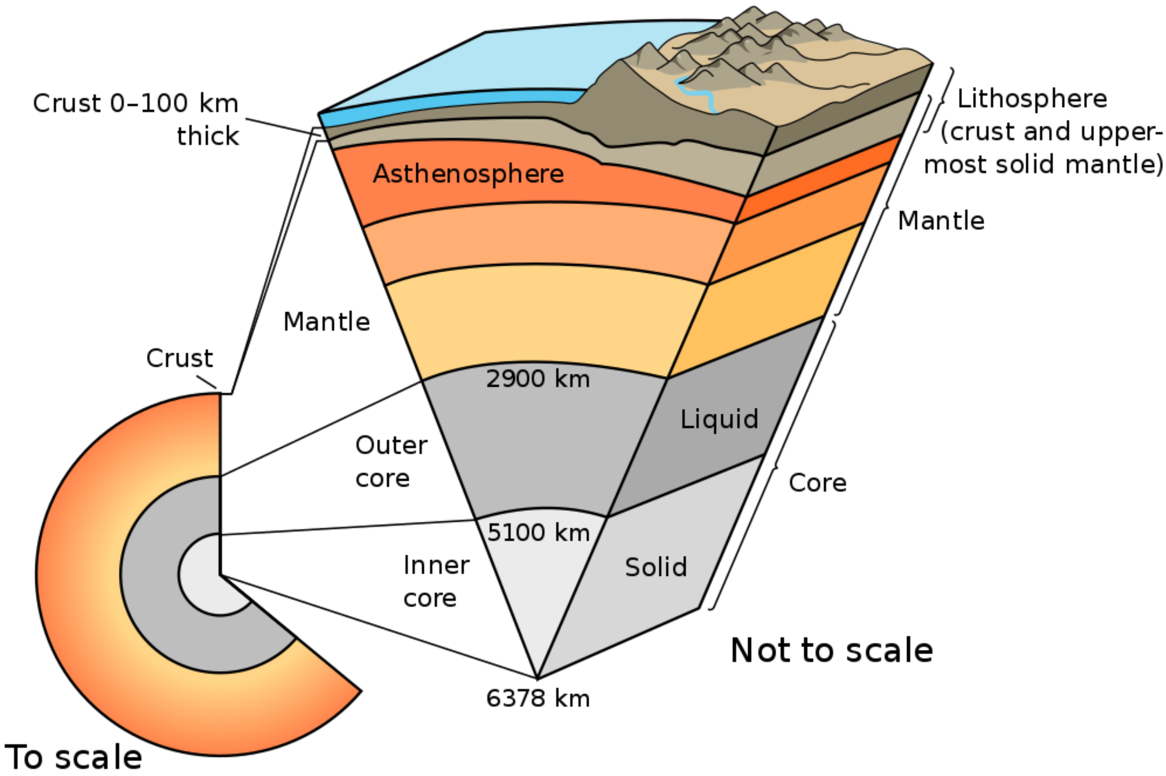
地质类文章背景知识

词汇补充

geologist (geologician) 地质学家
crust 地壳
continental crust 大陆地壳
oceanic crust 海洋地壳
layer (stratum; 复数 strata) 地层
mantle 地幔
core 地核
plate 板块
plate tectonics 板块构造论
fault 断层
disintegration (decomposition)分解
erosion 侵蚀
fossil 化石
rock 岩石
sedimentary rock 沉积岩
metamorphic rock 变质岩
quartz 石英
limestone 石灰岩
marble 大理石
granite 花岗岩
magma 岩浆
prospect 勘探
sounding 测探
mine 采矿
mineral 矿物
ore 矿石
deposit 矿床
platinum 白金;铂
copper 黄铜
aluminum 铝
zine 锌
nickel 镍
mercury (quicksilver)汞;水银
gem 宝石
diamond 钻石
glacier 冰川
glacial 冰川的
glacial epoch (age, period)冰川期
glacial drift 冰碛
iceberg 冰山
(ice)sheet 冰原;冰盖
frigid(refrigerated; freezing)寒冷的
thaw (melt) 融化
retreat 后退
terminate(end)结束
volcano 火山
active volcano 活火山
extinct volcano 死火山
eruption 火山喷发
crater 火山口
lava 火山岩浆
scoria 火山渣
volcanic 火山的
igneous rock 火成岩
solidified 固体化
molten 熔融的
wells 向上涌
interior （地球）内部
coarse-grained 纹理粗糙
fine-grained 纹理细致
erosion 腐蚀
crystal 晶体

背景知识

Tectonic plates



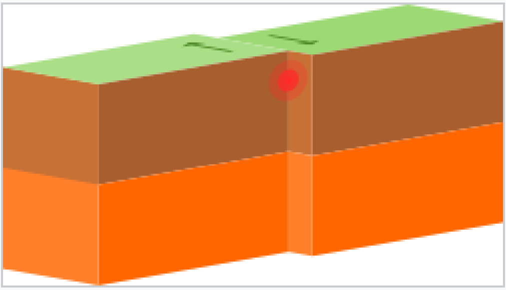
The lithosphere, which is the rigid outermost shell of a planet (the crust and upper mantle), is broken into tectonic plates. The Earth's lithosphere is composed of seven or eight major plates (depending on how they are defined) and many minor plates. Where the plates meet, their relative motion determines the type of boundary: convergent, divergent, or transform. Earthquakes, volcanic activity, mountain-building, and oceanic trench formation occur along these plate boundaries (or faults). The relative movement of the plates typically ranges from zero to 100 mm annually.

Tectonic plates are composed of oceanic lithosphere and thicker continental lithosphere, each topped by its own kind of crust. Along convergent boundaries, subduction, or one plate moving under another, carries the lower one down into the mantle; the material lost is roughly balanced by the formation of new (oceanic) crust along divergent margins by seafloor spreading. In this way, the total surface of the lithosphere remains the same. This prediction of plate tectonics is also referred to as the conveyor belt principle. Earlier theories, since disproven, proposed gradual shrinking (contraction) or gradual expansion of the globe.
Tectonic plates are able to move because the Earth's lithosphere has greater mechanical strength than the underlying asthenosphere. Lateral density variations in the mantle result in convection; that is, the slow creeping motion of Earth's solid mantle. Plate movement is thought to be driven by a combination of the motion of the seafloor away from spreading ridges due to variations in topography (the ridge is a topographic high) and density changes in the crust (density increases as newly formed crust cools and moves away from the ridge). At subduction zones the relatively cold, dense crust is "pulled" or sinks down into the mantle over the downward convecting limb of a mantle cell. Another explanation lies in the different forces

generated by tidal forces of the Sun and Moon. The relative importance of each of these factors and their relationship to each other is unclear, and still the subject of much debate.

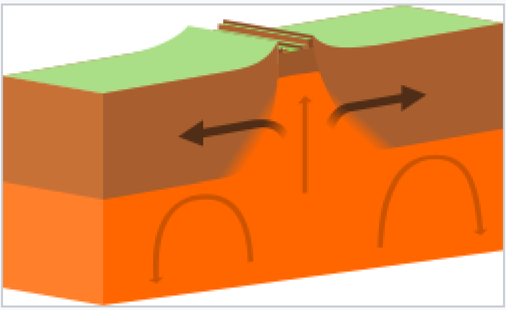
types of plate boundaries

1. ***Transform boundaries*** *(Conservative)* occur where two lithospheric plates slide, or perhaps more accurately, grind past each other along transform faults, where plates are neither created nor destroyed. The relative motion of the two plates is either sinistral (left side toward the observer) or dextral (right side toward the observer). Transform faults occur across a spreading center. Strong earthquakes can occur along a fault. The San Andreas Fault in California is an example of a transform boundary exhibiting dextral motion.



Transform boundary

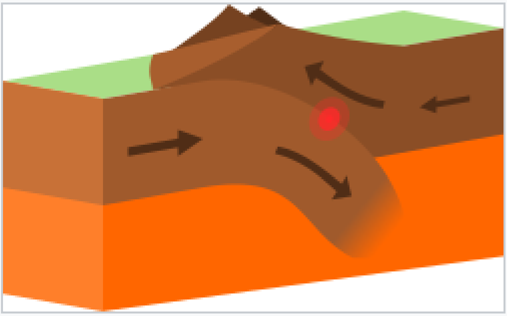
2. ***Divergent boundaries*** *(Constructive)* occur where two plates slide apart from each other. At zones of ocean-to-ocean rifting, divergent boundaries form by seafloor spreading, allowing for the formation of new ocean basin. As the ocean plate splits, the ridge forms at the spreading center, the ocean basin expands, and finally, the plate area increases causing many small volcanoes and/or shallow earthquakes. At zones of continent-to-continent rifting, divergent boundaries may cause new ocean basin to form as the continent splits, spreads, the central rift collapses, and ocean fills the basin. Active zones of mid-ocean ridges (e.g., the Mid-Atlantic Ridge and East Pacific Rise), and continent-to-continent rifting (such as Africa's East African Rift and Valley and the Red Sea), are examples of divergent boundaries.



Divergent boundary

3. ***Convergent boundaries*** *(Destructive)* (or *active margins*) occur where two plates slide toward each other to form either a subduction zone (one plate moving underneath the other) or a continental collision. At zones of ocean-to-continent subduction (e.g. the Andes mountain range in South America, and the Cascade Mountains in Western United States), the dense oceanic lithosphere plunges beneath the less dense continent. Earthquakes trace the path of the downward-moving plate as it descends into asthenosphere, a trench forms, and as the subducted plate is heated it releases volatiles, mostly water from hydrous minerals, into the surrounding mantle. The addition of water lowers the melting point of the mantle material above the subducting slab, causing it to melt. The magma that results typically leads to volcanism. At zones of ocean-to-ocean subduction (e.g. Aleutian islands, Mariana Islands, and the Japanese island arc), older, cooler, denser crust slips beneath less dense crust. This motion causes earthquakes and a deep trench to form in an arc shape. The upper mantle of the subducted plate then heats and magma rises to form curving chains

of volcanic islands. Deep marine trenches are typically associated with subduction zones, and the basins that develop along the active boundary are often called "foreland basins". Closure of ocean basins can occur at continent-to-continent boundaries (e.g., Himalayas and Alps): collision between masses of granitic continental lithosphere; neither mass is subducted; plate edges are compressed, folded, uplifted.



Convergent boundary

4. ***Plate boundary zones*** occur where the effects of the interactions are unclear, and the boundaries, usually occurring along a broad belt, are not well defined and may show various types of movements in different episodes.

Volcano

A **volcano** is a rupture in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamberbelow the surface.

Earth's volcanoes occur because its crust is broken into 17 major, rigid tectonic plates that float on a hotter, softer layer in its mantle.[1] Therefore, on Earth, volcanoes are generally found where tectonic plates are diverging or converging, and most are found underwater. For example, a mid-oceanic ridge, such as the Mid-Atlantic Ridge, has volcanoes caused by divergent tectonic plates whereas the Pacific Ring of Fire has volcanoes caused by convergent tectonic plates. Volcanoes can also form where there is stretching and thinning of the crust's plates, e.g., in the East African Rift and the Wells Gray-Clearwater volcanic fieldand Rio Grande Rift in North America. This type of volcanism falls under the umbrella of "plate hypothesis" volcanism.[2] Volcanism away from plate boundaries has also been explained as mantle plumes. These so-called "hotspots", for example Hawaii, are postulated to arise from upwelling diapirs with magma from the core–mantle boundary, 3,000 km deep in the Earth. Volcanoes are usually not created where two tectonic plates slide past one another.

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

Hotspots are volcanic areas believed to be formed by mantle plumes, which are hypothesized to be columns of hot material rising from the core-mantle boundary in a fixed space that causes large-volume melting.

Because tectonic plates move across them, each volcano becomes dormant and is eventually re-formed as the plate advances over the postulated plume. The Hawaiian Islands are said to have been formed in such a manner; so has the Snake River Plain, with the Yellowstone Caldera being the part of the North American plate above the hot spot. This theory, however, has been doubted.

El Niño & La Niña

El Niño (/ɛl ˈniːn.joʊ/; Spanish: [el ˈniɲo]) is the warm phase of the El Niño Southern Oscillation (commonly called ENSO) and is associated with a band of warm ocean water that develops in the central and east-central equatorial Pacific (between approximately the International Date Line and 120°W), including off the Pacific coast of South America. El Niño Southern Oscillation refers to the cycle of warm and cold temperatures, as measured by sea surface temperature(SST) of the tropical central and eastern Pacific Ocean. El Niño is accompanied by high air pressure in the western Pacific and low air pressure in the eastern Pacific. The cool phase of ENSO is called "La Niña" with SST in the eastern Pacific below average and air pressures high in the eastern and low in western Pacific. The ENSO cycle, both El Niño and La Niña, cause global changes of both temperatures and rainfall.

La Niña is the positive phase of the El Niño–Southern Oscillation and is associated with cooler-than-average sea surface temperatures in the central and eastern tropical Pacific Ocean.[3] However, each country and island nation has a different threshold for what constitutes a La Niña event, which is tailored to their specific interests.[4] For example, the Australian Bureau of Meteorology looks at the trade winds, SOI, weather models and sea surface temperatures in the Niño 3 and 3.4 regions before declaring that a La Niña event has started.[5] However, the Japan Meteorological Agencydeclares that a La Niña event has started when the average five-month sea surface temperature deviation for the NINO.3 region is more than 0.5 °C (0.90 °F) cooler for 6 consecutive months or longer.

Seafloor spreading

Seafloor spreading is a process that occurs at mid-ocean ridges, where new oceanic crust is formed through volcanic activity and then gradually moves away from the ridge.

Spreading center： Seafloor spreading occurs at spreading centers, distributed along the crests of mid-ocean ridges. Spreading centers end in transform faults or in overlapping spreading center offsets. A spreading center includes a seismically active plate boundary zone a few kilometers to tens of kilometers wide, a crustal accretion zone within the boundary zone where the ocean crust is youngest, and an instantaneous plate boundary - a line within the crustal accretion zone demarcating the two separating plates. Within the crustal accretion zone is a 1-2 km-wide neovolcanic zone where active volcanism occurs.

Incipient spreading： In the general case, sea floor spreading starts as a rift in a continental land mass, similar to the Red Sea-East Africa Rift System today. The process starts by heating at the base of the continental crust which causes it to become more plastic and less dense. Because less dense objects rise in relation to denser objects, the area being heated becomes a broad dome (see isostasy). As the crust bows upward, fractures occur that gradually grow into rifts. The typical rift system consists of three rift arms at approximately 120 degree angles. These areas are named triple junctions and can be found in several places across the world today. The separated margins of the continents evolve to form passive margins. Hess' theory was that new seafloor is formed when magma is forced upward toward the surface at a mid-ocean ridge.

If spreading continues past the incipient stage described above, two of the rift arms will open while the third arm stops opening and becomes a 'failed rift'. As the two active rifts continue to open, eventually the continental crust is attenuated as far as it will stretch. At this point basaltic oceanic crust begins to form between the separating continental fragments. When one of the rifts opens into the existing ocean, the rift system is flooded with seawater and becomes a new sea. The Red Sea is an example of a new arm of the sea. The East African rift was thought to be a "failed" arm that was opening somewhat more slowly than the other two arms, but in 2005 the Ethiopian Afar Geophysical Lithospheric Experiment reported that in the Afar region, September 2005, a 60 km fissure opened as wide as eight meters. During this period of initial flooding the new sea is sensitive to changes in climate and eustasy. As a result, the new sea will evaporate (partially or completely) several times before the elevation of the rift valley has been lowered to the point that the sea becomes stable. During this period of evaporation large evaporite deposits will be made in the rift valley. Later these deposits have the potential to become hydrocarbon seals and are of particular interest to petroleum geologists.

Sea floor spreading can stop during the process, but if it continues to the point that the continent is completely severed, then a new ocean basin is created. The Red Sea has not yet completely split Arabia from Africa, but a similar feature can be found on the other side of Africa that has broken completely free. South America once fit into the area of the Niger Delta. The Niger River has formed in the failed rift arm of the triple junction.

Continued spreading and subduction: As new seafloor forms and spreads apart from the mid-ocean ridge it slowly cools over time. Older seafloor is therefore colder than new seafloor, and older oceanic basins deeper than new oceanic basins due to isostasy. If the diameter of the earth remains relatively constant despite the production of new crust, a mechanism must exist by which crust is also destroyed. The destruction of oceanic crust occurs at subduction zones where oceanic crust is forced under either continental crust or oceanic crust. Today, the Atlantic basin is actively spreading at the Mid-Atlantic Ridge. Only a small portion of the oceanic crust produced in the Atlantic is subducted. However, the plates making up the Pacific Ocean are experiencing subduction along many of their boundaries which causes the volcanic activity in what has been termed the Ring of Fire of the Pacific Ocean. The Pacific is also home to one of the world's most active spreading centers (the East Pacific Rise) with spreading rates of up to 13 cm/yr. The Mid-Atlantic Ridge is a "textbook" slow-spreading center, while the East Pacific Rise is used as an example of fast spreading. Spreading centers at slow and intermediate rates exhibit a rift valley while at fast rates an axial high is found within the crustal accretion zone. The differences in spreading rates affect not only the geometries of the ridges but also the geochemistry of the basalts that are produced.

Since the new oceanic basins are shallower than the old oceanic basins, the total capacity of the world's ocean basins decreases during times of active sea floor spreading. During the opening of the Atlantic Ocean, sea level was so high that a Western Interior Seaway formed across North America from the Gulf of Mexico to the Arctic Ocean.

Glacier

A **glacier** (US: /ˈɡleɪʃər/ or UK: /ˈɡlæsiər/) is a persistent body of dense ice that is constantly moving under its own weight; it forms where the accumulation of snow exceeds its ablation (melting and sublimation) over many years, often centuries. Glaciers slowly deform and flow due to stresses induced by their weight, creating crevasses, seracs, and other distinguishing features. They also abrade rock and debris from their substrate to create landforms such as cirques and moraines. Glaciers form only on land and are distinct from the much thinner sea ice and lake ice that form on the surface of bodies of water.

On Earth, 99% of glacial ice is contained within vast ice sheets (also known as "continental glaciers") in the polar regions, but glaciers may be found in mountain ranges on every continent including Oceania's high-latitude oceanic island countries such as New Zealand and Papua New Guinea. Between 35°N and 35°S, glaciers occur only in the Himalayas, Andes, Rocky Mountains, a few high mountains in East Africa, Mexico, New Guinea and on Zard Kuh in Iran. Glaciers cover about 10 percent of Earth's land surface. Continental glaciers cover nearly 13 million km2 (5 million sq mi) or about 98 percent of Antarctica's 13.2 million km2 (5.1 million sq mi), with an average thickness of 2,100 m (7,000 ft). Greenland and Patagonia also have huge expanses of continental glaciers.

Glacial ice is the largest reservoir of fresh water on Earth. Many glaciers from temperate, alpine and seasonal polar climates store water as ice during the colder seasons and release it later in the form of meltwater as warmer summer temperatures cause the glacier to melt, creating a water source that is especially important for plants, animals and human uses when other sources may be scant. Within high-altitude and Antarctic environments, the seasonal temperature difference is often not sufficient to release melt water.

Since glacial mass is affected by long-term climatic changes, e.g., precipitation, mean temperature, and cloud cover, glacial mass changes are considered among the most sensitive indicators of climate change and are a major source of variations in sea level.

A large piece of compressed ice, or a glacier, appears blue, as large quantities of water appear blue. This is because water molecules absorb other colors more efficiently than blue. The other reason for the blue color of glaciers is the lack of air bubbles. Air bubbles, which give a white color to ice, are squeezed out by pressure increasing the density of the created ice.

Glaciers erode terrain through two principal processes: abrasion and plucking.

As glaciers flow over bedrock, they soften and lift blocks of rock into the ice. This process, called plucking, is caused by subglacial water that penetrates fractures in the bedrock and subsequently freezes and expands. This expansion causes the ice to act as a lever that loosens the rock by lifting it. Thus, sediments of all sizes become part of the glacier's load. If a retreating glacier gains enough debris, it may become a rock glacier, like the Timpanogos Glacierin Utah.

Abrasion occurs when the ice and its load of rock fragments slide over bedrock and function as sandpaper, smoothing and polishing the bedrock below. The pulverized rock this process produces is called rock flour and is made up of rock grains between 0.002 and 0.00625 mm in size. Abrasion leads to steeper valley walls and mountain slopes in alpine settings, which can cause avalanches and rock slides, which add even more material to the glacier.

Glacial abrasion is commonly characterized by glacial striations. Glaciers produce these when they contain large boulders that carve long scratches in the bedrock. By mapping the direction of the striations, researchers can determine the direction of the glacier's movement. Similar to striations are chatter marks, lines of crescent-shape depressions in the rock underlying a glacier. They are formed by abrasion when boulders in the glacier are repeatedly caught and released as they are dragged along the bedrock.
The rate of glacier erosion varies.

Six factors control erosion rate:

- Velocity of glacial movement
- Thickness of the ice
- Shape, abundance and hardness of rock fragments contained in the ice at the bottom of the glacier
- Relative ease of erosion of the surface under the glacier
- Thermal conditions at the glacier base
- Permeability and water pressure at the glacier base

When the bedrock has frequent fractures on the surface, glacial erosion rates tend to increase as plucking is the main erosive force on the surface; when the bedrock has wide gaps between sporadic fractures, however, abrasion tends to be the dominant erosive form and glacial erosion rates become slow.

Glaciers in lower latitudes tend to be much more erosive than glaciers in higher latitudes, because they have more meltwater reaching the glacial base and facilitate sediment production and transport under the same moving speed and amount of ice.
Material that becomes incorporated in a glacier is typically carried as far as the zone of ablation before being deposited.

Glacial deposits are of two distinct types:

- ***Glacial till*****:** material directly deposited from glacial ice. Till includes a mixture of undifferentiated material ranging from clay size to boulders, the usual composition of a moraine.
- ***Fluvial and outwash sediments*****:** sediments deposited by water. These deposits are stratified by size.

Larger pieces of rock that are encrusted in till or deposited on the surface are called "glacial erratics". They range in size from pebbles to boulders, but as they are often moved great distances, they may be drastically different from the material upon which they are found. Patterns of glacial erratics hint at past glacial motions.