Descobrir a Crusta terrestre

MAIN MENU

- Crustal Types
- Heat Flow
- Exhumation and Cratonization
- Rheology of the Continental Crust
- Measured Seismic Wave Velocities in Rocks
- Sampling of the Lower Continental Crust
- Chemical Composition of the Crust
- Terranes and Crustal Provinces
- Review

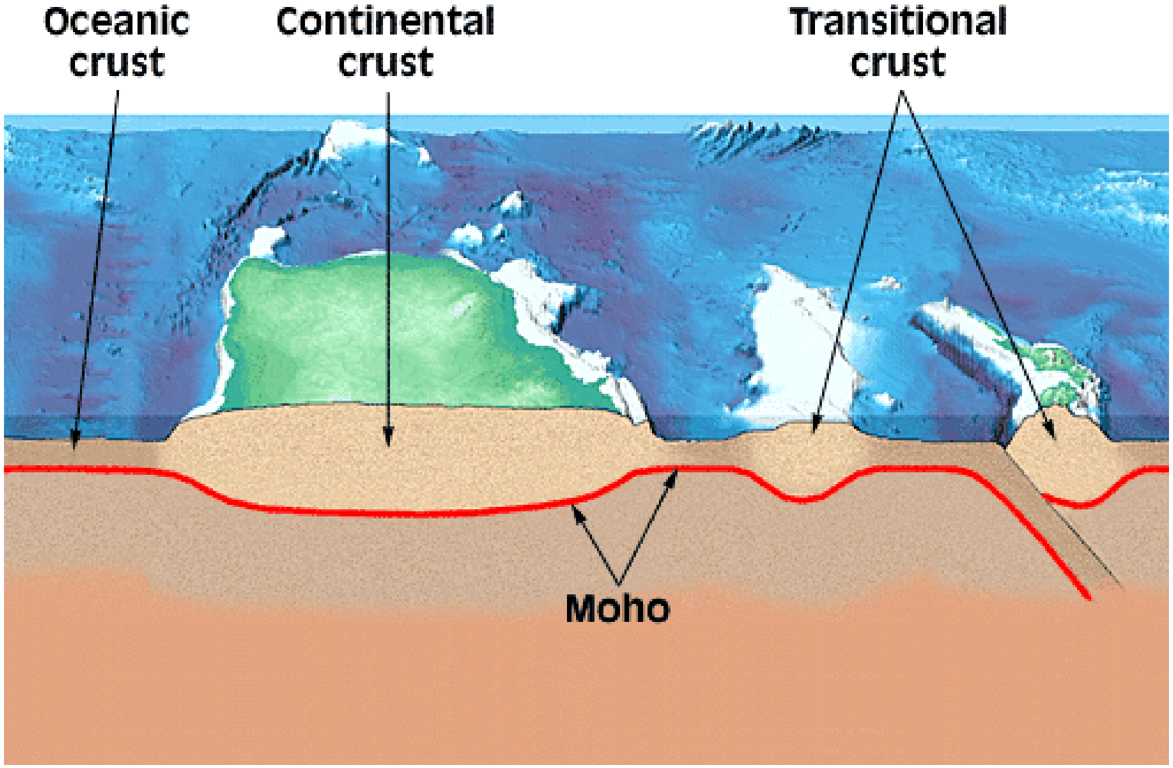
- Plate Tectonics
- The Earth's Crust
- Tectonic Settings
- The Earth's Mantle and Core
- Glossary

Tectónica de Placas

Crusta terrestre

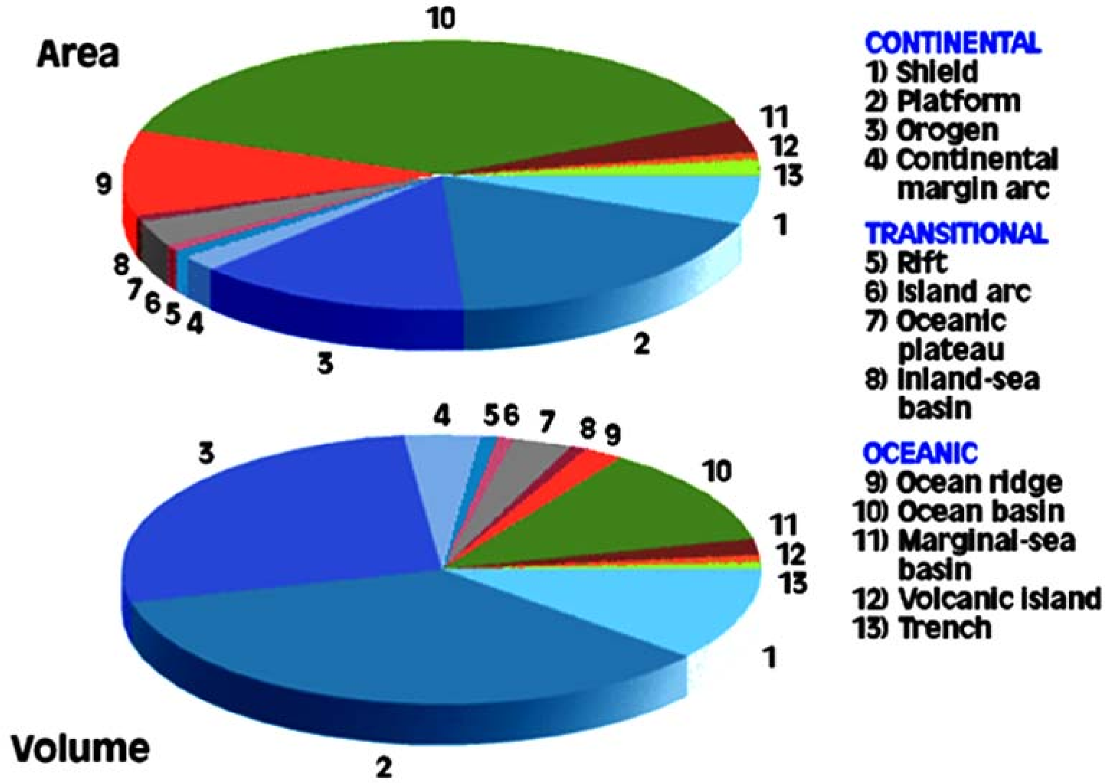
Ambientes Tectónicos

PRINCIPAIS TIPOS DE CROSTA



The Earth's crust is the upper rigid part of the lithosphere, the base of which is defined by a prominent seismic discontinuity, the Mohorovicic discontinuity or Moho. There are three crustal divisions: oceanic, transitional, and continental. (Click on the label **Moho**, above, to locate the Mohorovicic discontinuity position, within the lithosphere).

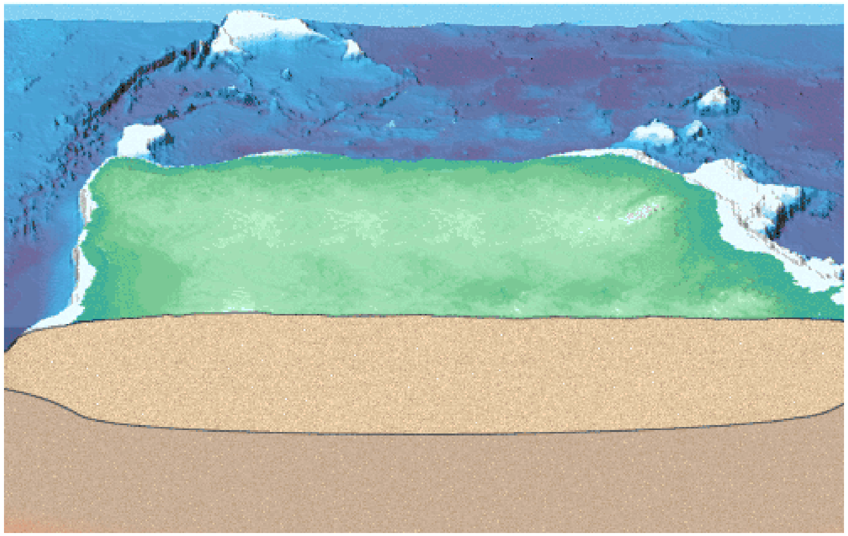
PRINCIPAIS TIPOS E SUB-TIPOS DE CROSTA



The crust can be further subdivided into crustal types, which are segments of the crust exhibiting similar geological and geophysical characteristics. There are 13 major crustal types, shown here in relative proportion by area and by volume of the total Earth's crust.

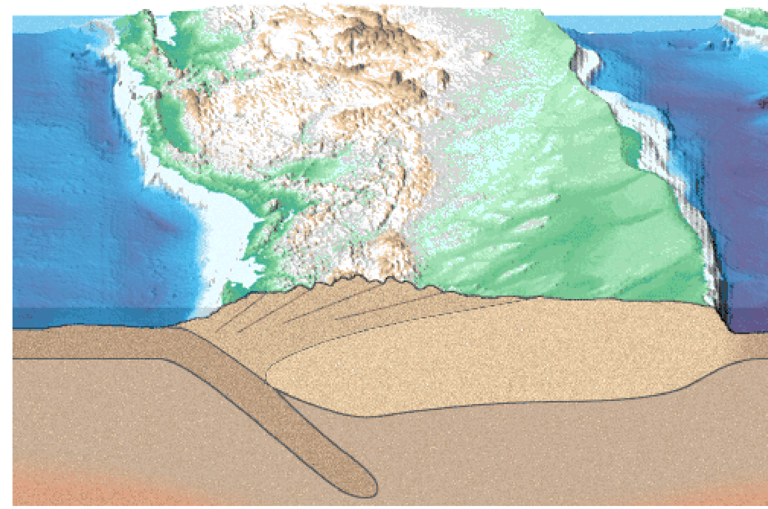
Escudos e Plataformas

Shield and Platform



Orógeno de colisão

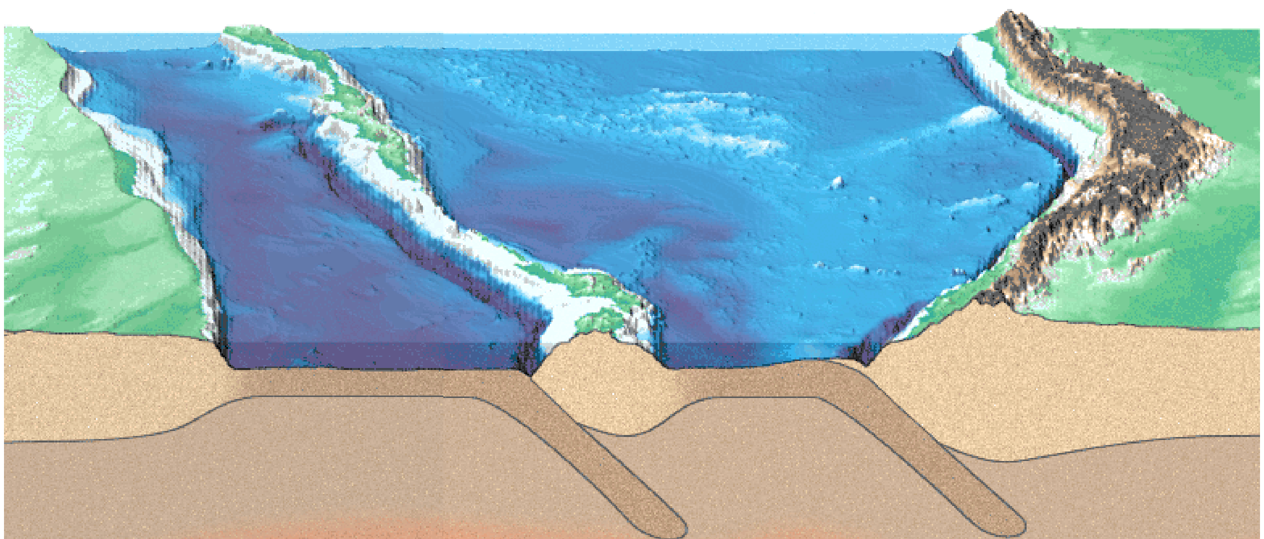
Collisional Orogen



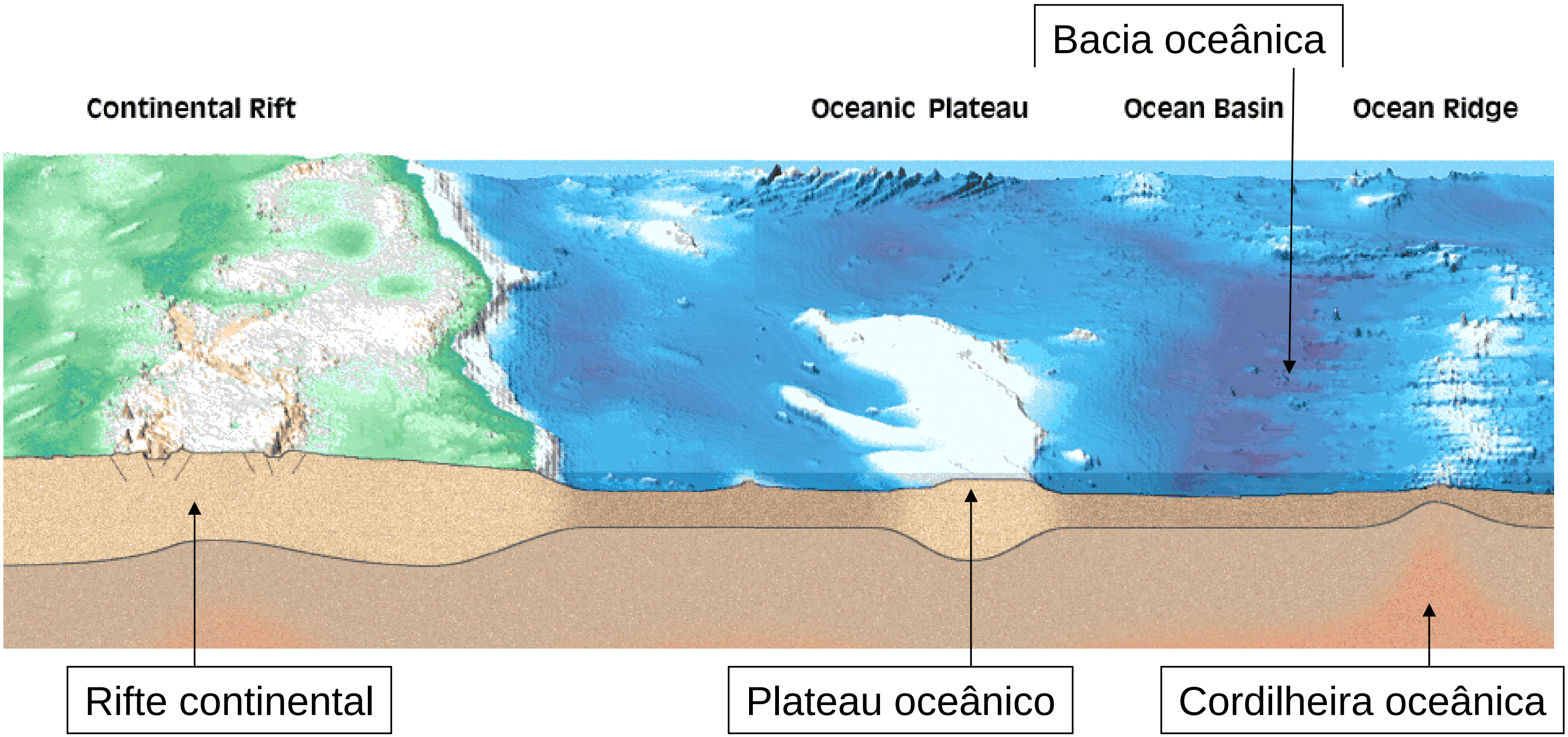
Arco vulcânico insular

Island Arc

Continental Margin Arc

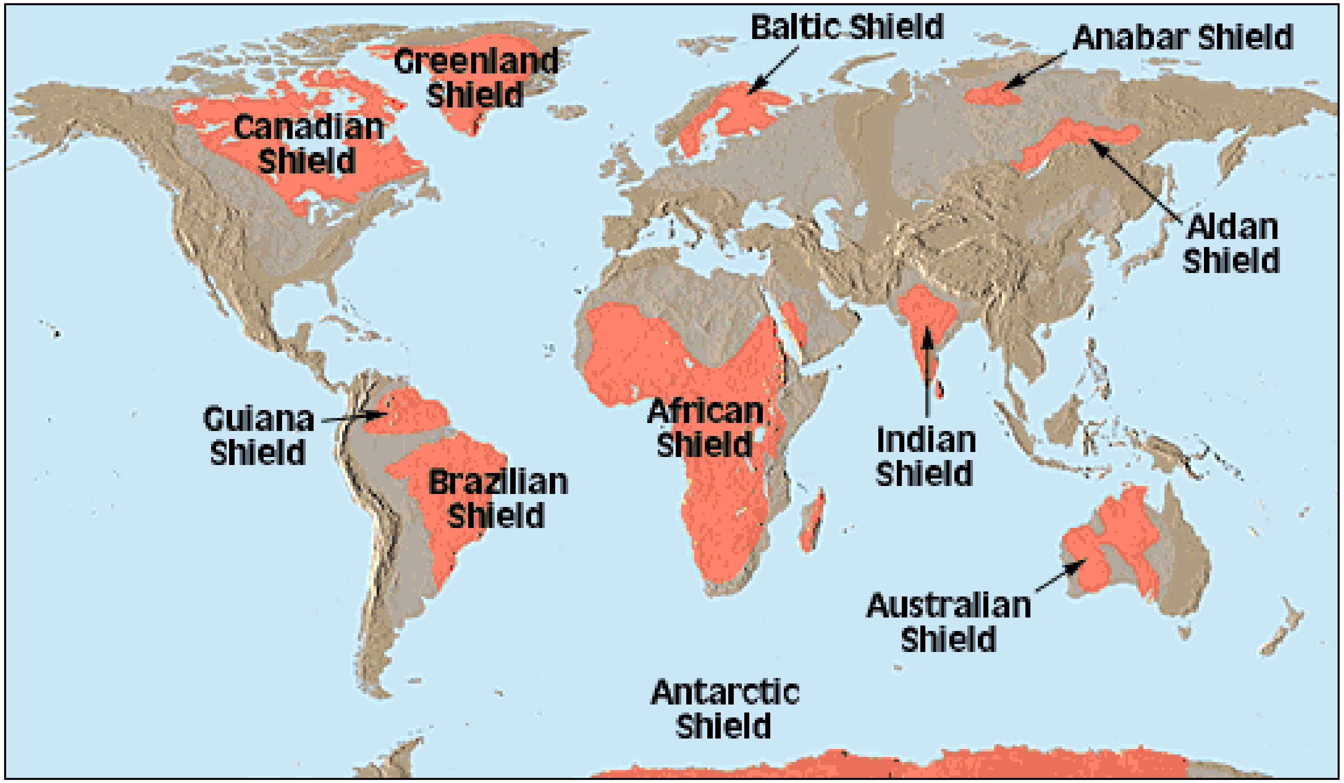


Arco de margem continental



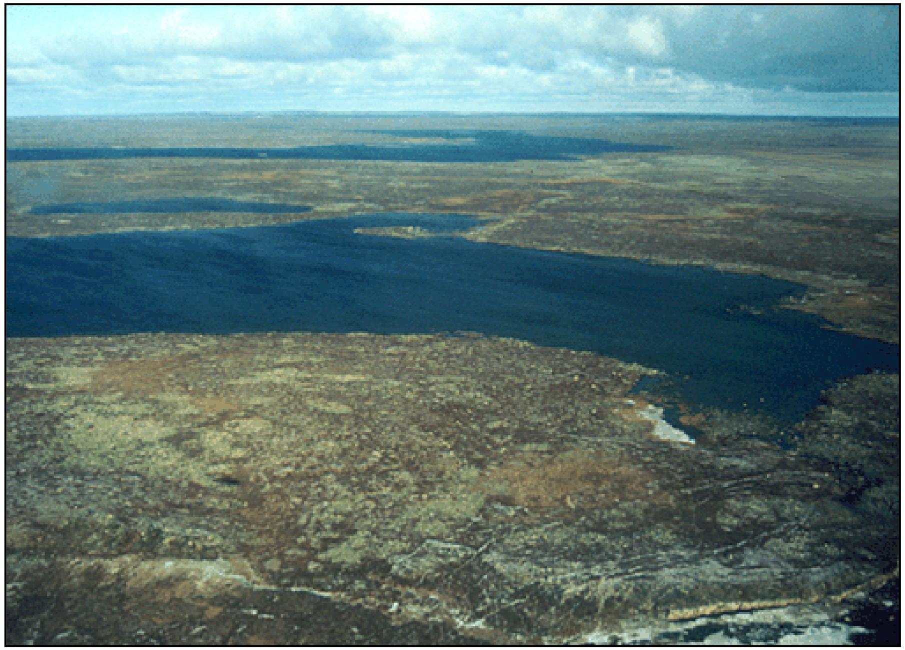
Bacia oceânica
Continental Rift
Oceanic Plateau
Ocean Basin
Ocean Ridge
Rifte continental
Plateau oceânico
Cordilheira oceânica

ESCUDOS E PLATAFORMAS

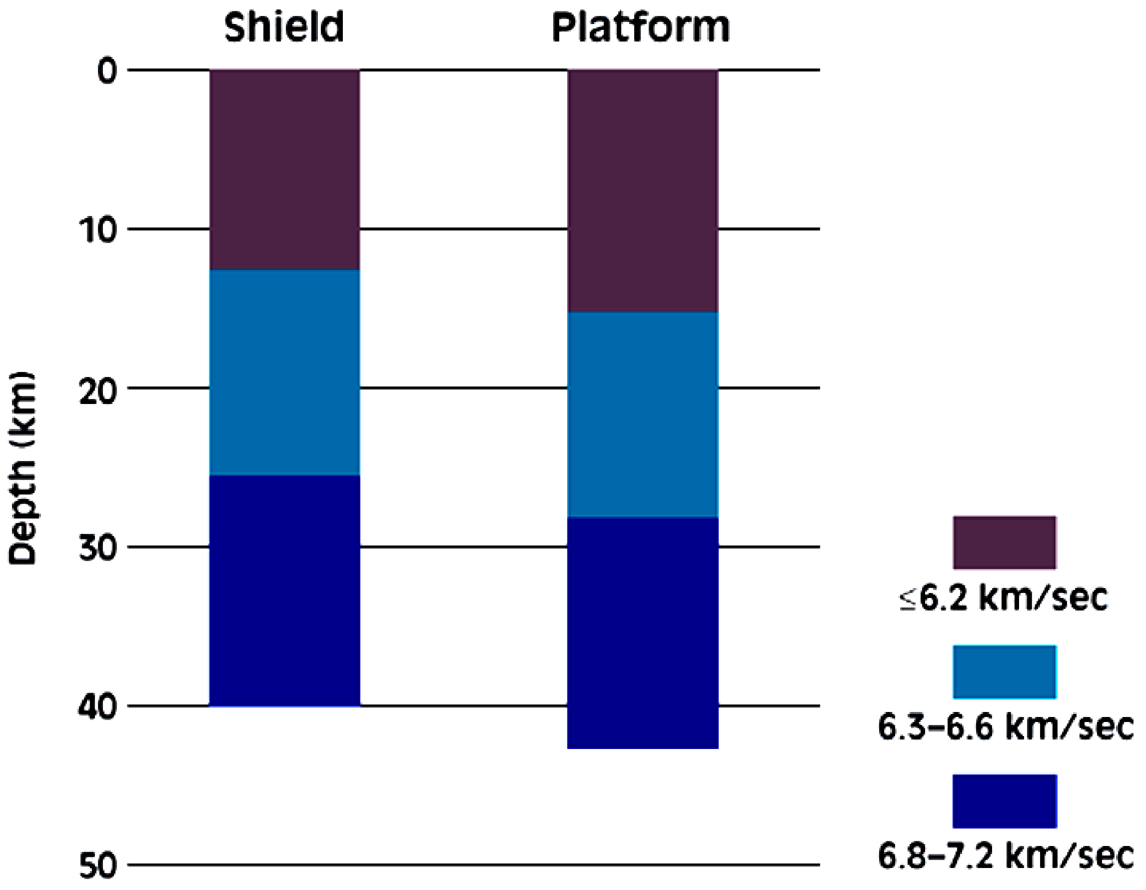


Precambrian shields are stable parts of the continents composed of Precambrian rocks; if they are overlain by a thin veneer of sediments (generally 1 to 3 km thick), they are called platforms. Shields and platforms exhibit very little relief and have remained tectonically stable for long periods of time. Collectively, shields and platforms are known as cratons.

Aerial view of the Canadian Shield in the Northwest Territories, Canada.

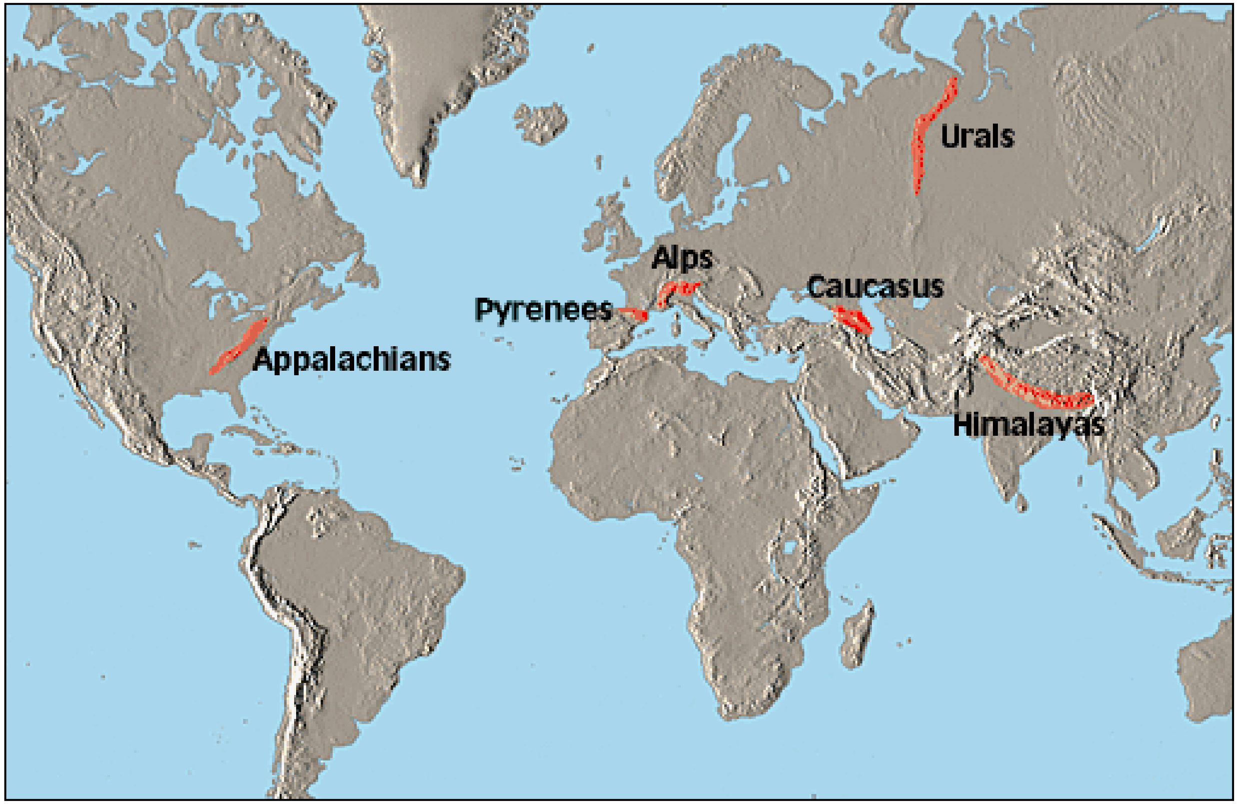


Aerial view of the lower part of the Mississippi River, a typical continental platform.



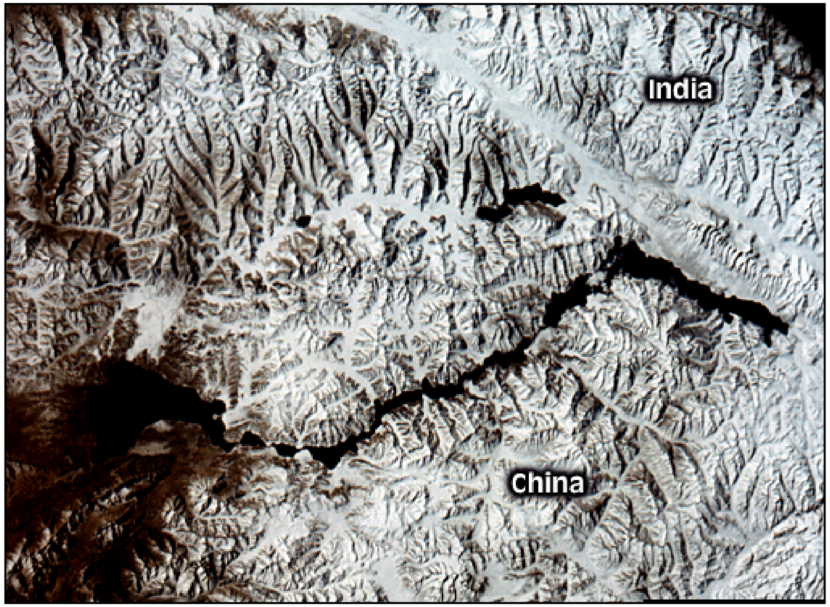
Shields and platforms average about 40 km thick and generally comprise three layers of approximately equal thicknesses and increasing seismic velocities with depth.

ORÓGENOS DE COLISÃO



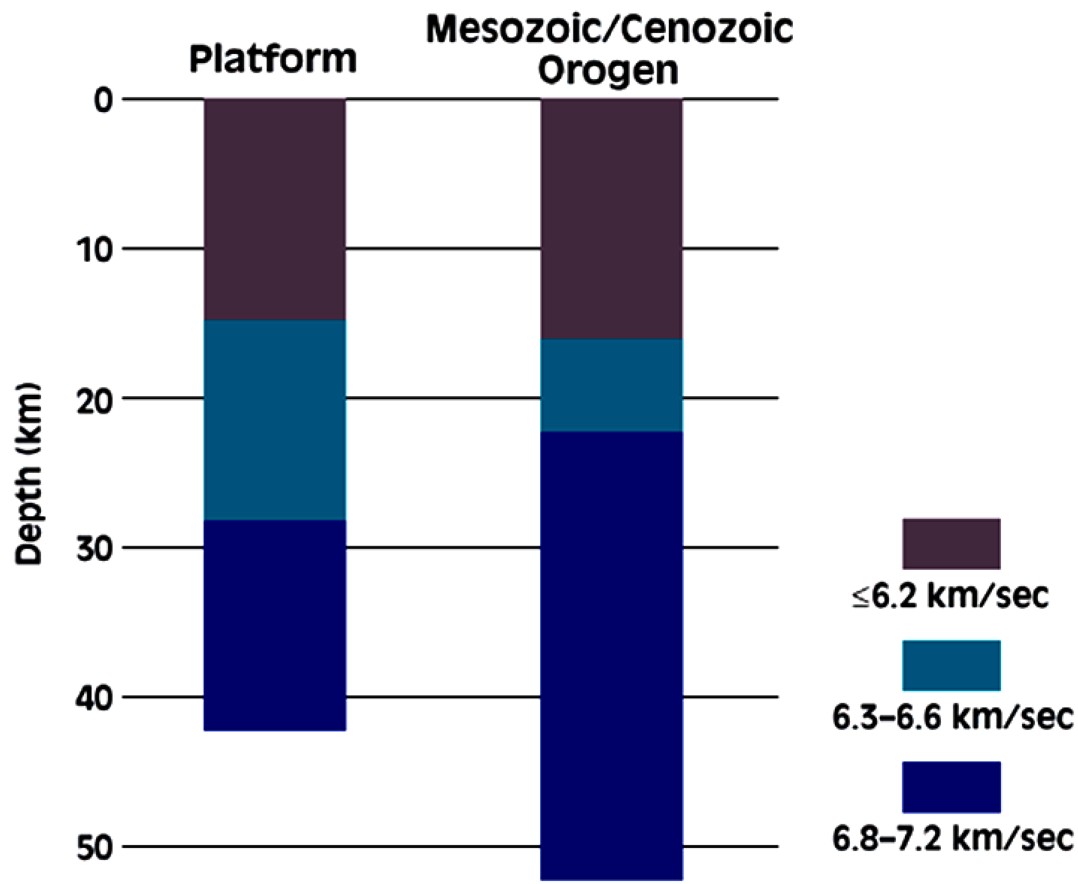
Collisional orogens are long, curvilinear belts of compressive deformation produced by the collision of continents. The Himalayas and Alps are examples of Tertiary collisional orogens, and the Appalachians and Urals are Paleozoic collisional orogens.

Satellite photo of the high Himalayas produced by collision between India and Tibet, beginning about 55 Ma.



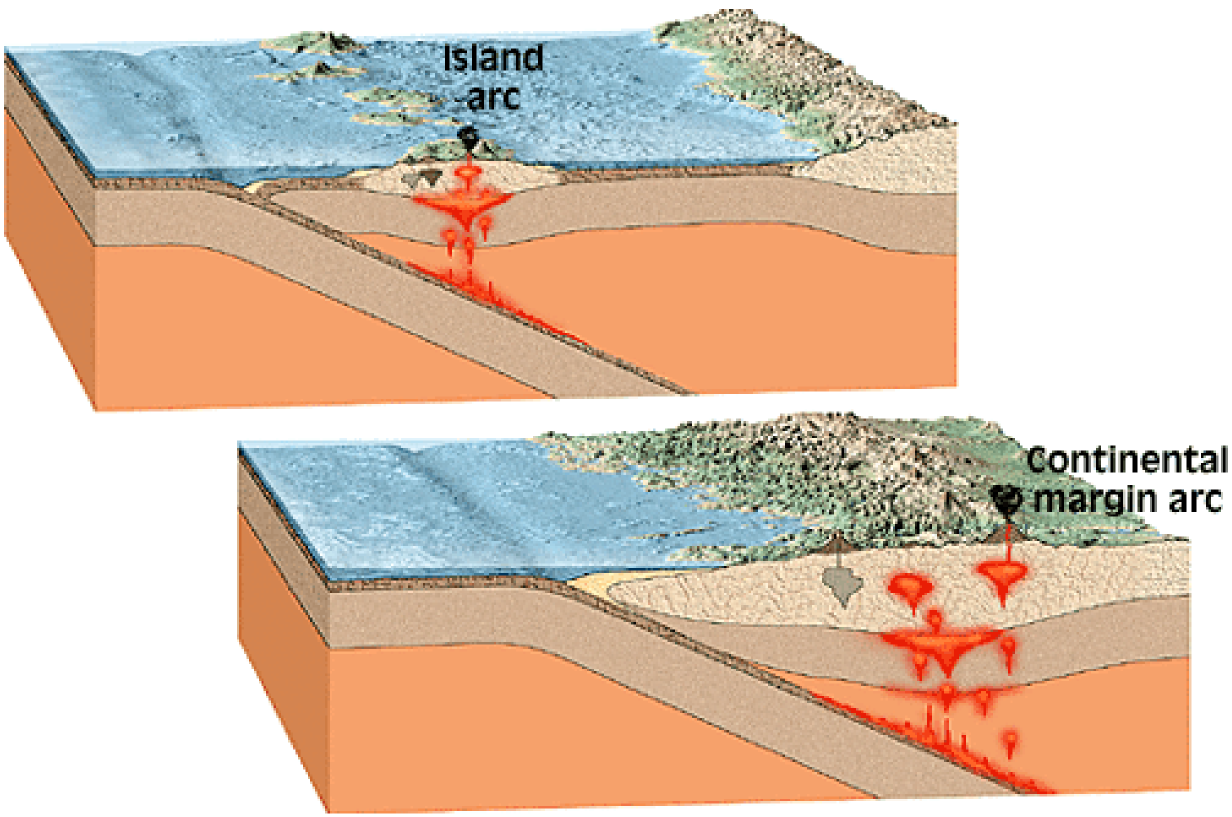
Older collisional orogens, such as the Appalachian Orogen in eastern North America are deeply eroded with only moderate relief, as illustrated by this image of the Appalachians in the eastern United States.

The boundary between the African (Apulian) and European Plates is a low-angle thrust mostly covered by the snow banks on the Matterhorn in Switzerland.



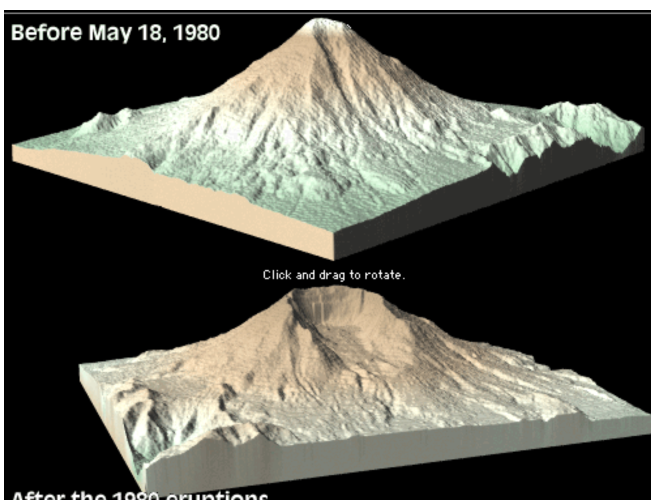
Crustal thickness in collisional orogens is extremely variable, ranging from about 30 km in some Precambrian orogens to 70 km beneath the Himalayas. In general, thickness decreases with age. In areas of very thick crust the thickening occurs primarily in the lower crustal layer.

Arcs

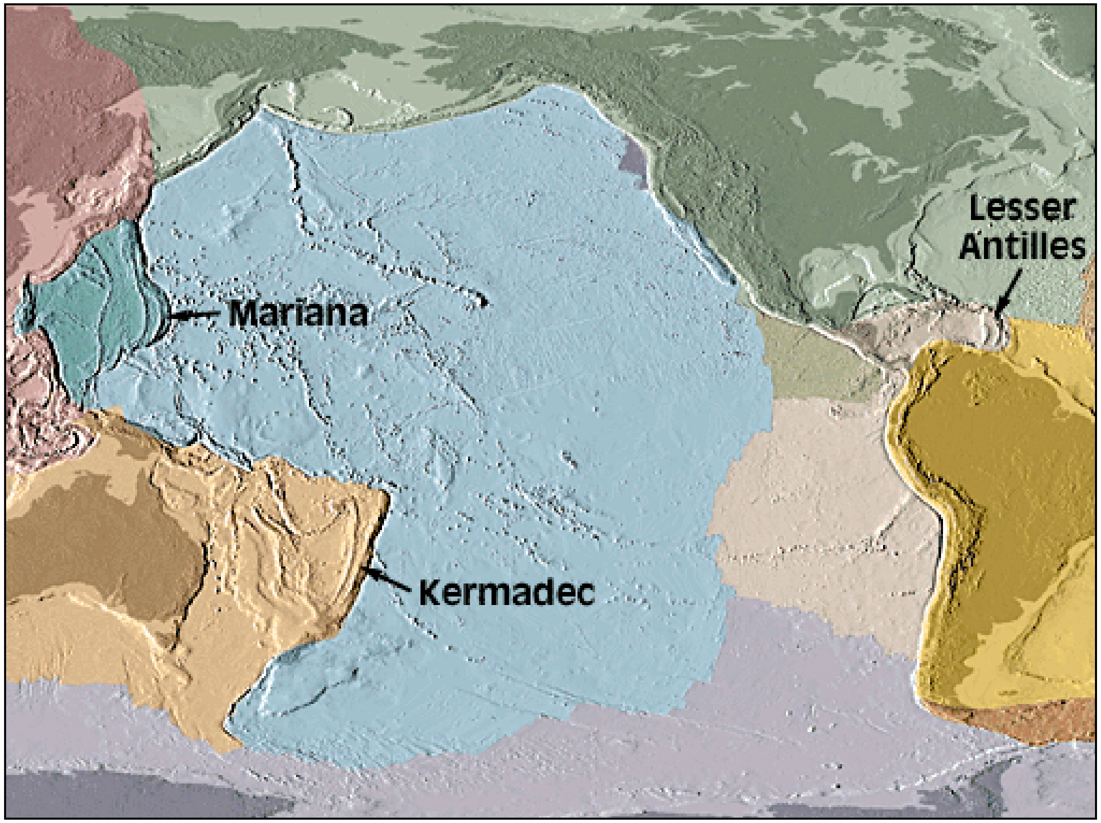


Arcs occur above active subduction zones where one plate dives beneath another. They are of two types: island arcs develop on oceanic crust, and continental-margin arcs develop on continental or transitional crust.

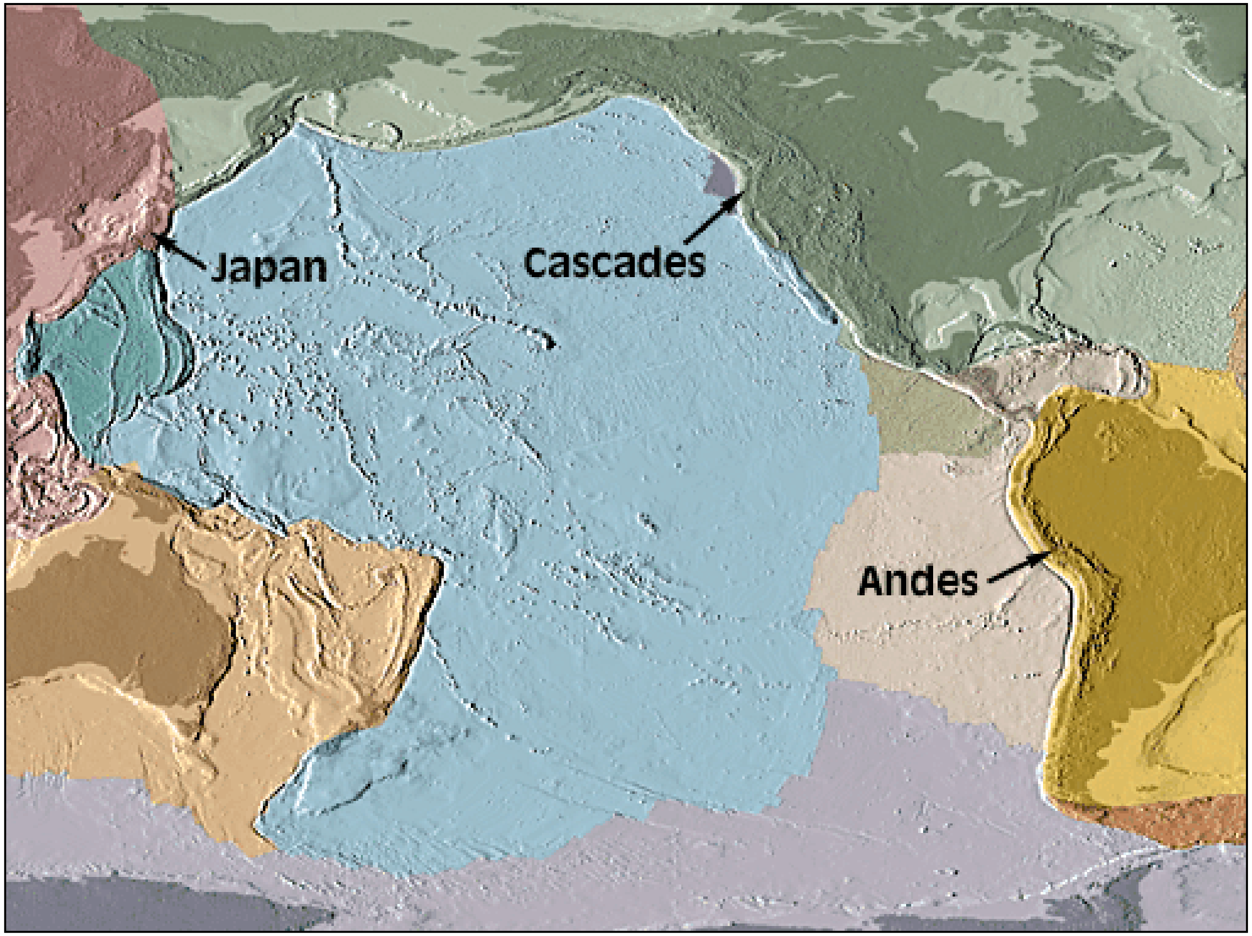
The outer Aleutian Arc is a typical island arc. Shown here is the eruption of Crater Peak at Mt. Spurr.



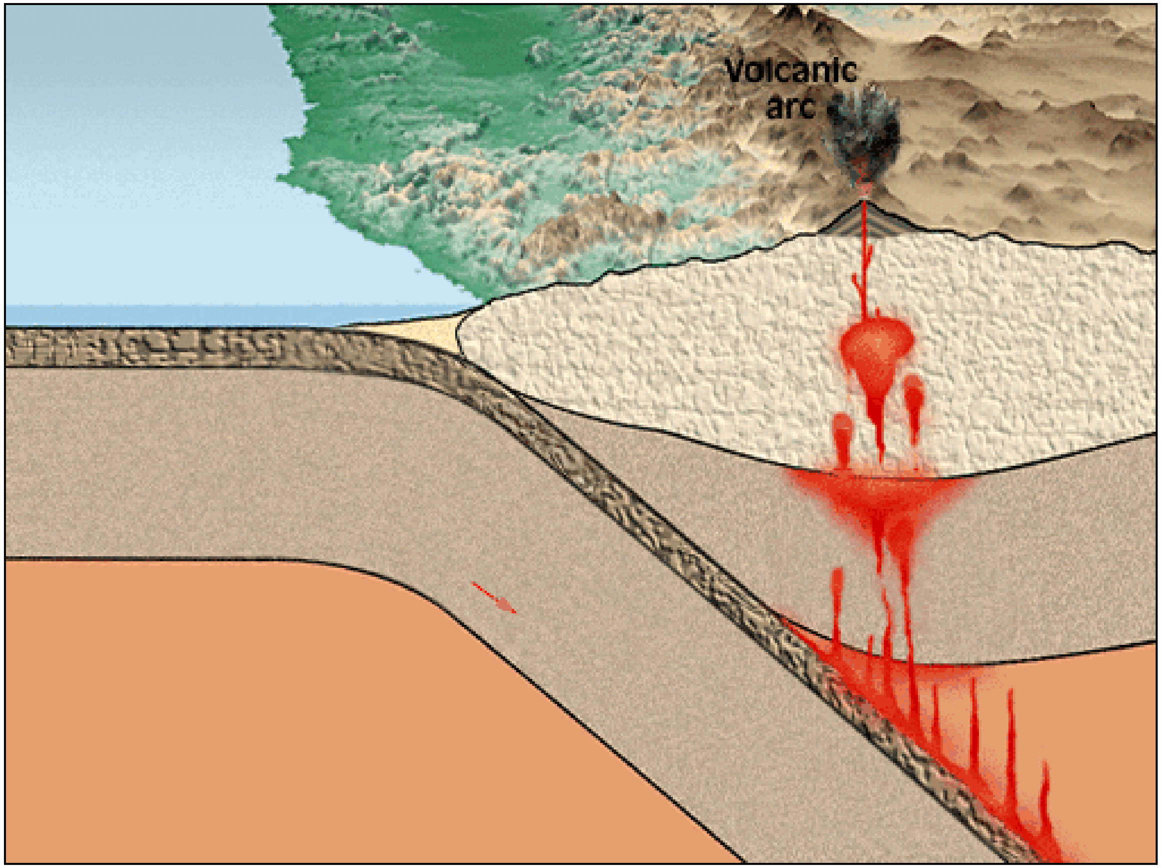
Mt. St. Helens in southern Washington state, shown here during its eruption in 1980, is a typical continental-margin arc volcano.



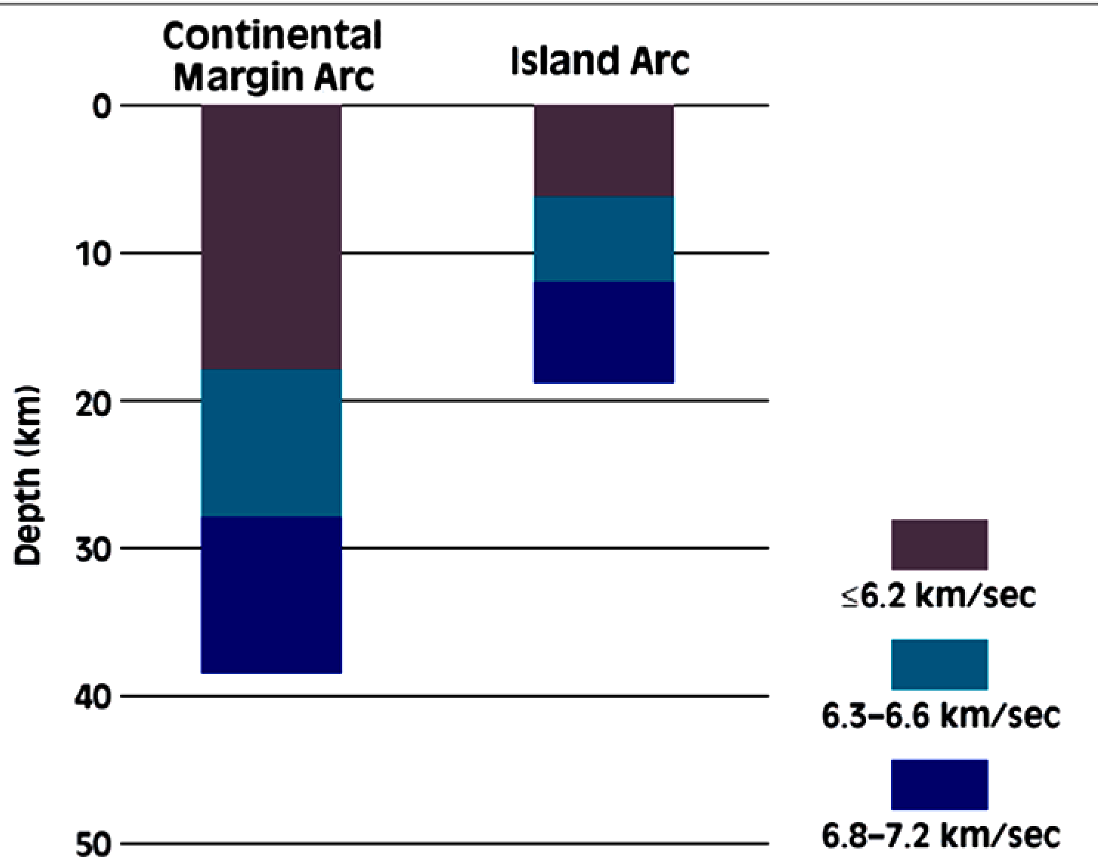
Island arcs commonly occur as arcuate chains of volcanic islands, such as the Mariana, Kermadec and Lesser Antilles Arcs.



Most large volcanic chains, such as the Andes, Cascades, and Japanese chains, are continental-margin arcs.

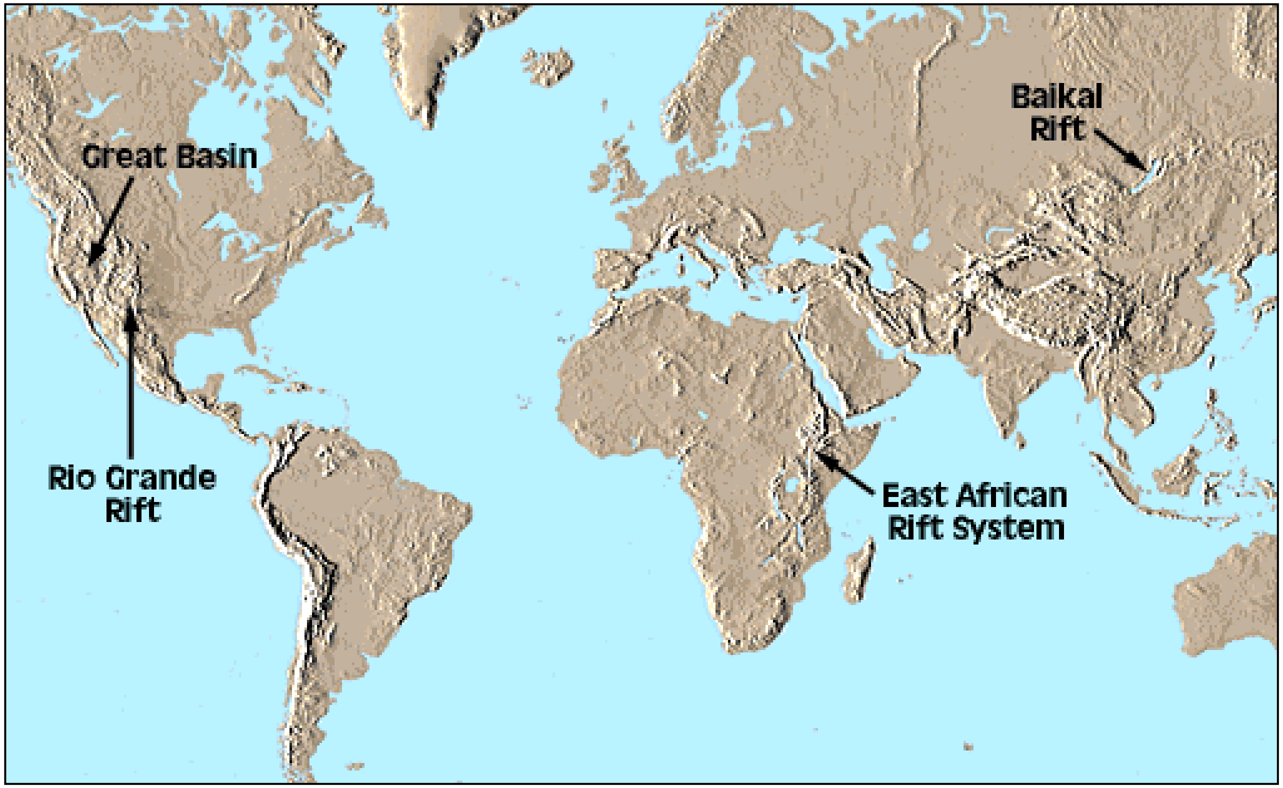


Modern arcs are characterized by variable, often intense earthquake activity and volcanism, and by variable heat flow, gravity, and crustal thickness.



Island arcs average about 19 km thick, whereas continental margin arcs average about 38 km. Notice the upper crustal layer is relatively thick in continental margin arcs.

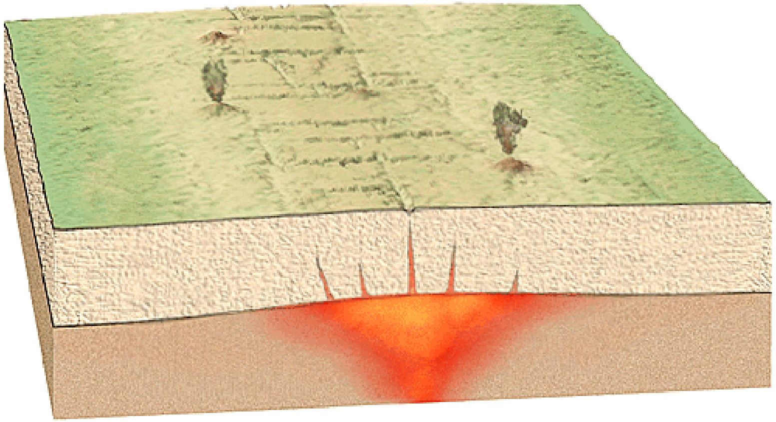
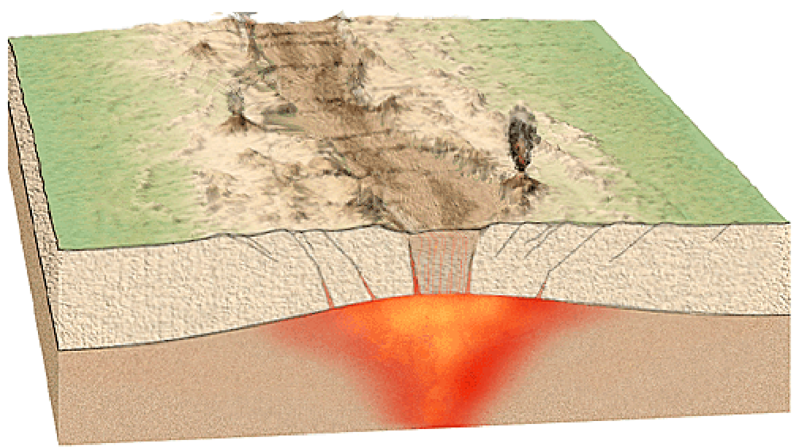
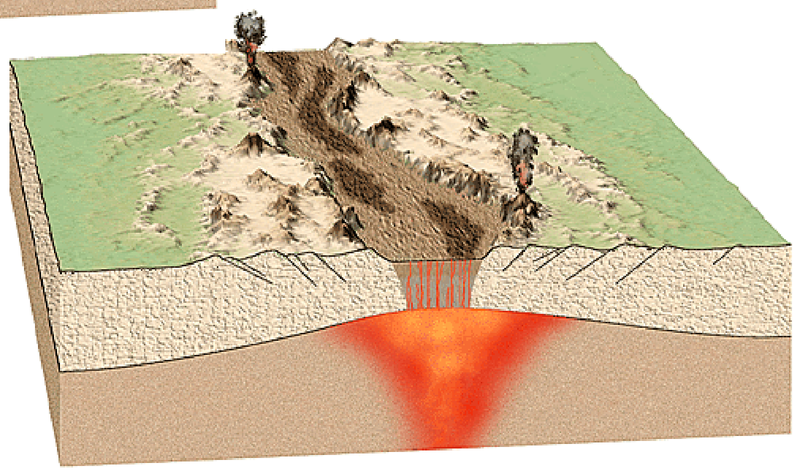
RIFTES CONTINENTAIS



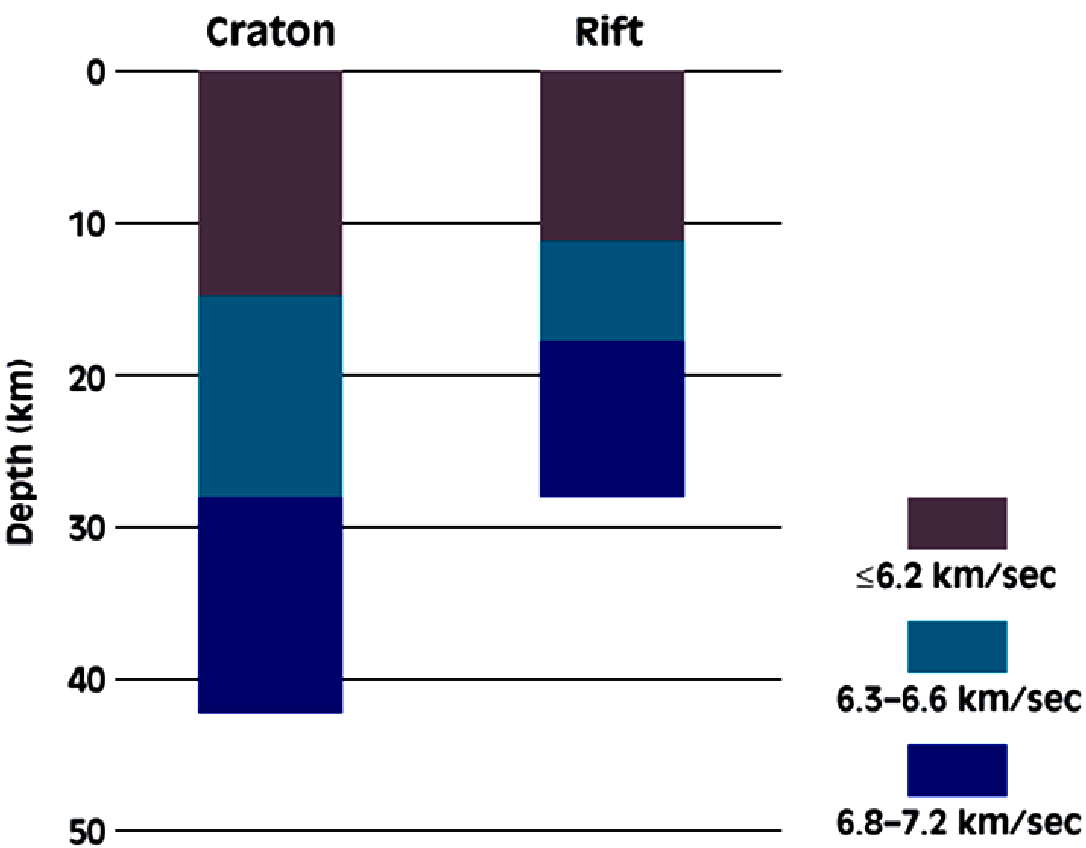
Continental rifts are fault-bounded valleys ranging in width from 30 to 75 km and in length from a few tens to thousands of kilometers. Above are shown four examples of young rift systems.

Looking across a large rift valley in eastern Nevada towards Wheeler Peak, in the Great Basin National Park.

The Basin and Range Province in Nevada extends from the Wasatch Range in Utah to the Sierra Nevada in California.

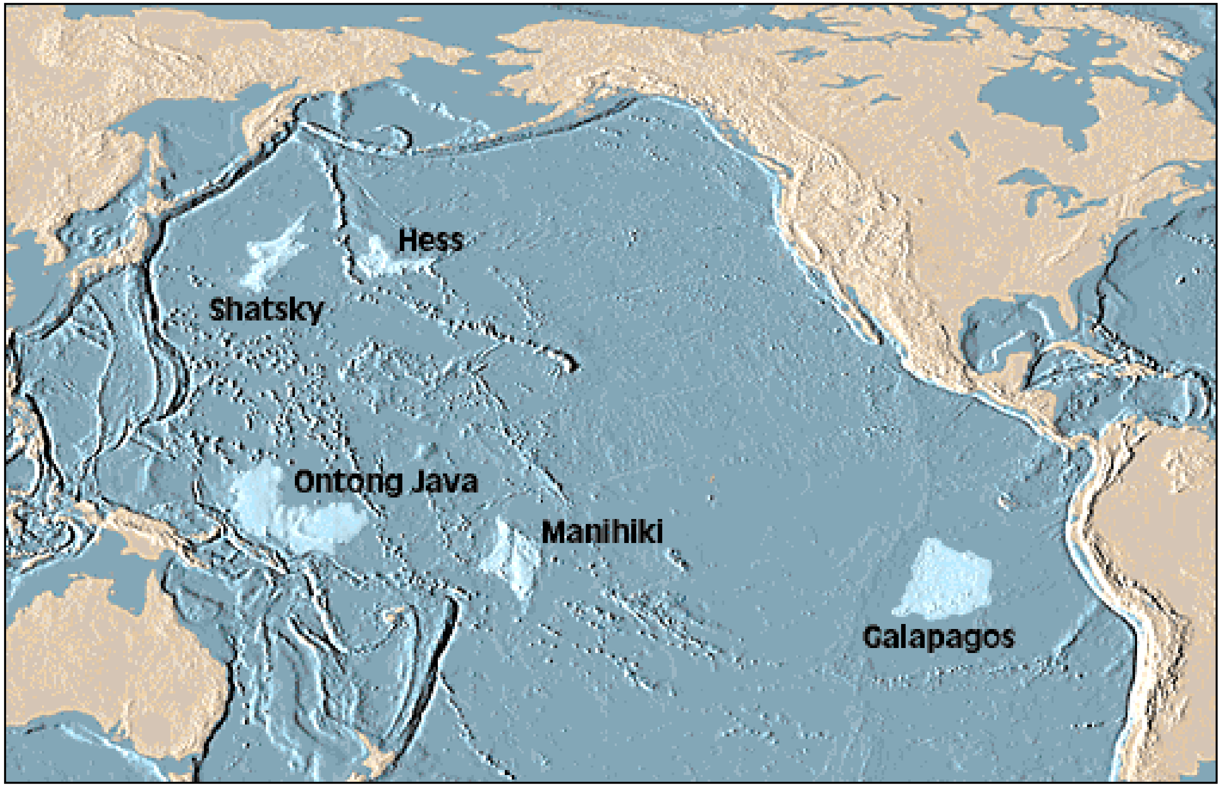




Os riftes têm pequena espessura crustal (20-30 km) devido, principalmente, ao adelgaçamento da crusta inferior à medida que o rifte vai abrindo

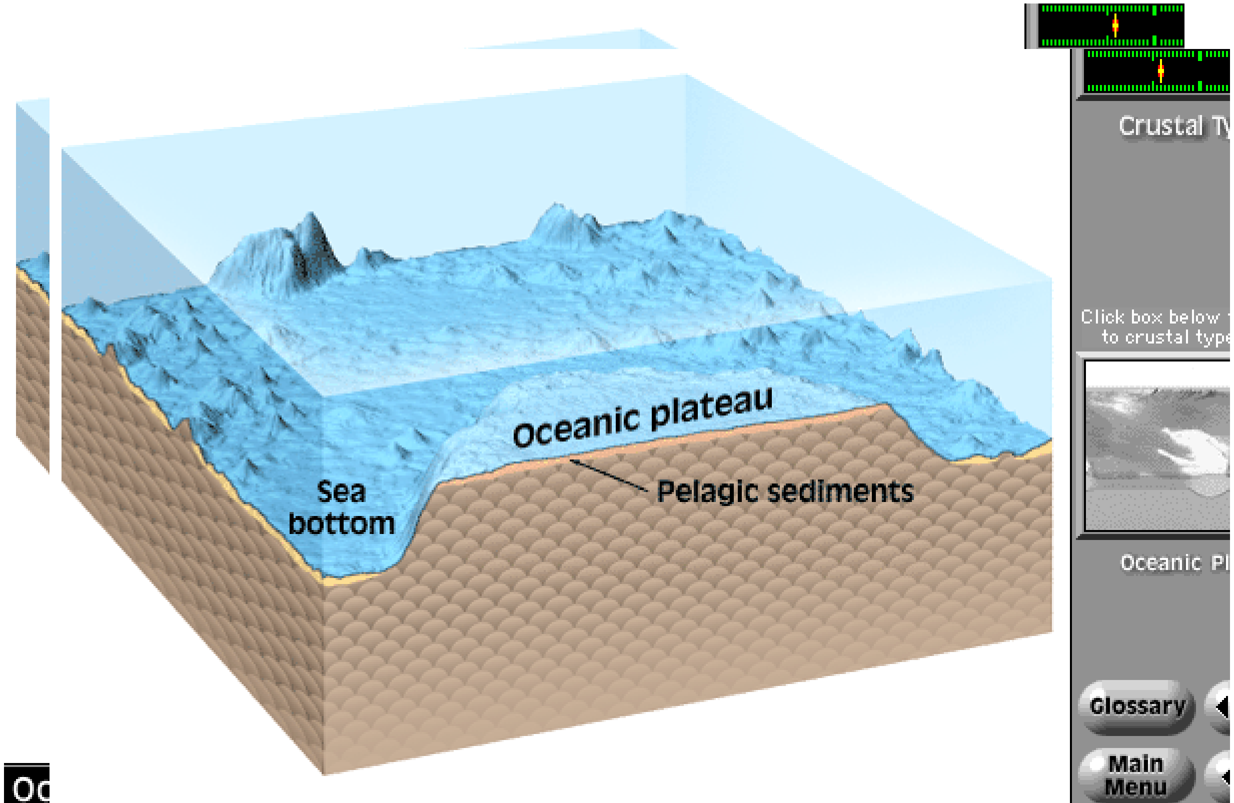


Thinning of the crust during rifting is due primarily to ductile thinning of mid and lower crustal layers.

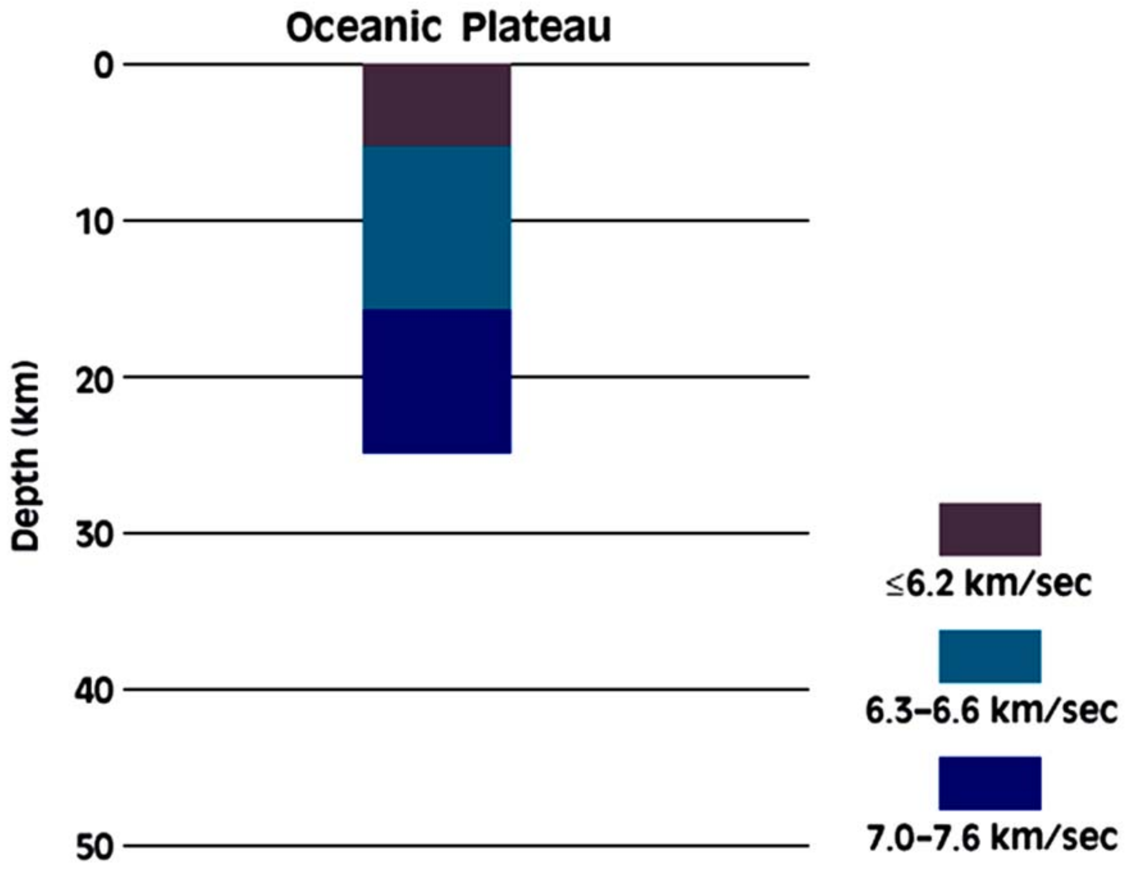
PLATEAU OCEÂNICO



Oceanic plateaus are large flat-topped plateaus on the seafloor composed largely of mafic volcanic and intrusive rocks. Shown on this map are five large oceanic plateaus in the Pacific.

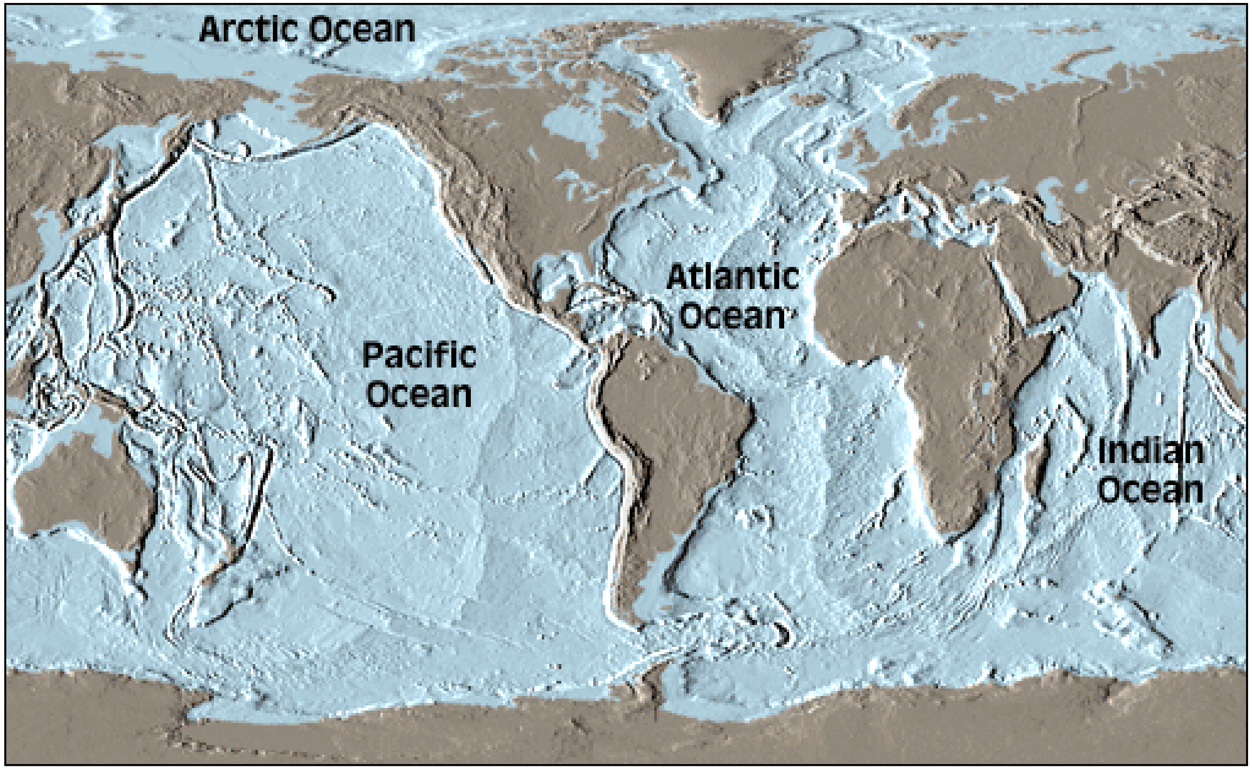


Oceanic plateaus are generally capped with a thin veneer of pelagic sediments (chert, limestone) and typically rise 2 km or more above the seafloor.

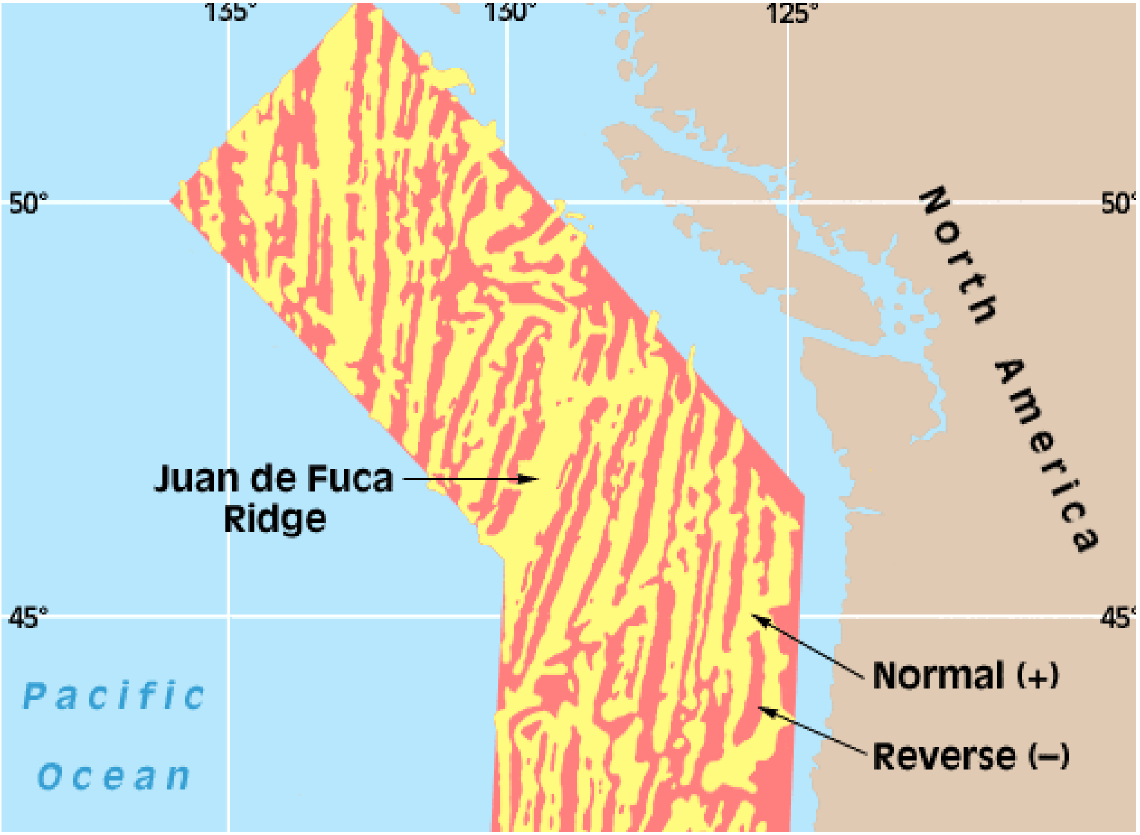


Most oceanic plateaus are 15-30 km thick, although some may exceed 30 km. Lower crustal P wave velocities are anomalously high (7.0-7.6 km/sec), perhaps reflecting large volumes of high-Mg basalts.

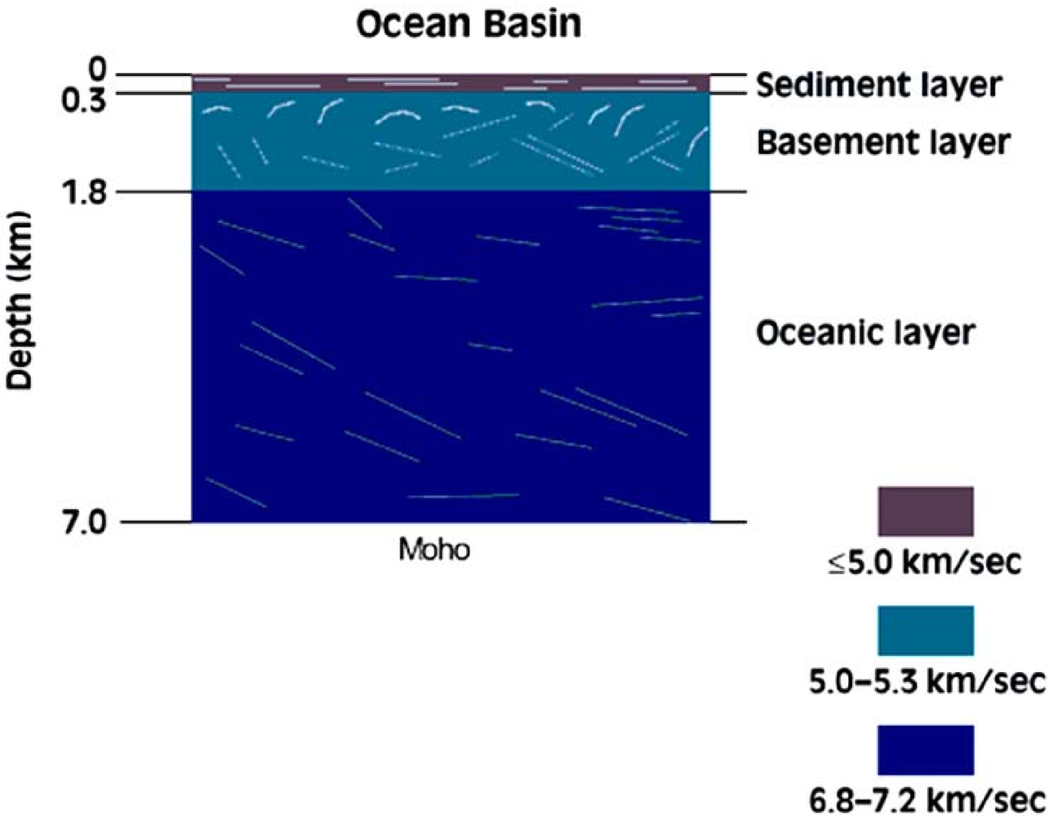
BACIAS OCEÂNICAS



Ocean basins are tectonically stable and are covered with a thin layer of pelagic sediments (0.3 km thick).

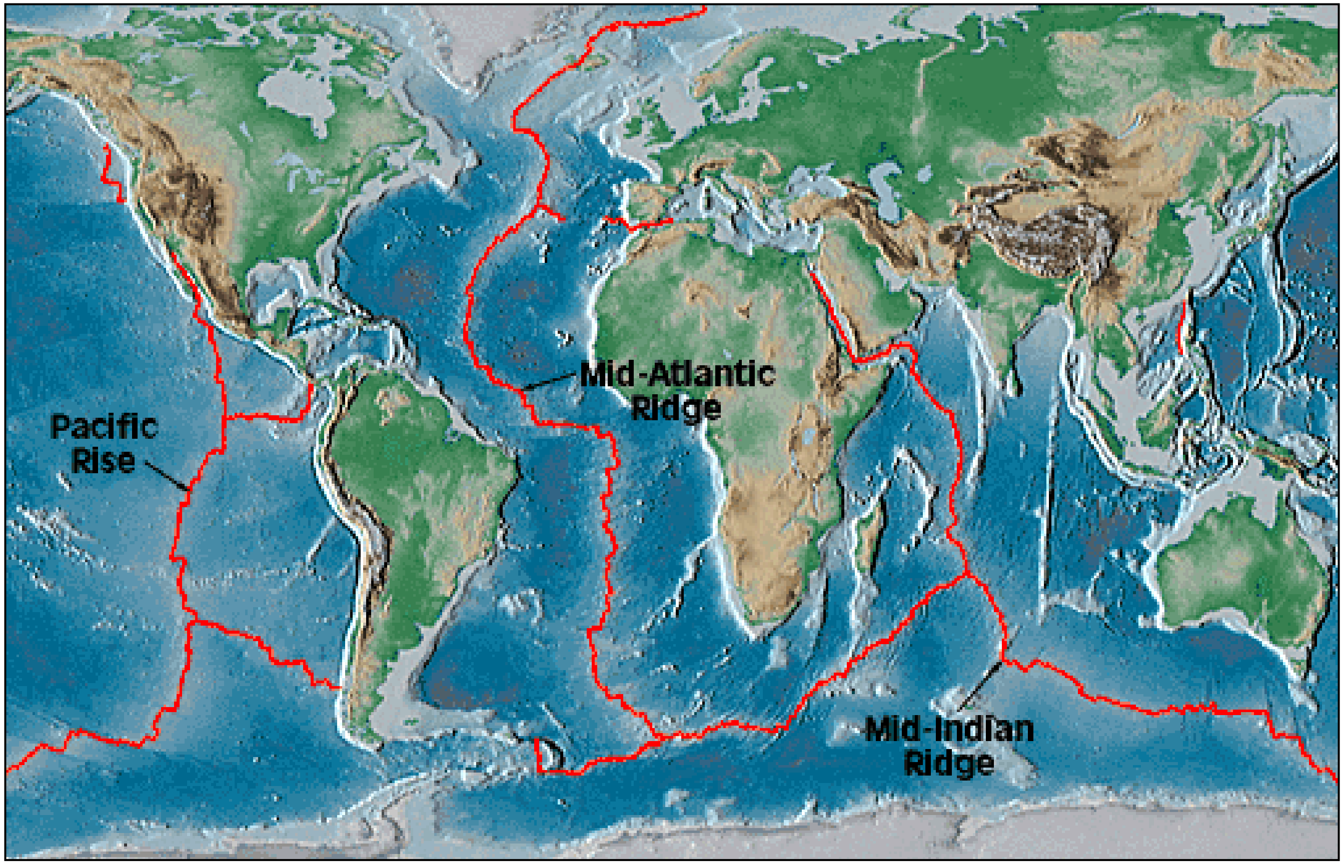


Much of the ocean floor has linear magnetic anomalies that are produced at ocean ridges during reversed and normal polarity intervals, as shown here for the Northeast Pacific.

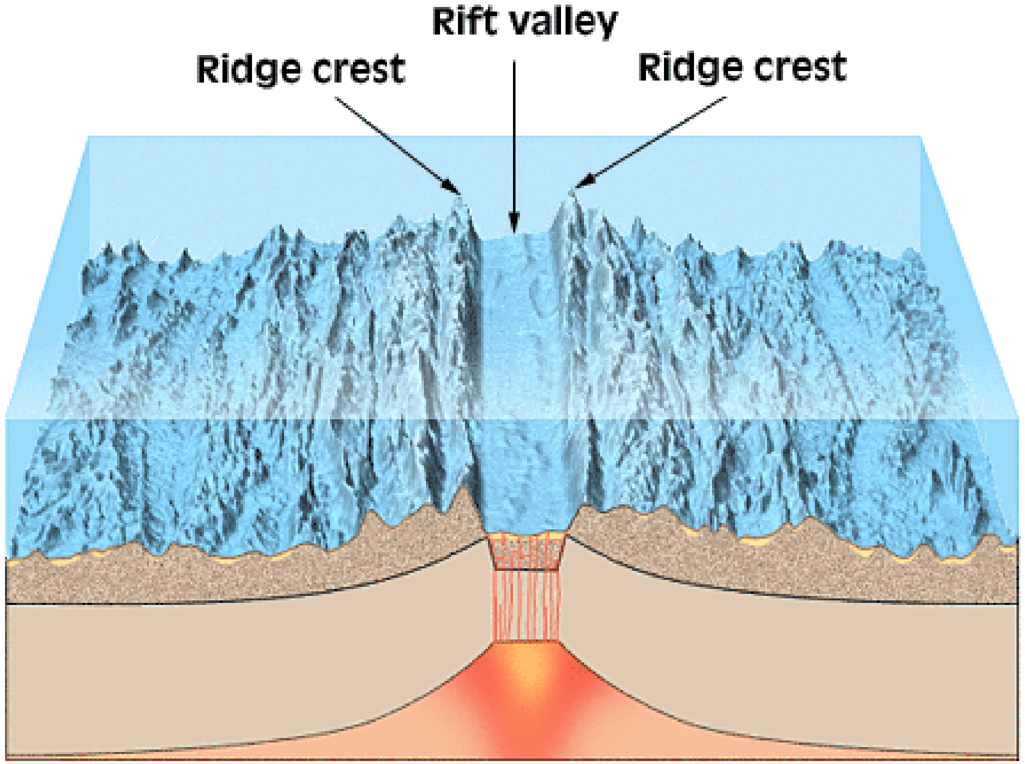


Crustal structure in ocean basins is rather uniform, not deviating greatly in either velocity or layer thickness. Lines in this section are seismic reflectors.

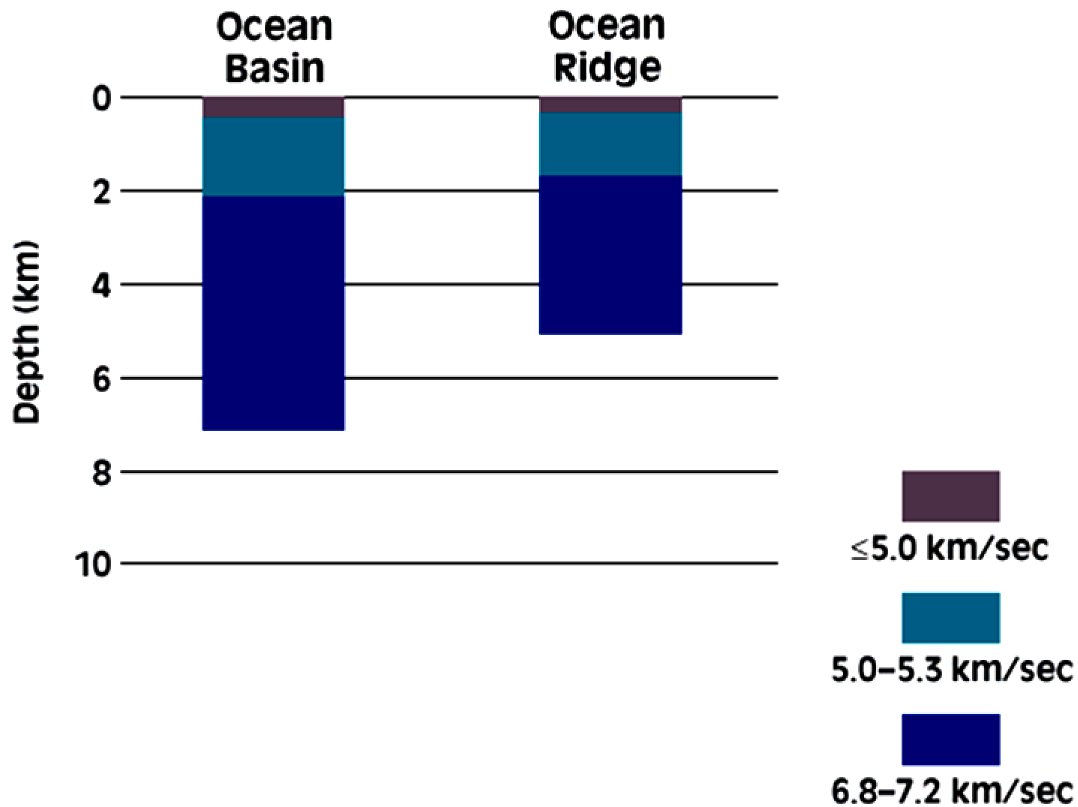
CORDILHEIRAS OCEÂNICAS



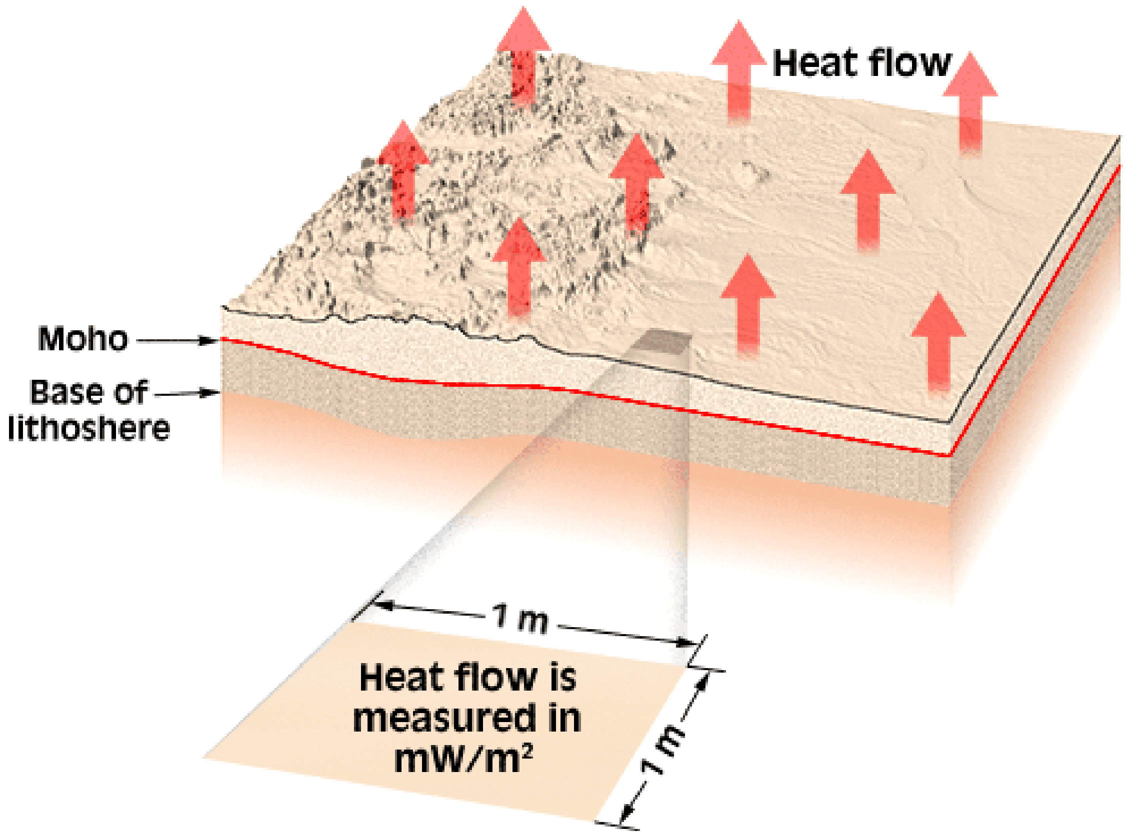
The ocean ridge system collectively extends for over 70,000 km in length.



Ocean ridges (divergent plate boundaries) have a medial rift valley near their crests in which new oceanic crust is produced by intrusion and extrusion of basaltic magmas. They are topographic highs on the seafloor and are tectonically unstable.



Oceanic crustal thickness ranges from 3-6 km, most of which is accounted for by the lower crustal layer. The sediment and upper crustal layers thin or disappear entirely on most ridges. Seismic reflections indicate magma chambers beneath ridges occur at depths of 1-3 km.



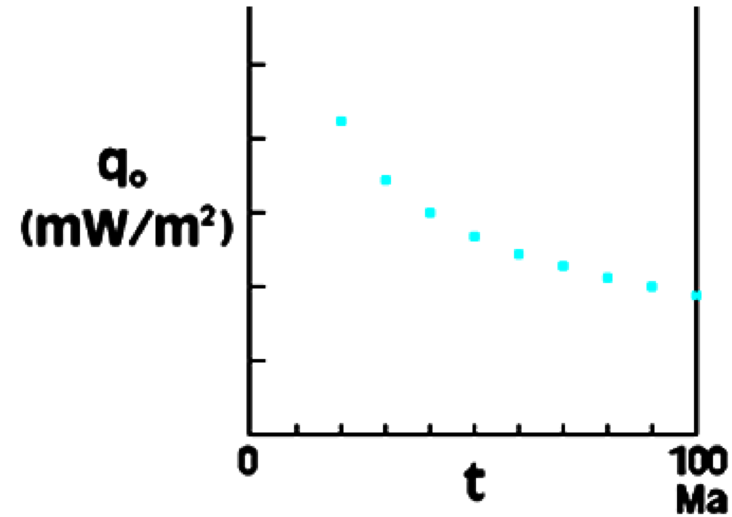
As the Earth cools, heat is convected upwards in the mantle to the base of the lithosphere, and then conducted through the lithosphere to the surface. By measuring the thermal gradient and thermal conductivity of rocks, the heat flow through the Earth's surface can be estimated.

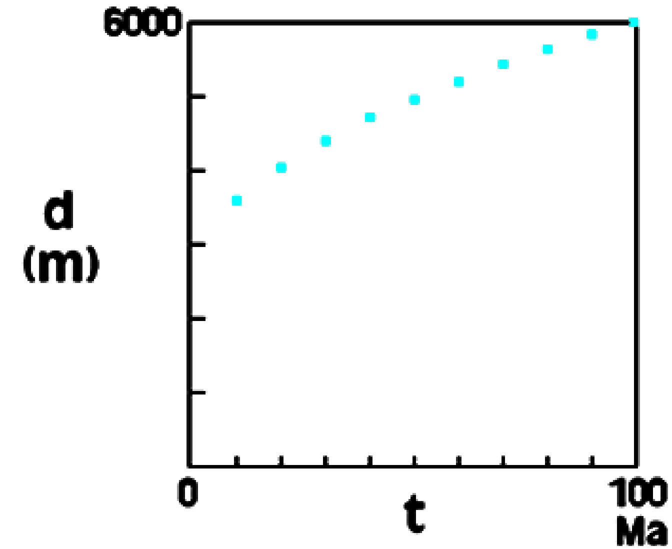
$$q_o = 472.3\, t^{(-1/2)}$$

where q_o is the surface heat flow in mW/m^2 and t is lithospheric age in years. The decrease in q_o is caused by cooling of the lithosphere as it ages. As the ocean floor cools, it sinks, and the depth beneath sea level (d) can be approximated by,

$$d \text{ (meters)} = 2500 + 350\, t^{(1/2)}$$

Age (Ma) (t)	Heat flow (q_o)	Depth (d)
10	149.4	3607
20	105.6	4065
30	86.2	4417
40	74.7	4713
50	66.8	4975
60	61.0	5211
70	56.5	5428
80	52.8	5631
90	49.8	5820
100	47.2	6000

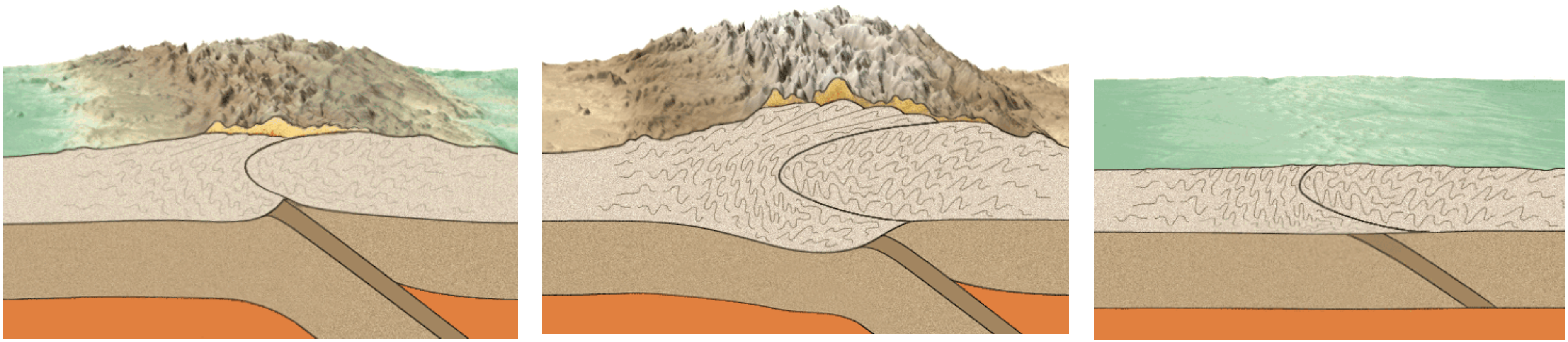




In oceanic areas, heat flow and depth decrease with the age of the lithosphere according to the above expressions.

EXUMAÇÃO CRUSTAL

ASCENSÃO EROSÃO



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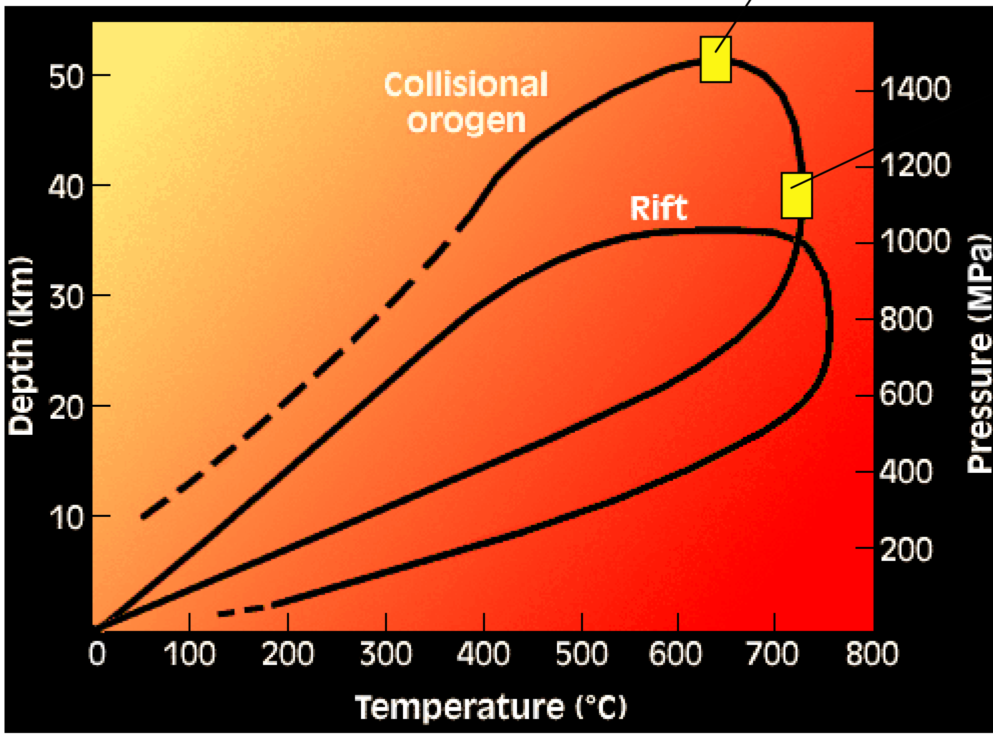
During continental collisions, large segments of continental crust are deformed and thickened and later they are uplifted and eroded to form cratons. The process of uplift and erosion is known as crustal exhumation.

PICO DE PRESSÃO

PICO DE TEMPERATURA



Crustal thermal history is imprinted in rocks as pressure-temperature-time trajectories, generally referred to as crustal P-T-t paths. By relating mineral growth relationships to experimentally determined P-T stability fields of metamorphic minerals, it is possible in some instances to pin down the pressure and temperature at which a given mineral assemblage grew.

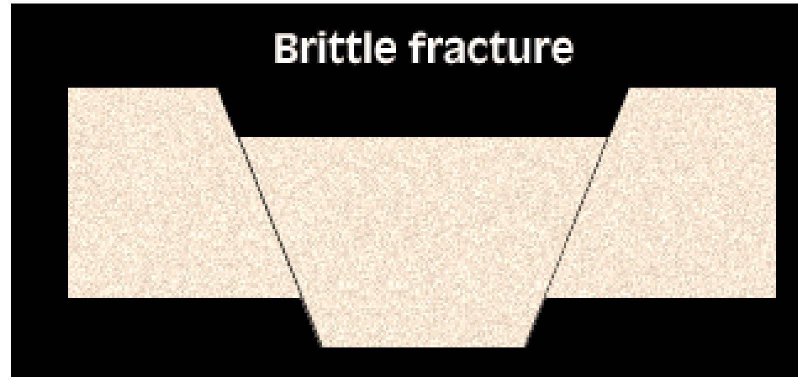
INTERPRETAR O INTERIOR DA TERRA

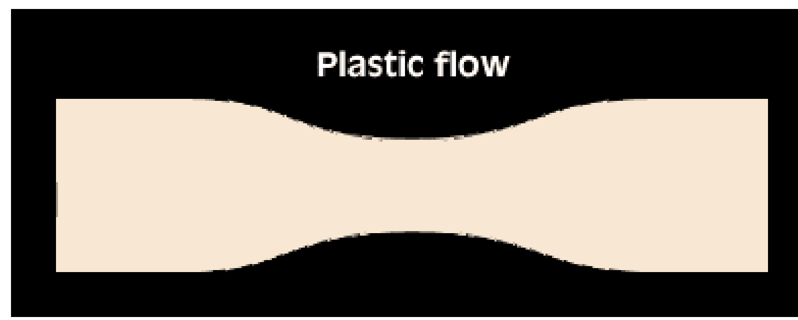
QUE MATERIAIS ? QUE COMPORTAMENTO ?

QUAIS AS TÉCNICAS E MÉTODOS UTILIZADOS?

Comportamento frágil ou rígido

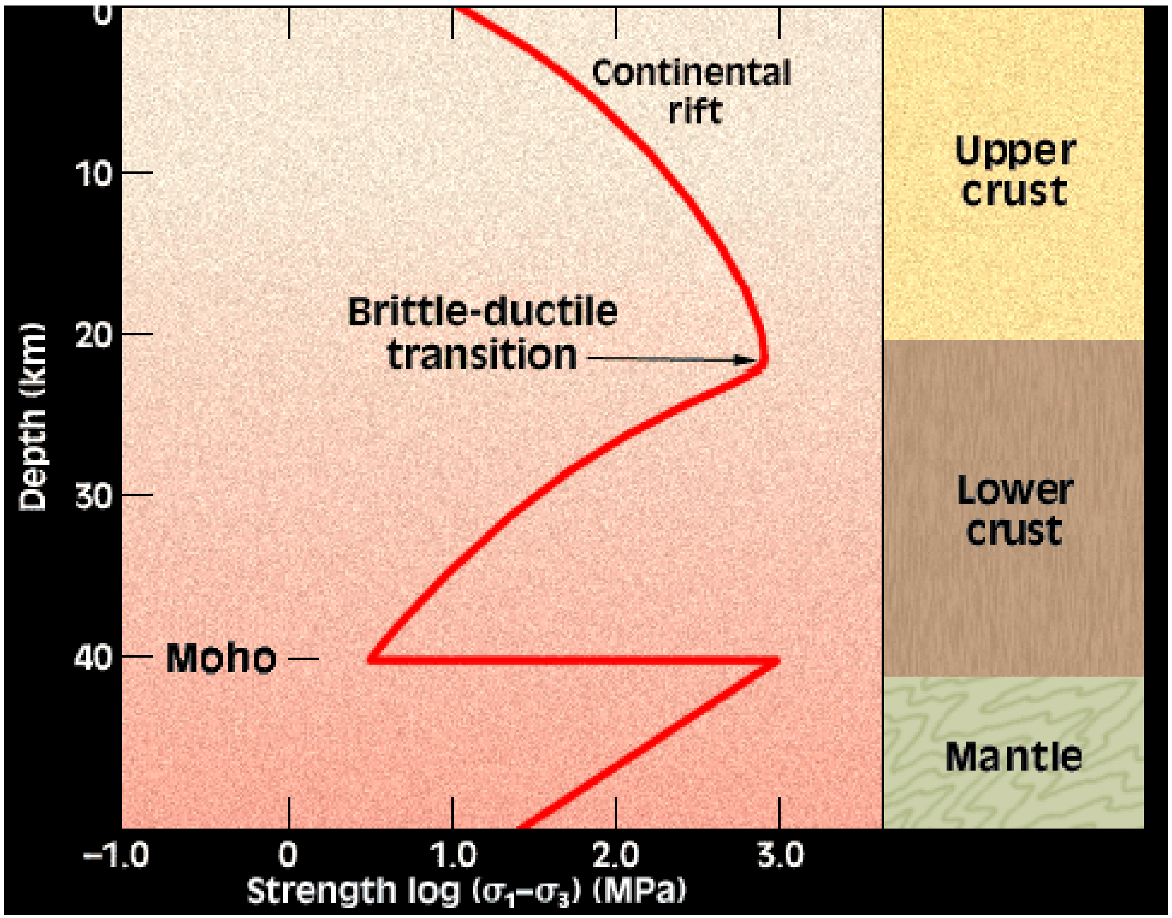
COMPORTAMENTOS MECÂNICOS DA CROSTA



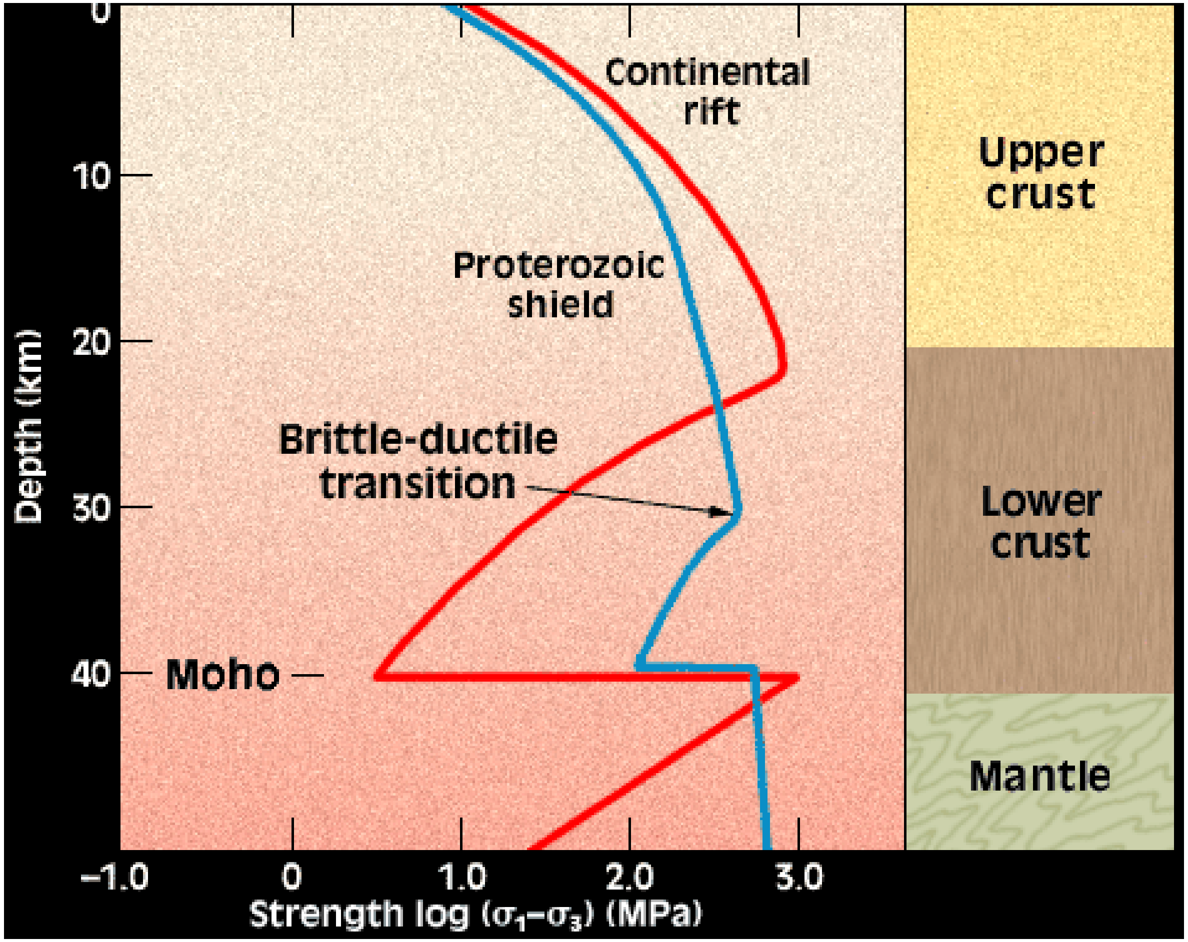


Comportamento plástico

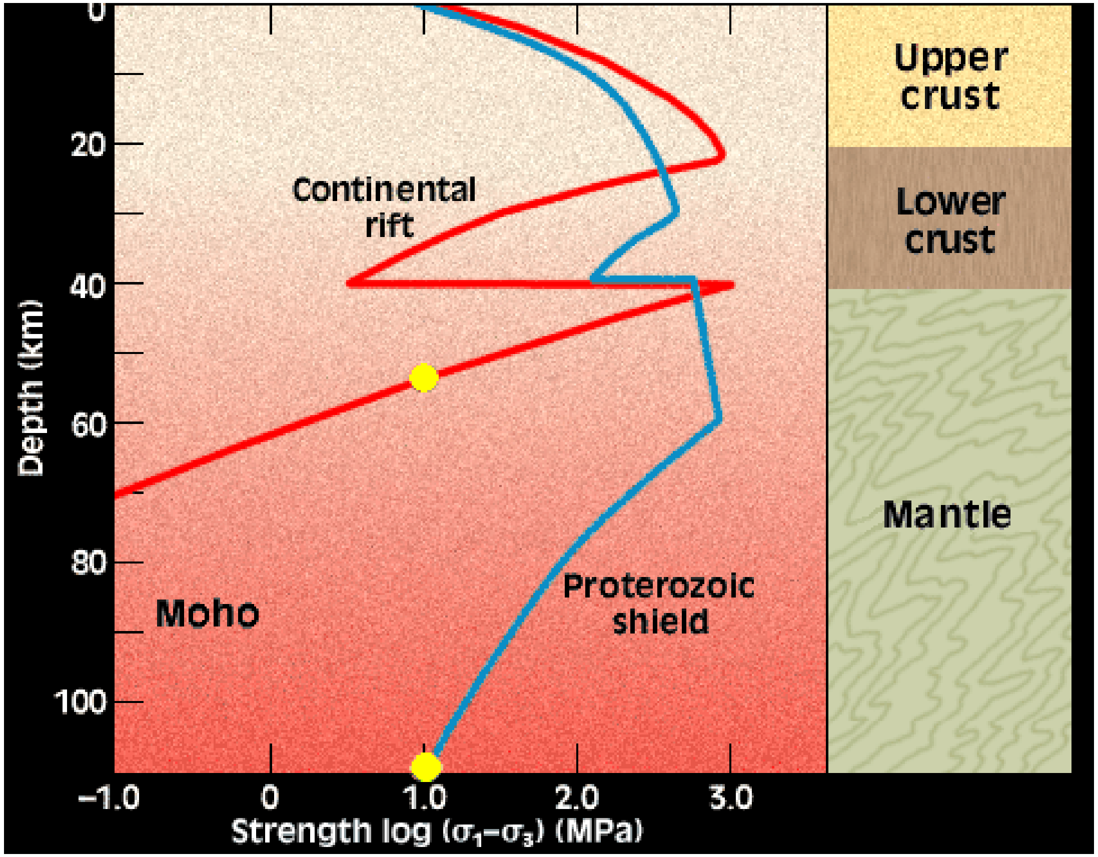
The behavior of the continental crust under stress depends on the temperature and the duration of stresses. The hotter the crust, the more it behaves like a ductile solid deforming by plastic flow, whereas if it is cool, it behaves as an elastic solid deforming by brittle fracture and frictional gliding.



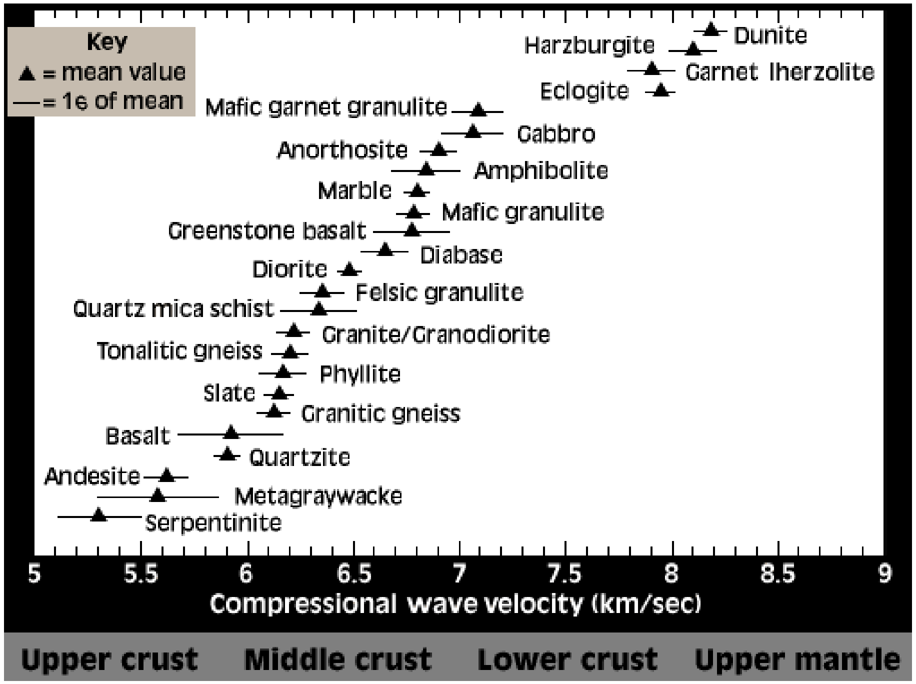
As temperature increases with depth in the crust, a point is reached at which the deformation switches from brittle to ductile. This brittle-ductile transition occurs at about 20 km depth in rifts where heat flow is high.

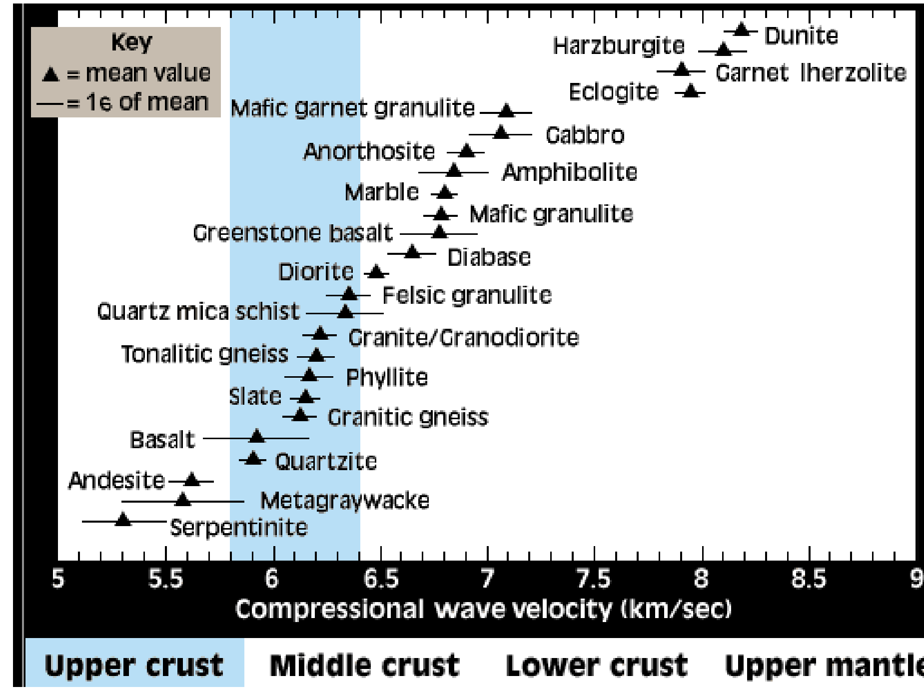


In Precambrian shields, which are cooler, the brittle-ductile transition occurs at greater depths of about 30 km.



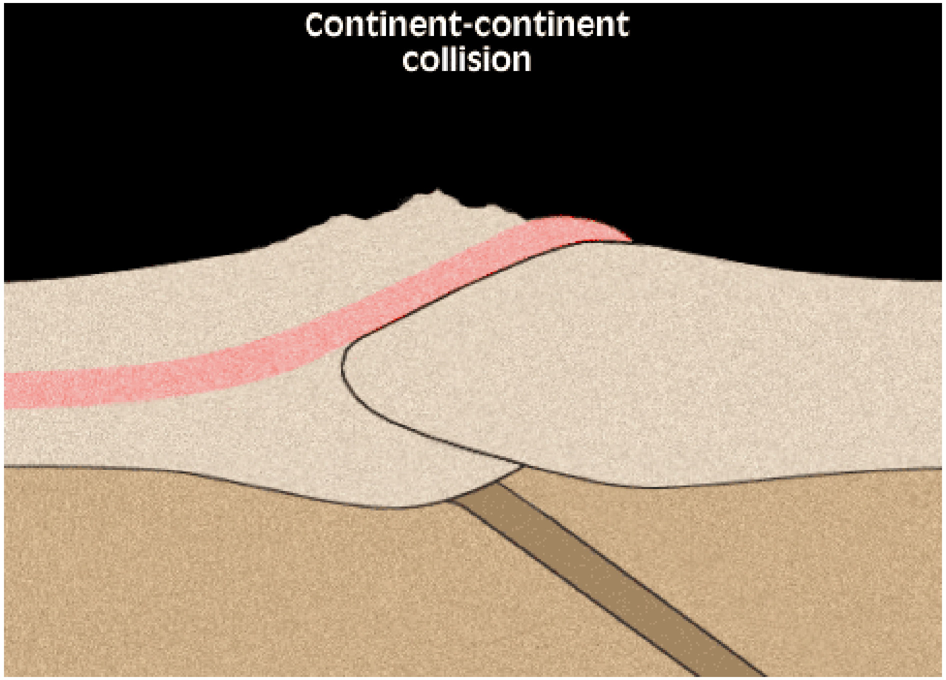
The rheological base of the lithosphere, which is generally taken as a strength equal to about 1 MPa, occurs at 55 km beneath the rift and 115 km beneath the Precambrian shield.



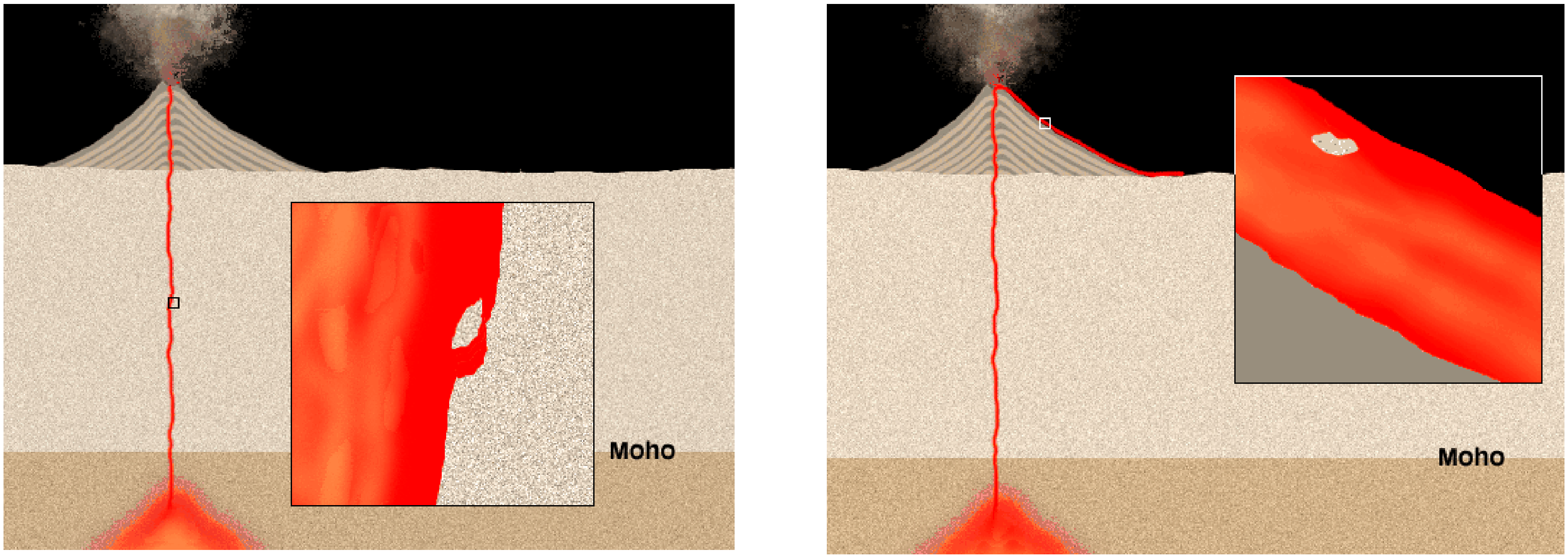


Because seismic wave velocities are related to rock density and density is related to rock composition, the measurement of these velocities provides an important constraint on the composition of both the oceanic and continental crust.

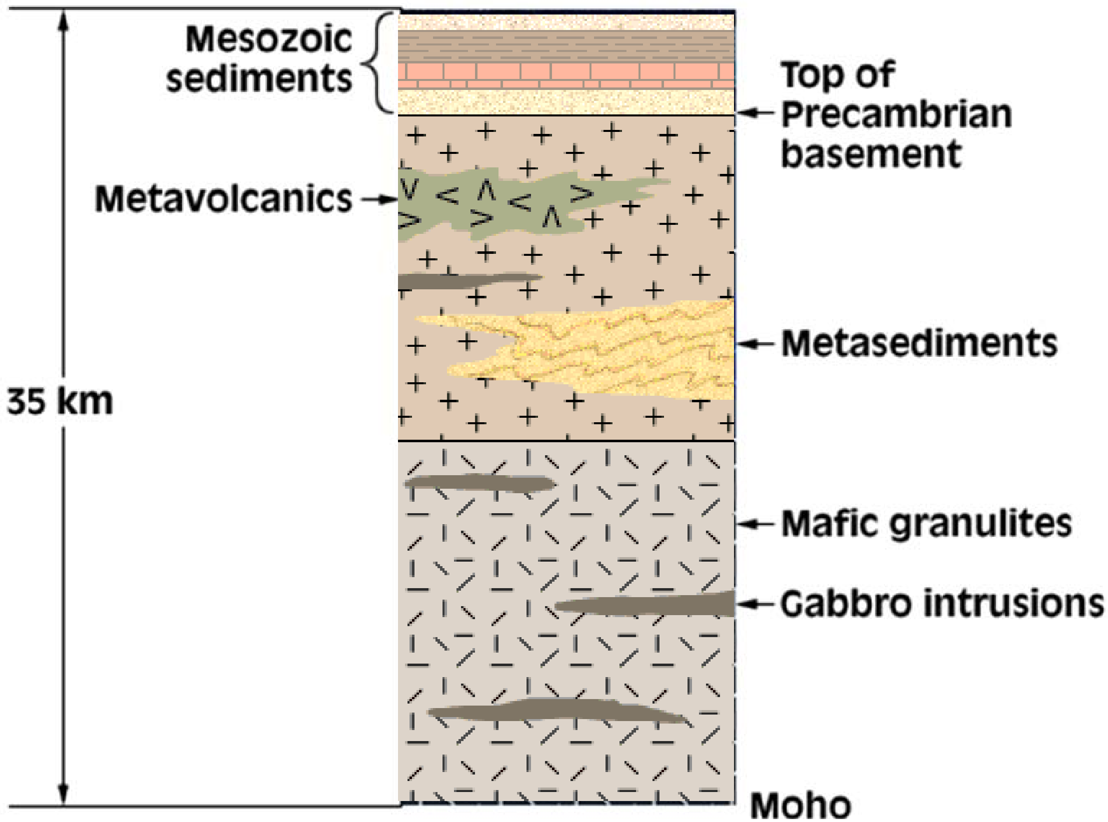
Several blocks of middle to lower continental crust have been recognized in Precambrian shields and in collisional orogens. This is a typical outcrop of felsic granulites from the Limpopo belt in South Africa representing Archean mid-crustal rocks.



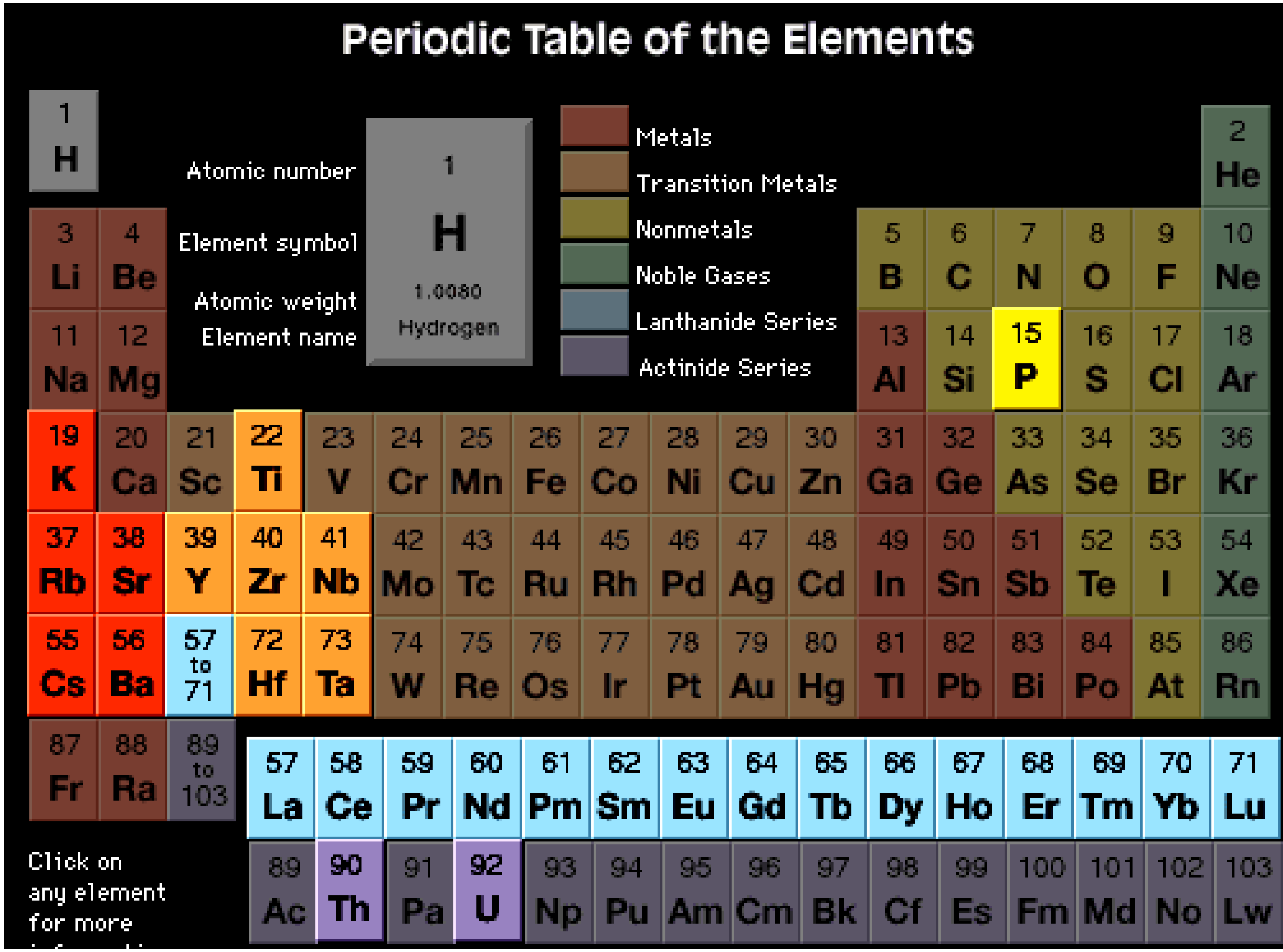
Lower crustal rocks are brought to the surface in large thrust sheets formed during continent-continent collisions.



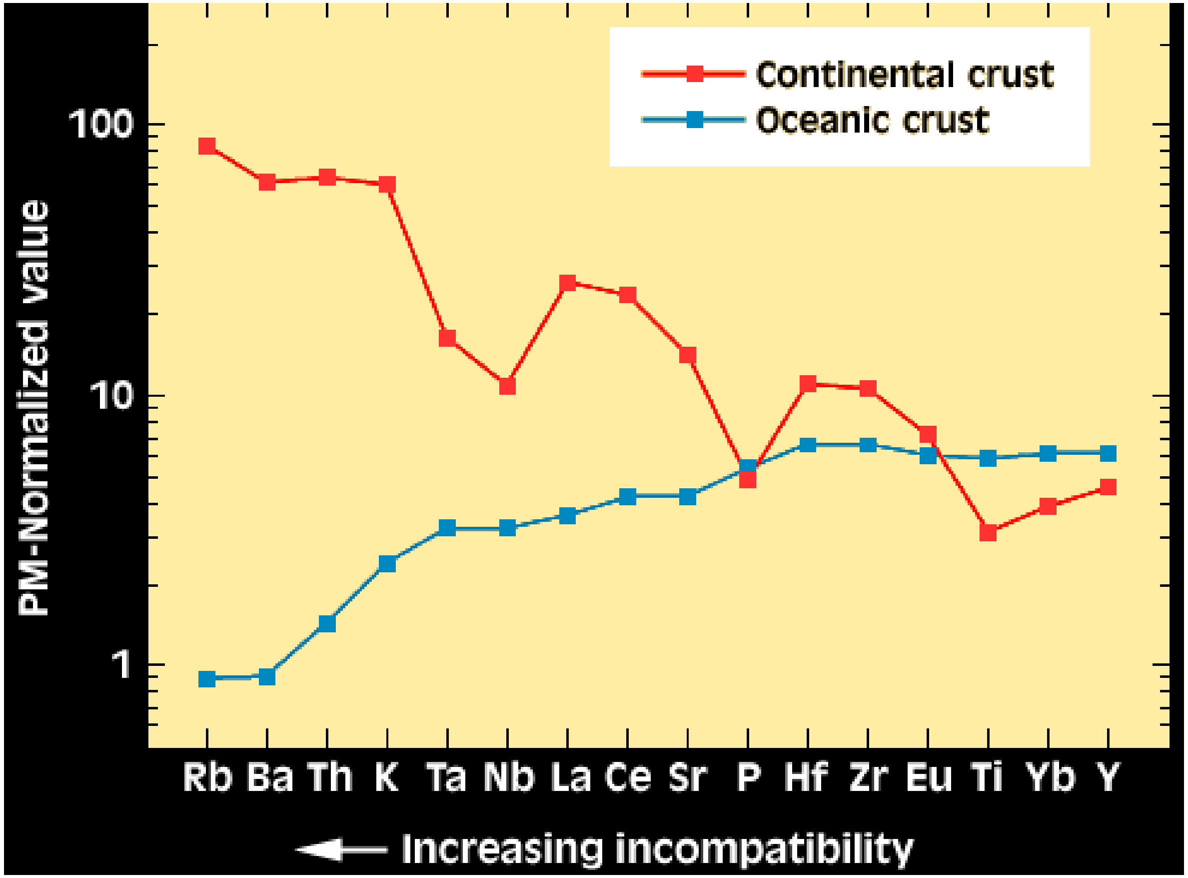
Crustal xenoliths are fragments of the crust brought to the Earth's surface by volcanic eruptions.



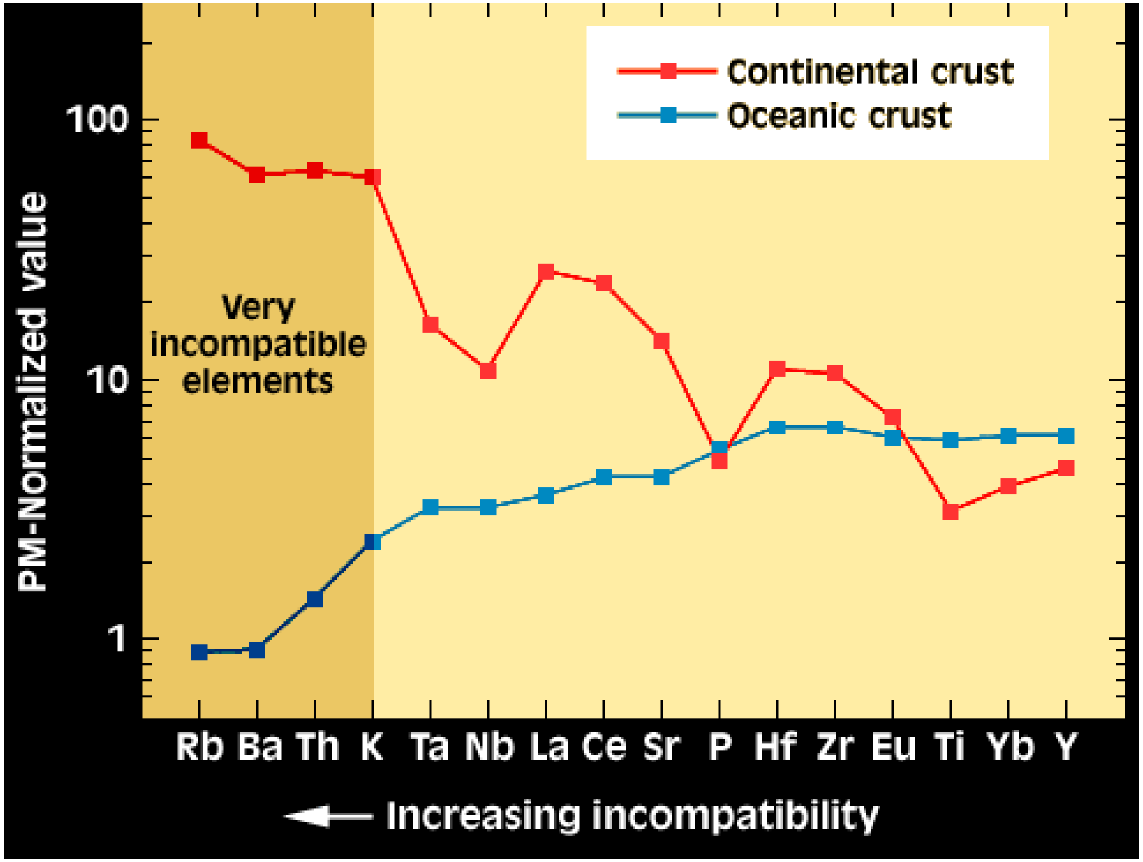
If one can determine the depth from which xenoliths come by thermobarometry, and estimate the relative abundances of various xenoliths in the crust, it should be possible to reconstruct a crustal cross-section, as for instance shown here for NE Arizona.



Incompatible elements are elements that prefer the liquid phase during melting or crystallization. Upon melting of the mantle, they enter basaltic melts and are transferred to the crust. Important incompatible elements in the mantle are shown on the above Periodic Table.

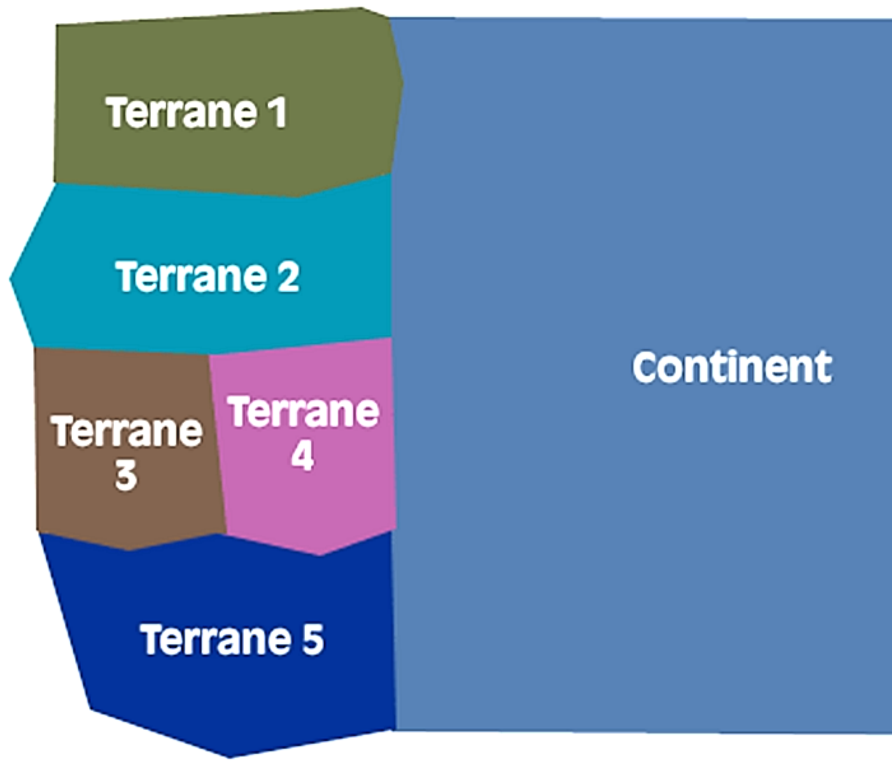


The average compositions of continental and oceanic crust relative to primitive mantle show complementary patterns on this primitive-mantle normalized spidergram. Elements are arranged in order or increasing incompatibility from right to left. Average continental crust is similar to andesite in composition and average oceanic crust is similar to ocean-ridge basalt.

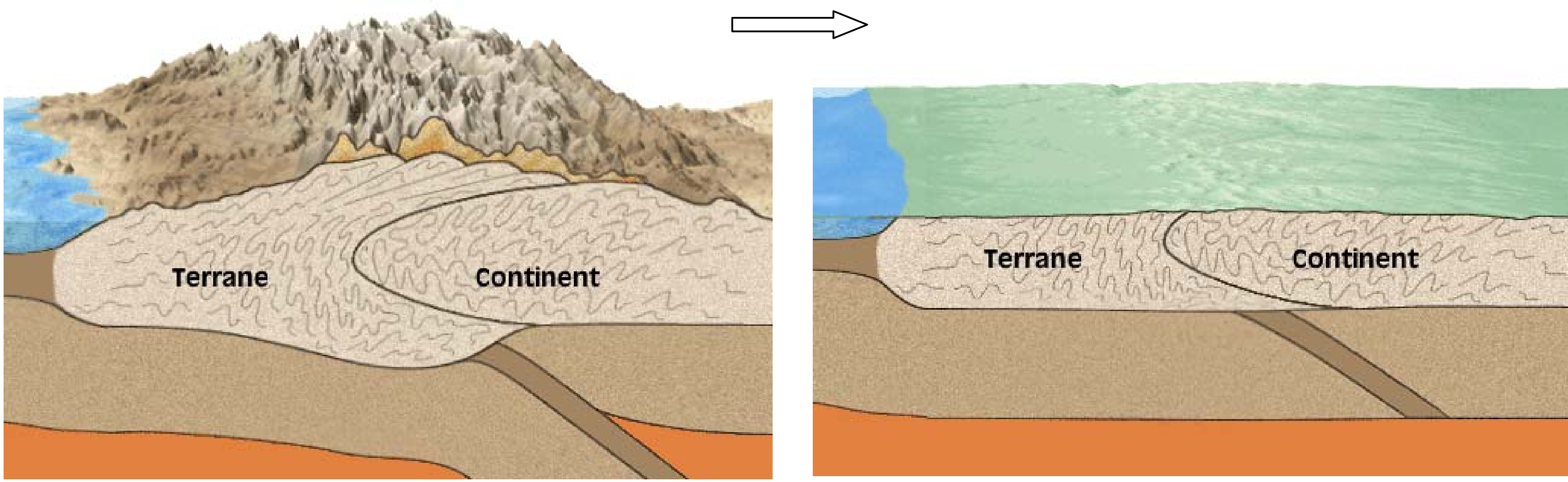


These complementary element patterns can be explained if most of the continental crust is extracted from the upper mantle, leaving an upper mantle depleted in very incompatible elements. The oceanic crust is then continuously produced from this depleted upper mantle throughout geologic time, inheriting the depleted element distribution.

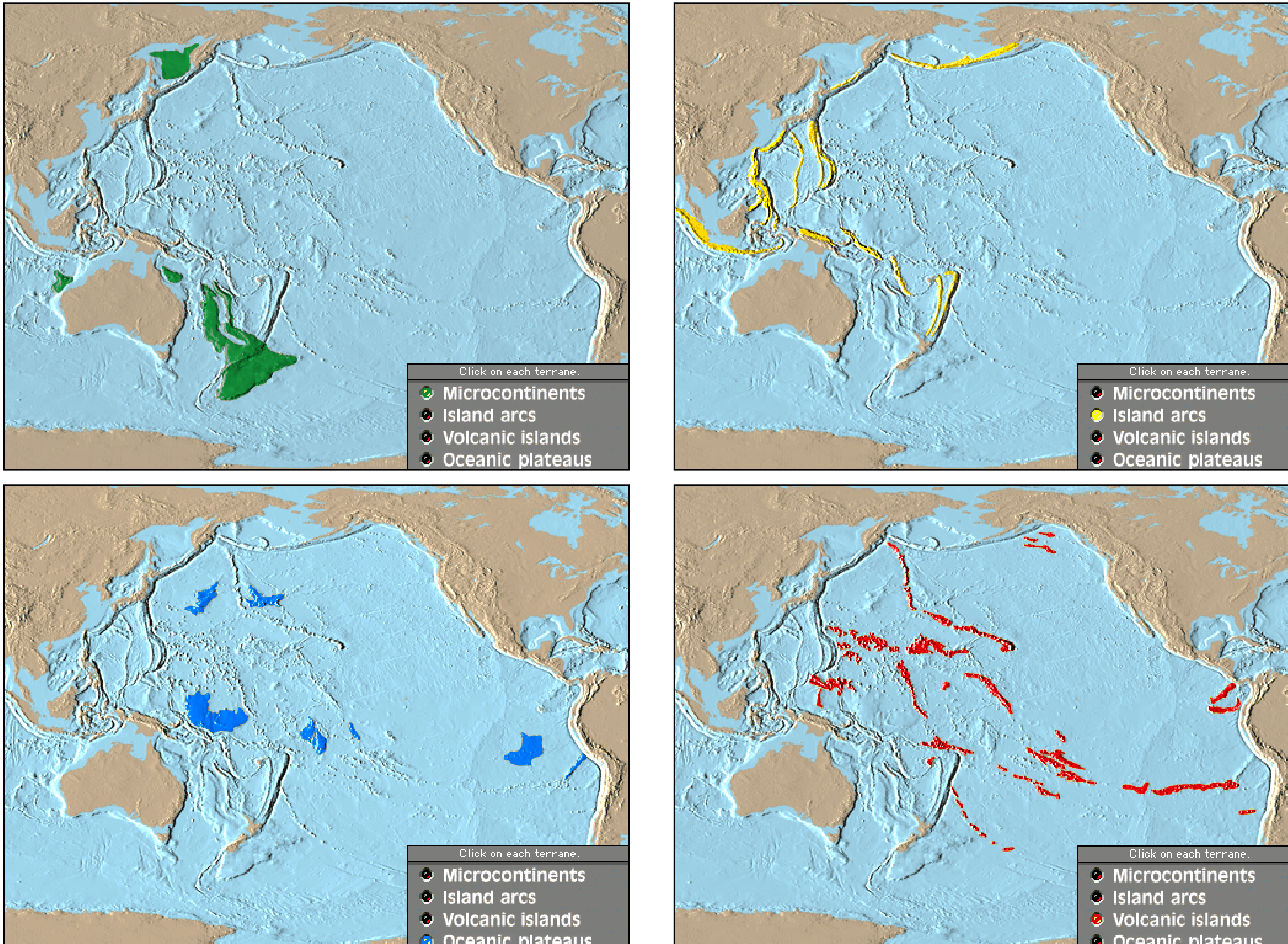
Idealized Terrane Map



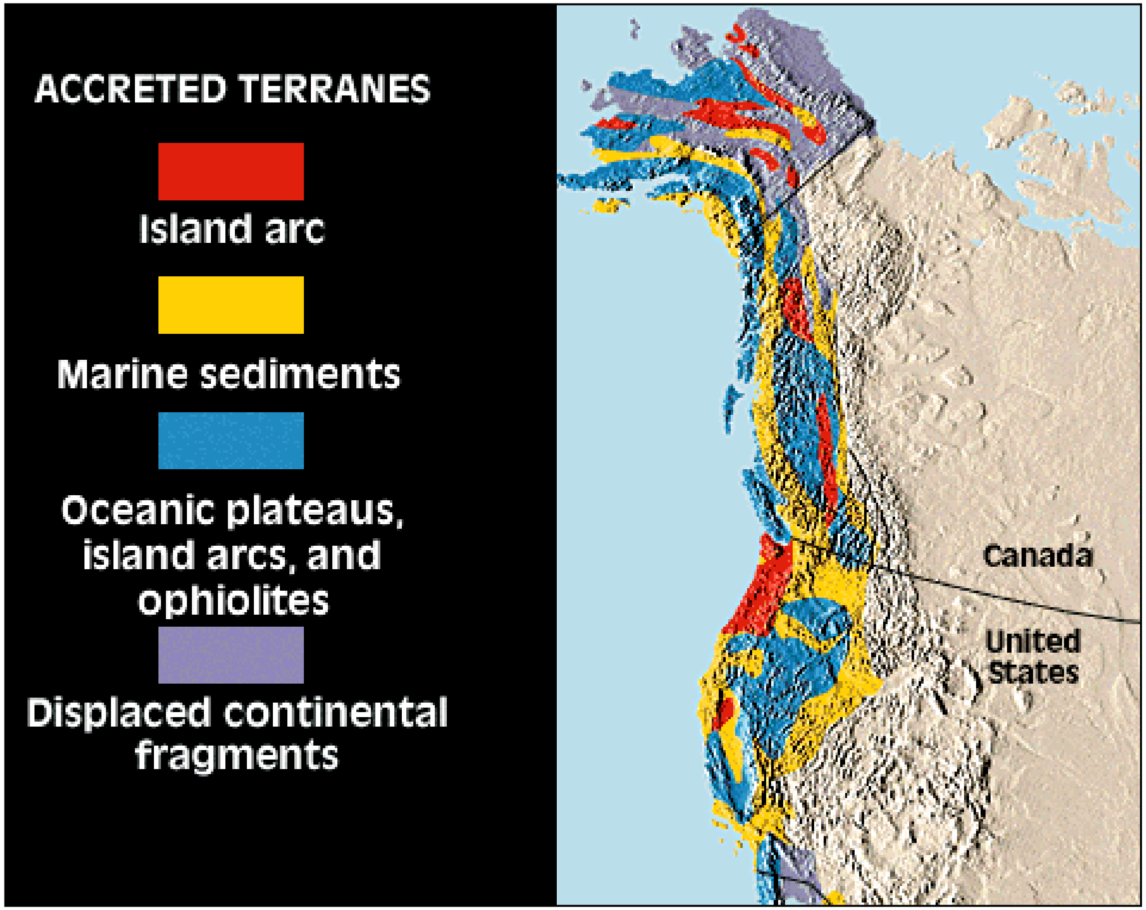
Terranes are fault-bounded lithospheric blocks that have distinct lithologic and stratigraphic successions and that have geologic histories different from neighboring blocks



Most terranes have collided with continental crust, either along transcurrent faults or at subduction zones, and have been sutured to continents.

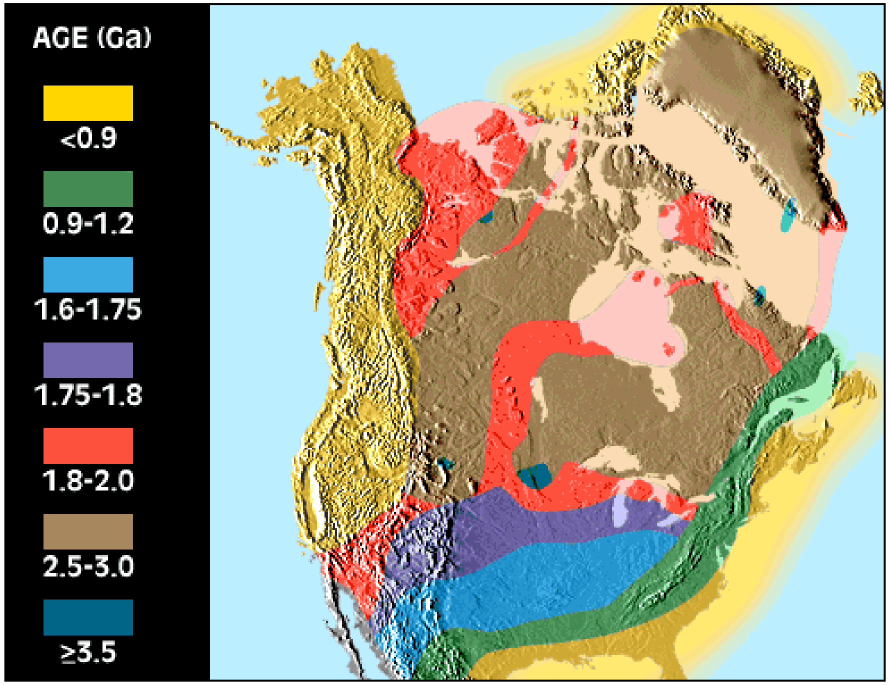


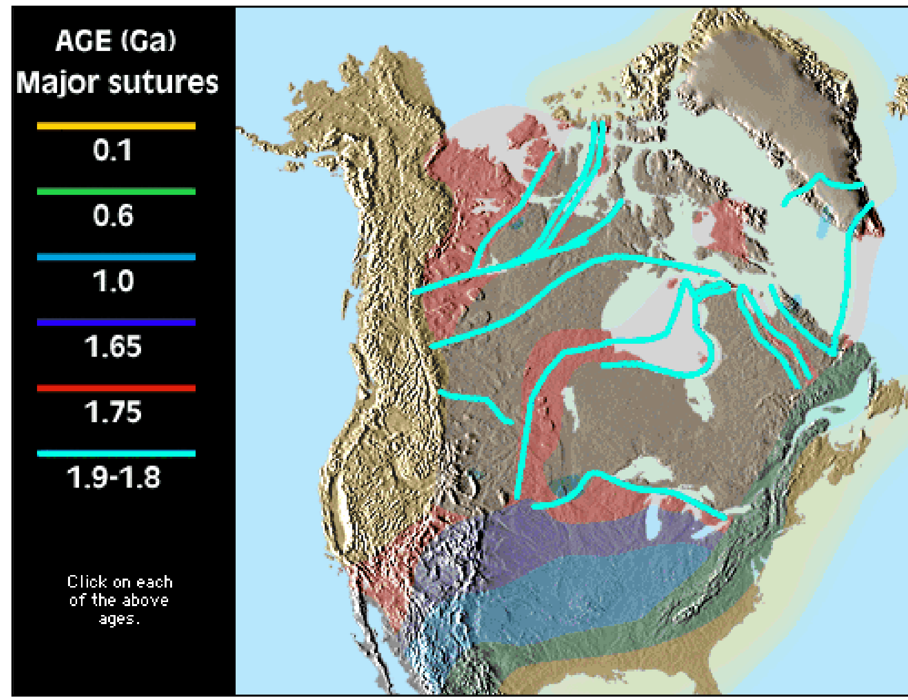
Terranes form in a variety of tectonic settings including island arcs, oceanic plateaus, volcanic islands, and microcontinents. Numerous potential terranes (i.e., they haven't collided yet) exist in the oceans today and are particulary abundant in the Pacific basin.



A crustal province is an orogen, active or exhumed, composed of terranes, and it records a similar range of isotopic ages and exhibits a similar post-accretion deformational history. As shown here for the Cordilleran Province in western North America, terranes are the basic building blocks of crustal provinces, and terrane collision is a major means by which continents grow in size.

North America is an amalgamation of crustal provinces, sometimes referred to as the "United Plates of America".





Although at least 50% of the North American crust was extracted from the mantle in the Archean, the continent was not assembled until the Early Proterozoic. Click on the key above to see the age of important sutures in North America.