analogues of geosynclines appear to be the thick deposits of sediment making up the continental shelves and continental rises (see ocean). Most geologists now believe that the geosynclinal sediments found in mountain ranges were initially deposited under similar conditions. The period of sedimentation is followed by folding and thrust faulting, with most high mountain ranges uplifted vertically subsequent to folding. The movements of the earth's surface that result in the building of mountains are compression, which produces folding, thrust faulting, and possibly some normal faulting; tension, which produces most normal faulting; and vertical uplift. Mountains are subject to continuous erosion during and after uplift. Sharp peaks are formed and are subsequently attacked and leveled. Mountains may be entirely base-leveled, or they may be rejuvenated by new uplifts.

The ultimate cause of mountain-building forces has been a source of controversy, and many hypotheses have been suggested. An old hypothesis held that earth movements were adjustments of the crust of the earth to a shrinking interior that contracted and set up stresses due either to heat loss or gravitational compaction. Another hypothesis suggested that earth movements were primarily isostatic, i.e., adjustments that kept the weights of sections of the crust nearly equal (see continent). A third hypothesis, popular from the early 1960s to today, ascribed mountain-building stresses to convection currents in a hot semiplastic region in the earth's mantle.

According to the plate tectonics theory, the lithosphere is broken into several plates, each consisting of oceanic crust, continental crust, or a combination of both. These plates are in constant motion, sideswiping one another or colliding, and continually changing in size and shape. Where two plates collide, compressional stresses are generated along the margin of the plate containing a continent. Such stresses result in the deformation and uplift of the continental shelf and continental rise sediments into complex folded and faulted mountain chains (see seafloor spreading; continental drift).

Distribution of mountain in India.

India has some of the highest mountain ranges and mountain roads in the world. India is home to seven major mountain ranges that have peaks of over 1000 metres.The most famous and the highest mountain range of India is the Himalayan range. It is also the youngest and the longest mountain range in India and has almost every largest peak of the world. The Himalayan mountain range bisects India from the rest of Asia and is the primary source of mighty rivers in India. The highest mountain range of India, Himalaya literally translates to "abode of snow" from Sanskrit.The Himalayan Mountain is the youngest range of India and is a new fold mountain formed by the collision of two tectonic plates.

The Himalayan Mountain Range has almost every highest peak of the world and on an average they have more than 100 peaks with height more than 7200m.

Nanga Parbat and Namcha Barwa is considered as the western and eastern point of the Himalayas.Mount Everest is the highest peak of the world at 8848m. It lies in the Himalayan Range in Nepal.Himalayas is also the source of many great river ranges, including the Ganges, Brahmaputra and Indus.

Himalayas also play a vital role in regulating the climate in northern India by preventing cold air from entering Indian mainland in winter season.

Karakoram Range and Pir Panjal Ranges

Karakoram Range and Pir Panjal Range lies to the North-west and south of the Himalayan Range.A major part of the Karakoram Range lies under the disputed category of Indian and Pakistan and both countries have declared a claim over it. Karakoram Range, with a length of 500km holds many largest peaks of Earth. K2, the second highest peak of the world, at 8,611m lies in the Karakoram Range.Hindu-Kush, an extension of the Karakoram Range runs in

Afghanistan.Karakoram has the most glaciers excluding Polar Regions. The Siachen Glacier and The Biafo Glacier, which are world's 2nd and 3rd largest glaciers, are located in this range.The Pir Panjal Range is located in southern direction of Himalayas starting from Himachal Pradesh in India and running north-west towards Jammu & Kashmir and disputed area of Jammu & Kashmir.This range is also known as Lower Himalayas. Rivers like Ravi, Chenab and Jhelum flow through this range. The city of Gulmarg, a very important hill station, lies here.

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Eastern mountain range (or) Puurvanchal Range.

The Purvanchal Range can be considered as the extension of Himalayas in the eastern part of India as the process of formation of this range is quite similar to that of Himalayas, although the range is not as high as the Himalayas.The Purvanchal Range or the Eastern Mountain Range comprises three parts: The Patkai-Bum Hill, The Garo-Khasi-Jaintia Hills and Lushai Hill (Mizo Hill).Mawsynram, in Meghalaya is the wettest place on Earth because of these hills and it lies in the Khasi Hill.This range covers all the eastern states of India, which are commonly known as the Seven Sisters.

The Saptpura and Vindhaya

The Satpura and Vindhaya Range lies in central India and both these ranges run parallel to each other.Out of these two, Satpura range is higher in length and is the source of rivers like Narmada and Tapti.Both Satpura and Vindhaya are mainly situated in Madhya Pradesh and Maharashtra with some extension to Gujarat, Chattisgarh and Uttar Pradesh.Kalumar Peak (752m) and Duphgarh Peak (1350m) are the highest point in Vindhaya and Satpura range.These ranges are famous for a large no of tourist spot like Panchmarhi Hill Station, Kanha National Park, Amarkantak and Omkareshwar temple.

The Aravalli Ranges

The oldest mountain range of India, The Aravalli Range is also the oldest mountain range in the world. Width of range varies from 10km to 100km.In local language, Aravalli translates to 'line of peaks', and spans a total length of 800 km, covering the Indian states of Delhi, Haryana, Rajasthan and Gujrat.Aravalli Range plays a very important role in Indian climate as it block wind carrying rain to reach Thar Desert.

Guru Shikhar is highest point of Aravalli Range with total elevation of 1722m.This range is famous for many tourist attractions and Mount Abu the only hill station in Rajasthan is situated on this range.City of Udaipur also lies on its southern slope. City of Udaipur, which is also known as Venice of the East, lies in the southern slopes of Aravalli Mountains.Banas, Luni, and Sabarmati are the rivers that flow through this range.

The Western Ghats

Western Ghats is 1600m long mountain range that runs from Gujrat to Kanyakumari in south India.This mountain range is also called "Sahyadri Mountains".It comprises the mountain range of Nilgiris, Anaimalai and Cardomom.Tapti River marks its beginning in Gujarat and then it runs parallel to Arabian Sea crossing states of Maharashtra, Goa, Karnataka and Tamil Nadu.Anaimalai Hills with elevation of 2695 m in Kerala is highest peak of this range.Western Ghats is one of the UNESCO World Heritage Sites and has great bio-diversity.It is home for some 139 mammal species, 508 bird species, 179 amphibian species and 250 reptile species.Famous tourist attractions include Jog falls, Ooty, Bandipur National Park.Godavari, Krishna and Kaveri are the important rivers in this range.

The Eastern Ghats

Eastern Ghats is mountain range running in eastern part of Indian Peninsula parallel to Bay of Bengal.This range is not continuous and is lower in elevation when compared to Western Ghats. The range runs through Indian states of West Bengal, Orissa, Andhra Pradesh and Tamil Nadu.Arma Konda with elevation of 1680m is highest peak of this region.Eastern Ghats have a significant role in Indian agriculture as four major rivers of India i.e. Godavari, Mahanadi, Krishna and Kaveri fall into Bay of Bengal through Eastern Ghats. They create a large fertile region which is suitable for crops like rice.Ghats are older than Western Ghats and they have some very important pilgrim sites like Tirumala Venkateshwara Temple in Andhra Pradesh.

Vishakhapatnam and Bhubaneswar are important cities located in Eastern Ghats.

Isostasy

Concept of Isostasy, ideal theoretical balance of all large portions of Earth’s lithosphere as though they were floating on the denser underlying layer, the asthenosphere, a section of the upper mantle composed of weak, plastic rock that is about 110 km (70 miles) below the surface. Isostasy controls the regional elevations of continents and ocean floors in accordance with the densities of their underlying rocks. Imaginary columns of equal cross-sectional area that rise from the asthenosphere to the surface are assumed to have equal weights everywhere on Earth, even though their constituents and the elevations of their upper surfaces are significantly different. This means that an excess of mass seen as material above sea level, as in a mountain system, is due to a deficit of mass, or low-density roots, below sea level. Therefore, high mountains have low-density roots that extend deep into the underlying mantle. The concept of isostasy played an important role in the development of the theory of plate tectonics.

In 1735, expeditions over the Andes led by Pierre Bouguer, a French photometrist and the first to measure the horizontal gravitational pull of mountains, noted that the Andes could not represent a protuberance of rock sitting on a solid platform. If it did, then a plumb-line should be deflected from the true vertical by an amount proportional to the gravitational attraction of the mountain range. The deflection was less than that which was anticipated. About a century later, similar discrepancies were observed by Sir George Everest, surveyor general of India, in surveys south of the Himalayas, indicating a lack of compensating mass beneath the visible mountain ranges.

In the theory of isostasy, a mass above sea level is supported below sea level, and there is thus a certain depth at which the total weight per unit area is equal all around the Earth; this is known as the depth of compensation. The depth of compensation was taken to be 113 km (70 miles) according to the Hayford-Bowie concept, named for American geodesists John Fillmore Hayford and William Bowie. Owing to changing tectonic environments, however, perfect isostasy is approached but rarely attained, and some regions, such as oceanic trenches and high plateaus, are not isostatically compensated.

Model of isostasy.

Airy's model

The Airy hypothesis says that Earth's crust is a more rigid shell floating on a more liquid substratum of greater density. Sir George Biddell Airy, an English mathematician and astronomer, assumed that the crust has a uniform density throughout. The thickness of the crustal layer is not uniform, however, and so this theory supposes that the thicker parts of the crust sink deeper into the substratum, while the thinner parts are buoyed up by it. According to this hypothesis, mountains have roots below the surface that are much larger than their surface expression. This is analogous to an iceberg floating on water, in which the greater part of the iceberg is underwater.

Pratt's model

The Pratt hypothesis, developed by John Henry Pratt, English mathematician and Anglican missionary, supposes that Earth's crust has a uniform thickness below sea level with its base everywhere supporting an equal weight per unit area at a depth of compensation. In essence, this says that areas of the Earth of lesser density, such as mountain ranges, project higher above sea level than do those of greater density. The explanation for this was that the mountains resulted from the upward expansion of locally heated crustal material, which had a larger volume but a lower density after it had cooled.

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