Continental crust

Blocks of wood with different densities displaced different amounts of water, and thus floated at various heights above the surface of the water. Blocks of higher density displaced more water than blocks of lower density. Oceanic crust is composed mainly of basalt, which has an average density of about 2.9 g/cm^3. Continental crust is composed of more granitic rock, which has an average density of about 2.8 g/cm^3. The slightly higher density of oceanic crust causes it to displace more of the mantle — which has a density of about 3.3 g/cm^3 — than the same thickness of continental crust.

Differences in elevation, however, are not caused by density differences alone. Thicker wood block was placed in the water, it displaced more water than the other thinner blocks, however, because of its density, it floated higher in the water than the denser block. Continental crust, which is thicker and less dense than oceanic crust, behaves similarly. It extends deeper into the mantle because of its thickness, and it rises higher above Earth's surface than oceanic crust because of its lower density,

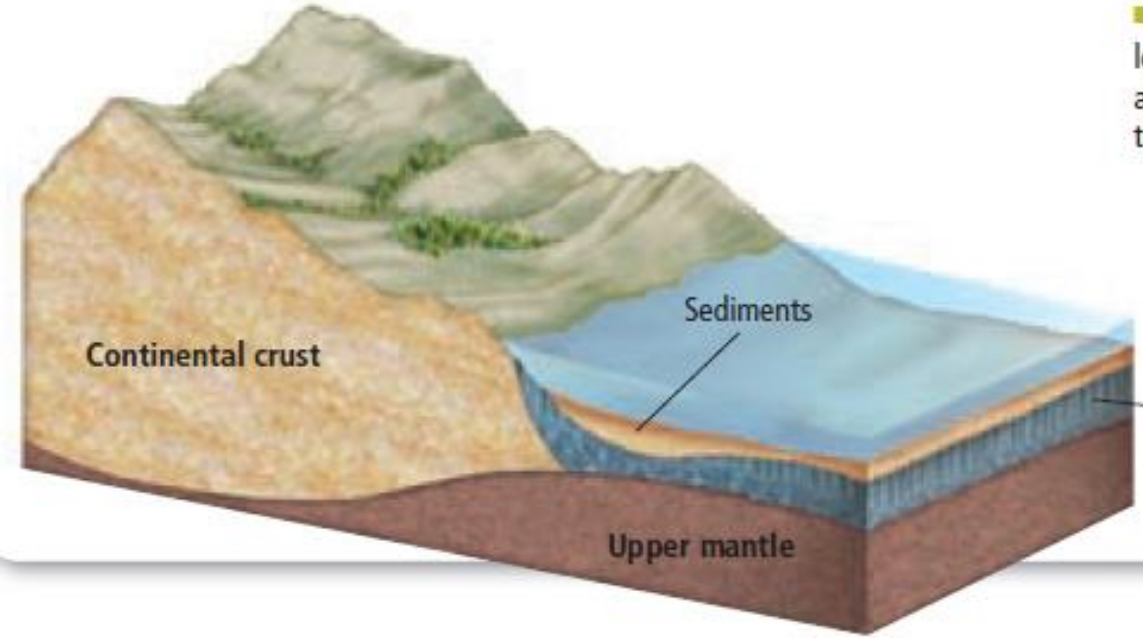
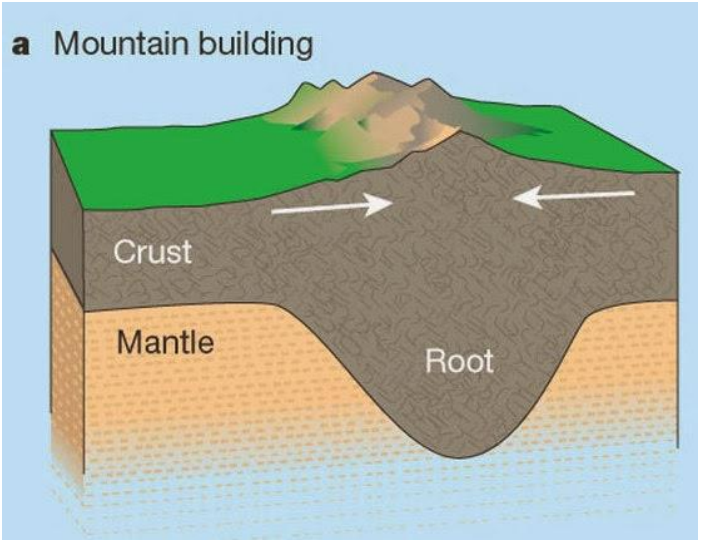


Figure 20.3 Continental crust is thicker and less dense than oceanic crust, so it extends higher above Earth's surface and deeper into the mantle than oceanic crust.

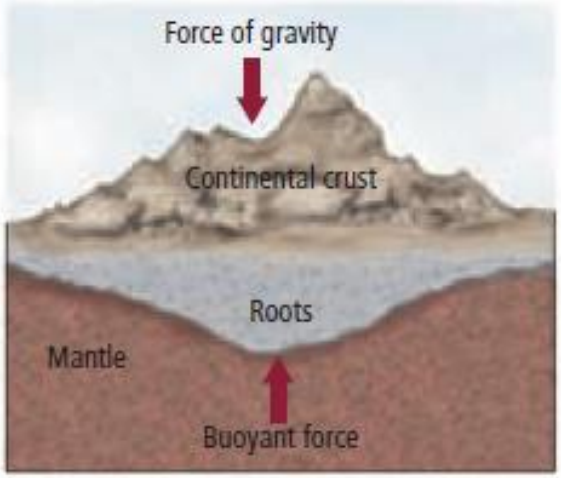
Isostasy

The displacement of the mantle by Earth's continental and oceanic crust is a condition of equilibrium called **isostasy.** The crust and mantle are in equilibrium when the downward force of gravity on the mass of crust is balanced by the upward force of buoyancy that results from displacement of
the mantle by the crust. This balance might be familiar to you if you have ever watched people get in and out of a small boat. As the people boarded the boat, it sank deeper into the water. Conversely, as the people got out of the boat, it displaced less water and floated higher in the water. A similar sinking and rising that results from the addition and removal of mass occurs within Earth's crust. Gravitational and seismic studies have detected thickened areas of continental material, called **roots, that extend** into the mantle below Earth's mountain ranges

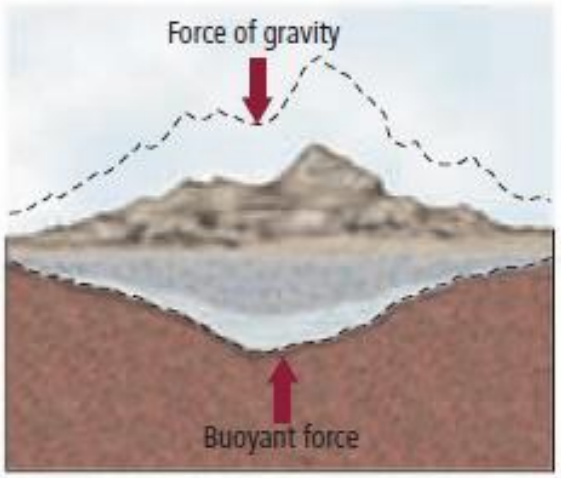


Mountain Roots

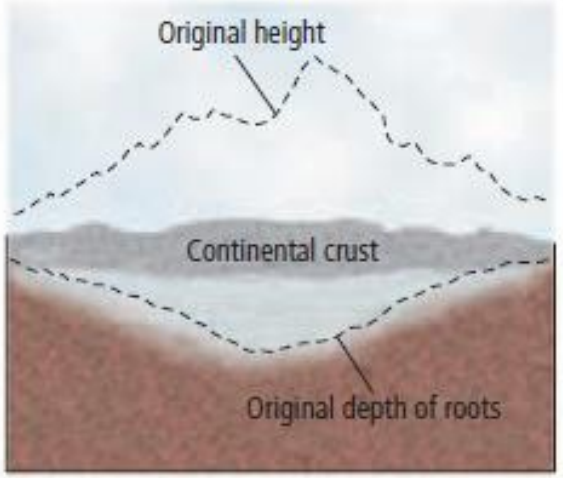
A mountain range requires large roots to counter the enormous mass of the range above Earth's surface. **According to the principle of isostasy,** parts of the crust rise or subside until these parts are buoyantly supported by their roots. Continents and mountains are said to float on the mantle because they are less dense than the underlying mantle. They project into the mantle to provide the necessary buoyant support. What do you think happens when mass is removed from a mountain or mountain range? If erosion continues, the mountain will eventually disappear, exposing the roots.



Massive roots underlie mountains.



As erosion takes place, the mountain loses mass. The root rises in response to this decrease in mass.



When the mountain erodes to the average continental thickness, both root and mountain are gone.

Isostasy and Erosion

The Appalachian Mountains, in the eastern United States formed hundreds of millions of years ago when the North American continent collided with Gondwana. Rates of erosion on land are such that these mountains should have been completely eroded millions of years ago. Why, then, do these mountains still exist? As the mountains rose above Earth's surface, deep roots formed until isostatic equilibrium was achieved and the mountains were buoyantly supported. As peaks eroded, the mass decreased. This allowed the roots themselves to rise and erode**.** A balance between erosion and the decrease in the size of the root will continue for hundreds of millions of years until the mountains disappear and the roots are exposed at the surface. This slow process of the crust's rising as the result of the removal of overlying material is called **isostatic rebound. Erosion and** rebound allows metamorphic rocks formed at great depths to rise to the top of mountain ranges such as the Appalachians.

Seamounts

Crustal movements resulting from isostasy are not restricted to Earth's continents. When these mountains are underwater, they are called seamounts. On the geologic time scale, these mountains form very quickly. What do you think happens to the seafloor after these seamounts form? The seamounts are added mass. As a result of isostasy, the oceanic crust around these peaks displaces the underlying mantle until equilibrium is achieved.

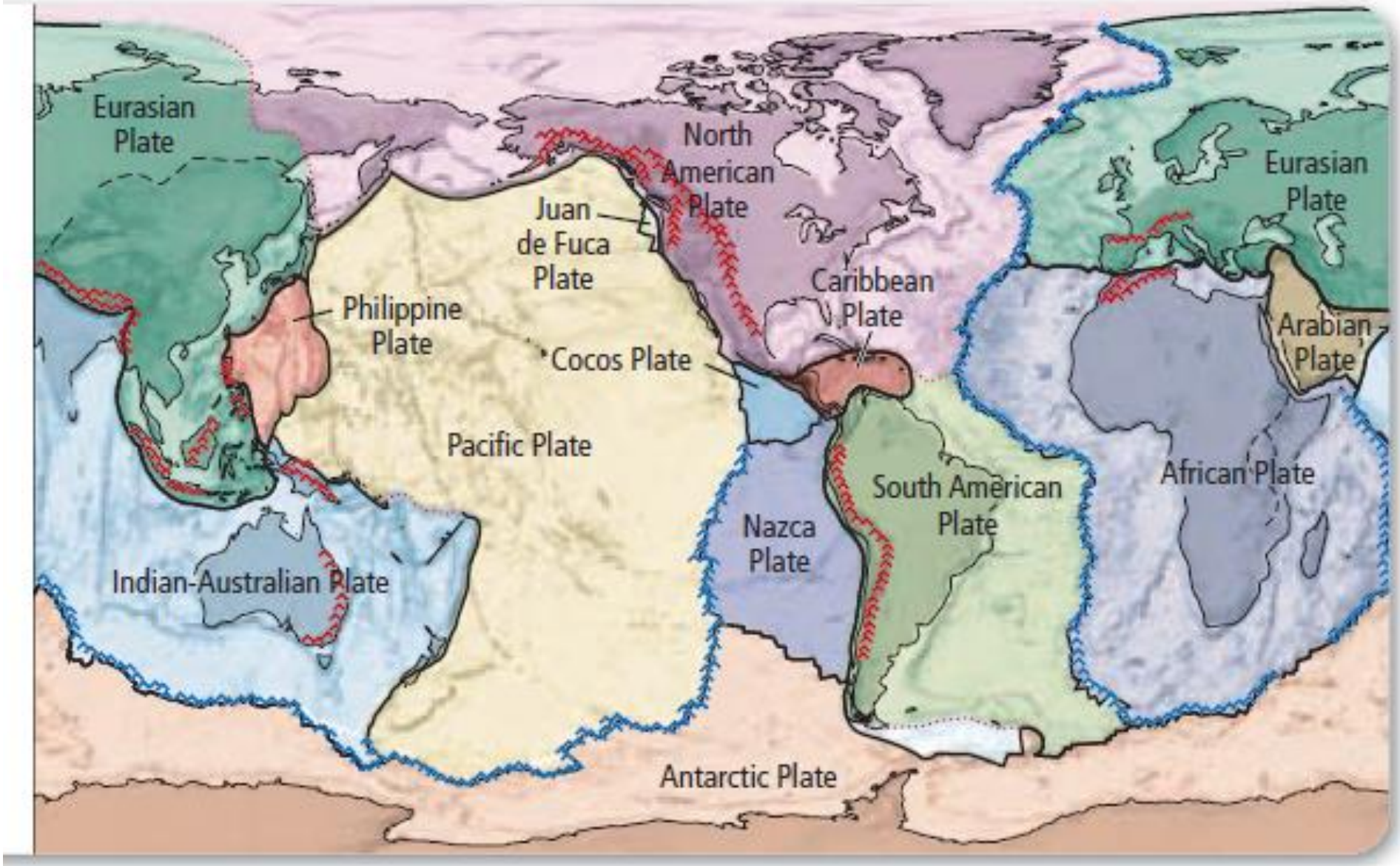
Mountain roots can be many times as deep as a mountain is high. Mount Everest, **towers nearly 9 km above sea** level and is the tallest peak in the Himalayas. Some parts of the Himalayas are underlain by roots that are nearly 70 km thick. As India continues to push northward into Asia, the Himalayas, including Mount Everest, continue to grow in height.

Mountain Building at Convergent Boundaries

What is Orogeny?

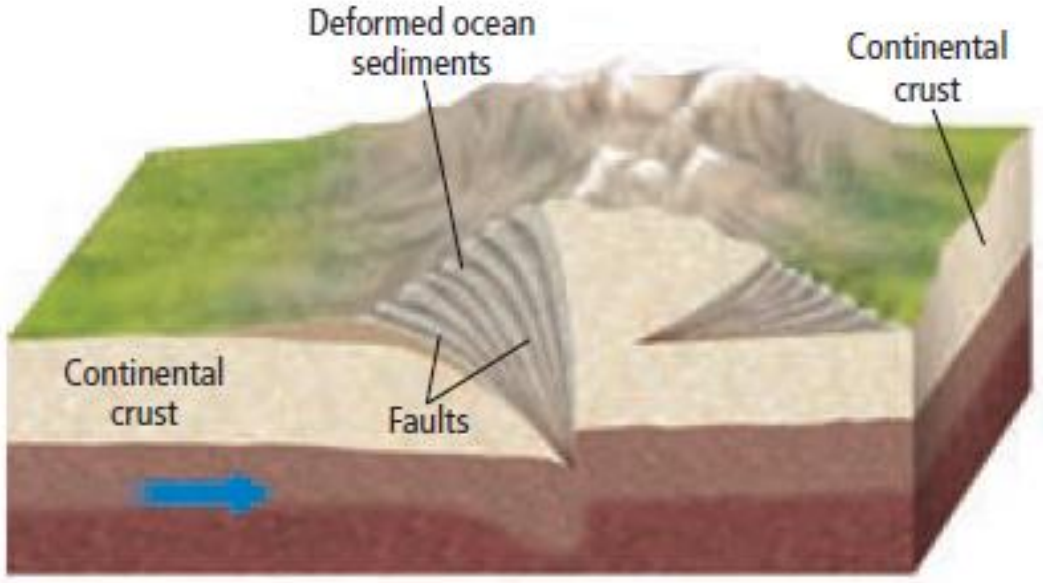
Orogeny refers to all processes that form mountain ranges.

Most orogenic belts are associated with convergent plate boundaries. Here, compressive forces squeeze the crust and cause intense deformation in the form of folding and faulting. In general, the tallest and most varied orogenic belts form at convergent boundaries.


Eurasian Plate
North American Plate
Juan de Fuca Plate
Philippine Plate
Caribbean Plate
Eurasian Plate
Arabian Plate
Cocos Plate
Pacific Plate
African Plate
South American Plate
Nazca Plate
Indian-Australian Plate
Antarctic Plate

Continental Convergent Boundary

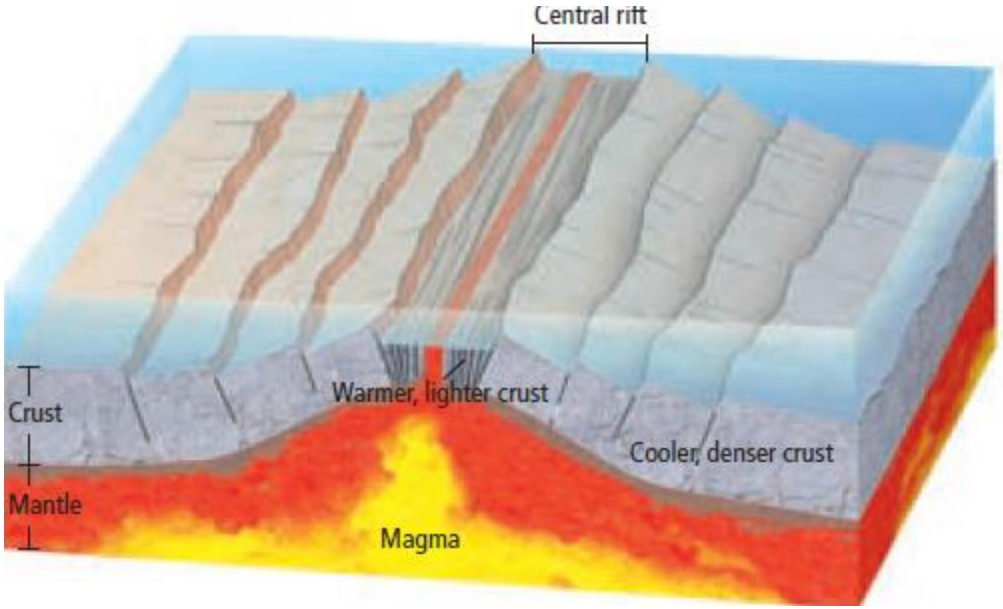
Earth's tallest mountain ranges, including the Himalayas, are formed at continental-continental plate boundaries. Because of its relatively low density, continental crust cannot be subducted into the mantle when two continental plates converge. Instead, the low-density continental crust becomes highly folded, faulted, and thickened. Compressional forces break the crust into thick slabs that are thrust onto each other along low-angle faults. This process can double the thickness of the deformed crust. Deformation can also extend laterally for hundreds of kilometers into the continents involved. For example, studies of rocks in southern Tibet suggest that the original edge of Asia has been pushed approximately 2000 km eastward since the collision of Indian and Eurasian plates. The magma that forms as a result of continental-continental mountain building solidifies beneath Earth's surface to form granite batholiths.



Divergent-Boundary Mountains

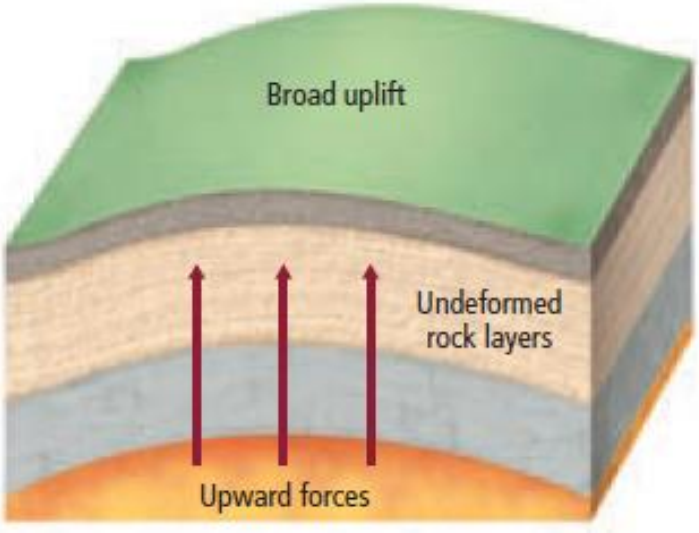
When ocean ridges were first discovered, people in the scientific community were stunned simply because of their length. These under water volcanic mountains form a continuous chain that snakes along Earth's ocean floor for over 65,000 km. In addition to their being much longer than most of their continental counterparts, these mountains formed as a result of different orogenic processes.Ocean ridges are regions of broad uplift that form when new oceanic crust is created by seafloor spreading. The newly formed crust and underlying mantle at the ocean ridge are hot. When rocks are heated, they expand,

which results in a decrease in density. This decrease allows the ridge to bulge upward**.** As the oceanic plates move away from the ridge, the newly formed crust and mantle cool and contract, and the surface of the crust subsides. As a result, the crust stands highest where the ocean crust is youngest, and the underwater mountain chains have gently sloping sides.



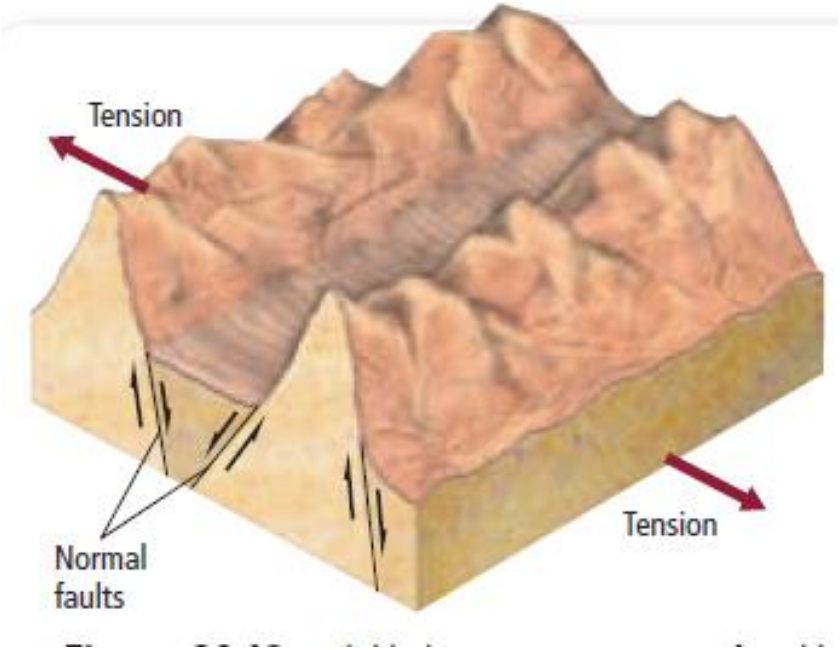
Uplifted Mountains

Some mountains form when large regions of Earth have been slowly forced upward as a unit. These mountains are called **uplifted mountains. The Adirondack** Mountains in New York State, shown in **are uplifted** mountains. Generally, the rocks that make up uplifted mountains undergo less deformation than rocks associated with plate-boundary orogeny, which, as you have just read, are highly folded and faulted. The cause of large-scale regional uplift is not well understood. One popular hypothesis is that the part of the lithosphere made of mantle rocks becomes cold and dense enough that it sinks into the underlying mantle. The mantle lithosphere is replaced by hotter and less dense mantle. The lower density of the new mantle provides buoyancy which vertically lifts the overlying crust. This process has been used to explain the uplift of the Sierra Nevadas, in California.**When a whole region is uplifted, a** relatively flat-topped area called a **plateau can form, like the Colorado** Plateau, which extends through Colorado, Utah, Arizona, and New Mexico. Erosion eventually carves these relatively undeformed, uplifted masses to form peaks, valleys, and canyons.



Fault-Block Mountains

Another type of mountain that is not necessarily associated with plate boundaries is a fault-block mountain. Movement at faults lifts land on one side of a fault and drops it on the other. Between large faults when pieces of crust are tilted, uplifted, or dropped downward. The Basin and Range Province of the southwestern United States and northern Mexico **consists of hundreds of nearly parallel mountains separated** by normal faults. The Grand Tetons in Wyoming are also faultblock mountains.



Fault-block mountains are areas of Earth's crust that are higher than the surrounding landscape as the result of faulting. The Basin and Range Province consists of hundreds of mountains separated by normal faults.

Some Basic terms

• **Mountain Ridge** :-It is a system of long narrow and high hills. Generally the slope of one side of a ridge is steep, while the other side is of moderate slope.

•**Mountain Range**:- It is a system of mountains and hills, having several ridges, peaks summits and valleys. A mountain range stretches in a linear manner.

•**Mountain chain**:- Consists of several parallel long and narrow mountains of different periods. Sometimes the mountain ranges are separated by flat upland or plateau.

•**Mountain System**:- Consists of different mountain ranges of the same period.

•**Mountain group**:- Consists of several unsystematic pattern of different mountain systems.

•**Cordillera-** Consists of several mountain groups and systems. In fact cordillera is a community of mountains having different ridges ranges mountain chains and mountain systems.

Classification of Mountains

On the Basis of Height:

(i) Low mountains; height ranges between 700 to 1,000 m.
(ii) Rough mountains; height-1000 m to 1,500 m
(iii) Rugged mountains; height-1,500 to 2,000 m.
(iv) High mountains; height above 2,000 m.

On the Basis of Location:
(i) Continental mountains:
(a) Coastal mountains, examples:
Applachians, Rockies, Alpine mountain chains, Western and Eastern Ghats of India etc.

(b) Inland mountains:
examples, Ural mountains (Russia), Vosges and Black Forest block mountains (Europe), Himalayas, Aravallis, Satpura, Maikal, Kaimurs etc. (India), Kunlun, Tienshan, Altai etc. (Asia) etc.

(ii) Oceanic mountains:

Most of the oceanic mountains are below the water surface (below sea level). Oceanic mountains are located on continental shelves and ocean floors. Some oceanic mountains are also well above sea level. If the height of the mountains is considered from the oceanic floor and not from the sea level, many of the oceanic mountains will become much higher than the Mount Everest.

For example, Mauna Kea volcanic mountain of Hawaii Island is 4200 m high from the sea level but if its height is considered from the sea bottom, its height becomes 9140 m which is higher than the highest mountain, Mount Everest.. Most of the oceanic mountains are volcanic mountains.

On the Basis of Mode of Origin:

(1) Original or tectonic mountains are caused due to tectonic forces e.g. compressive and tensile forces motored by endogenetic forces coming from deep within the earth. These mountains are further divided into 4 types on the basis of orogenetic forces responsible for the origin of a particular type of mountain.

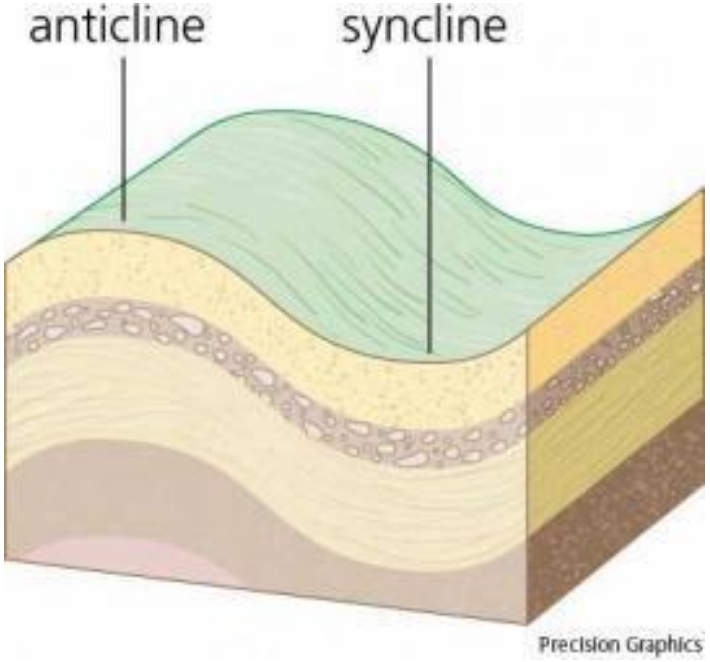
(i) Folded mountains are further divided into 3 sub-types on the basis of their area.

These are originated by compressive forces:

(A) Young folded mountains.

(B) Mature folded mountains.

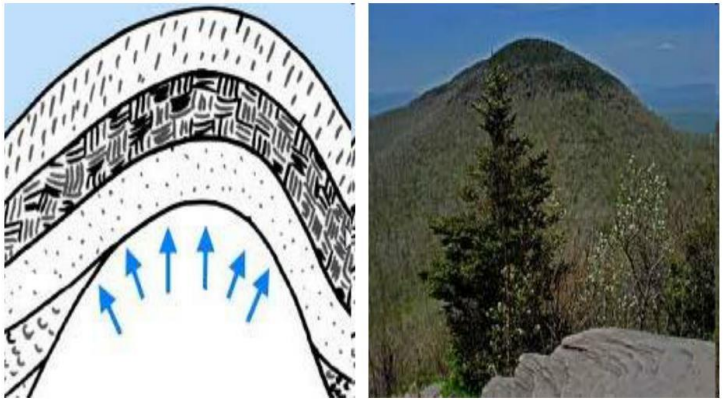
(C) Old folded mountains.



(ii) Block mountains are originated by tensile forces leading to the formation of rift valleys. They are also called as horst mountains.

(iii) Dome mountains are originated by magmatic intrusions and up-warping of the crustal surface. Examples, normal domes, lava domes, batholithic domes, laccolithic domes, salt domes etc.

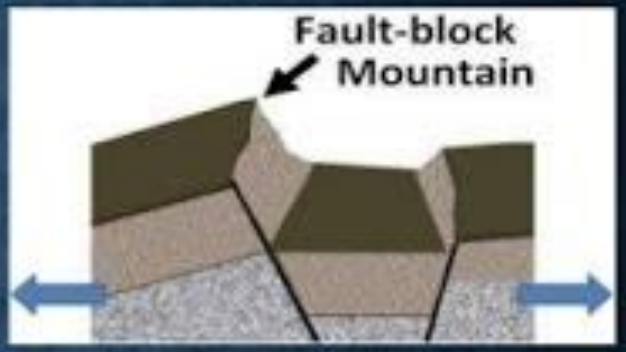
Dome Mountains



(iv) Mountains of accumulations are formed due to accumulation of volcanic materials. Thus, these are also called as volcanic mountains. Different types of volcanic cones (e.g., cinder cones, composite cones, acid lava cones, basic lava cones etc.) come under this category.

TYPES OF MOUNTAINS

Volcanic



Fault-block

Fold

Dome

(2) Circum-erosional or relict mountains: examples, Vindhyachal ranges, Aravallis, Satpura, Eastern Ghats, Western Ghats etc. (all from India).

Relict Mountains

Due to the different wreathing process of prolonged duration the rocks that are not very assistant get disintegrated and only those resistant parts remain. These mountains are called residual mountains.

Aravalli Range

On the Basis of Period of Origin:

(1) Pre-cambrian Mountains:

Examples, Laurentian mountains, Algoman mountains,. Kilarnean mountains etc. (North America), mountains of Feno- Scandia, North-West Highlands and Anglesey etc. (Europe).

(2) Caledonian Mountains:

Mountains formed during Silurian and Devonian periods, examples: Taconic mountains of the Applachian system, mountains of Scotland, Ireland and Scandinavia (Europe), Brazilides of South America, Aravallis, Mahadeo, Satpura etc. of India.

(3) Hercynian Mountains:

Hercynian mountains formed during Permian and Permocarboniferous periods (The **Permo-Carboniferous** refers to the time **period** including the latter parts of the Carboniferous and early part of the **Permian period**), examples: mountains of Ireland, Spanish Messeta, Brittany of France, South Wales, Cornwall, Mendips, Paris basin, Belgian coalfields, Rhine Mass, Bohemian plateau, mountains of Puna area of Atacama, Gondwanides of Argentina etc.

(4) Alpine mountains:

mountains formed during Tertiary period, examples, Rockies (North America), Andes (South America), Alpine mountain systems of Europe (main Alps, Carpathians, Pyrenees, Balkans, Caucasus, Cantabrians, Appenines, Dinaric Alps etc.), Atlas mountains of north-west Africa; Himalayas and mountains coming out of Pamir Knot of Asia (Taurus, Pauntic, Zagros, Elburg, Kunlum etc.).