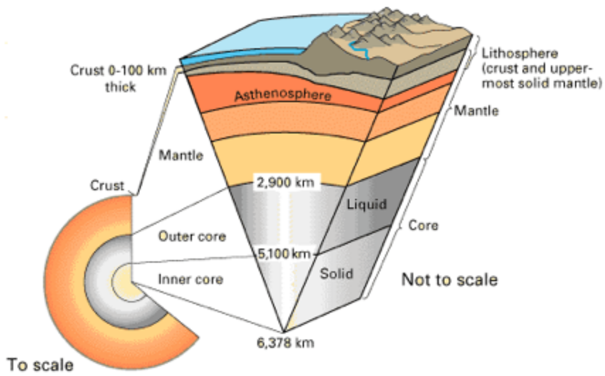
TECTONIC PLATES

LAYERS OF THE EARTH



INNER CORE

A solid metallic ball that is unattached to the mantle. The solidified state is the result of a very intense pressure-freezing process. The aggregate state depends of the pressure AND the temperature. The higher the pressure the higher the boiling and melting temperature. Due to the high pressure the temperature couldn't provide the conditions that the core stays liquid.

- Density: 12.8 – 13.1 g/cm^3
- Composition: Iron and nickel
- Temperature: 5500°

OUTER CORE

The outer core is liquid. It is believed that the earth's magnetic field is generated by the movements in the liquid outer core. The liquid layer which is electrically conductive (elektrisch leitend) moves around the solid inner core. The nickel and iron parts move counterrally against each other and convection takes place. (The movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, and colder, denser material to sink under the influence of gravity, which consequently results in transfer of heat). The combination of the rotation and the convection causes a dynamo effect. The result is a force field of electrical currents, the magnetic field. For a dynamo effect to happen, a planet needs a liquid layer and iron.

It protects us from the sun radiation (the ionized particles from the solar wind) by deflecting them to the north and south pole showing there as the northern lights (radioactive). The magnetic field is responsible for the functioning of mechanical and biological compasses. There is a risk that we have an electric break down is there. Particles ionized in a solar wind gast can affect voltage in a power line/power plant and make a short circuit (Kurzschluss). The risk is higher at solar maximum, every 11th year this maximum is reached.

- Density: 9.9 – 12.2 g/cm^3
- Composition: Mainly iron and nickel, Sulphur and oxygen
- Temperature: ?

LOWER MANTLE

Solid layer of the earth. Making the earth abundant in the chemical elements contained there.

- Density: 3.4 – 9.6 g/cm^3
- Composition: silicon, magnesium, oxygen
- Temperature:

UPPER MANTLE

Semi solid layer of the earth.

- Density: 3.4 – 9.6 g/cm^3
- Composition: Crystalline forms of Olivine and Pyroxene
- Temperature:

OCEANIC CRUST

Solid layer and smallest part of the earth's mass. Has higher density than the continental crust. Is thinner than the continental crust.

- Density: 2.2 – 2.9 g/cm^3
- Composition: Basalt (darker rocks), silica and magnesium
- Temperature:

CONTINENTAL CRUST

Solid and is heavier but less dense than the oceanic crust.

- Density: 2.2 – 2.9 g/cm^3
- Composition: crystalline rocks made of low-density minerals --> quartz and feldspars, granite, silica and aluminum
- Temperature:

MORE INFO

DENSITY

Because of the Earth gravity (during the Earth formation, when the Earth still was liquid), havier elements move in the center. Equals more dense material move towards the center and less dense material float on top of more dense material.

EARTH'S SURFACE

Because of mountain ranges, the rotation of the earth flattens it → The gravitation isn't strong enough so the diameter at the equator gets bigger, gravity isn't everywhere the same, because the density is not equally distributed, the gravitation of the moon, the tides, also effects the land (about 10 cm).

BOREHOLE

The Russians searched for Moho, the density difference from crust and mantle, or rather the mantle. They could reach 12 kilometers depth and water inside the crust.

ASTENOSPHERE

Lower part of the upper mantle;
Differentiation: semi molten, viscose, moves very slowly (They don't differentiate with the composition.)

LITOSPHERE

Continental crust, oceanic crust and upper part of mantle;

Differentiation: solid

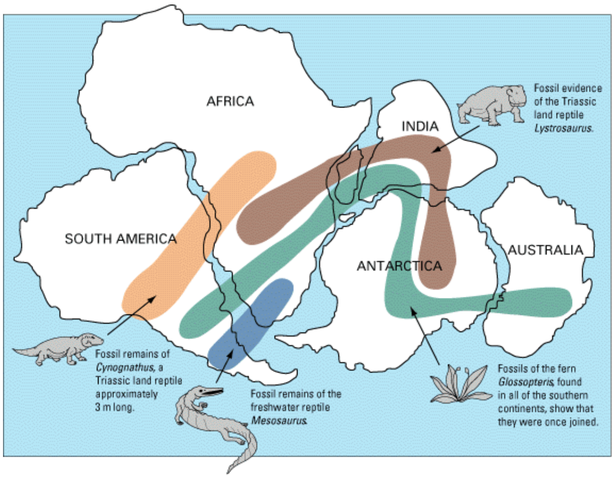
CONRAD DISCONTINUITY

Division between the continental and oceanic crust.

CONTINENTAL DRIFT

Theory that continents move slowly on the earth's surface.

ALFRED WEGENER



Alfred investigated the fit of the Atlantic coast. He was able to group all continents together into one land mass, Pangea, by looking at the similarities from fossils and geological features and the coast lines. He thought that the breaking apart started 200 million years ago.

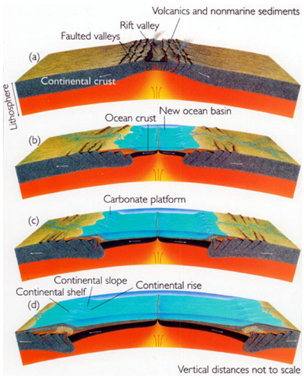
The glaciers in Scandinavia were so heavy that they pushed the whole area down 200 - 300 meters. As the glaciers melted away Scandinavia rose again a few centimeters per year. The upward movement and the followed inflow of matter indicates, that the magma must be liquid in order to inflow. Like a floss on water.

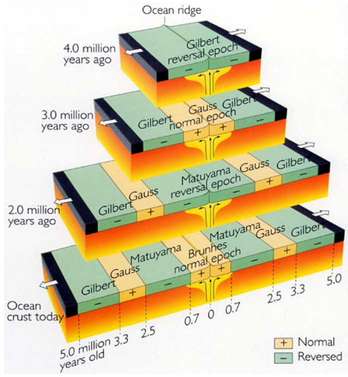
Wrong about his theory was the fact that continental drift started way before 200 million years ago. The continents have always slowly been moving. He thought the sea floor remains and the continents move like ships on the seafloor but actually part of the ocean floor does also belong to the plate

PALEOMAGNETISM – STUDY OF MAGNETISM IN ACIENT ROCKS

Rocks are magnetized in a direction to the earth's magnetic field. The earth's magnetic field has reversed its direction many times. When rocks are formed, they are magnetized, because they contain iron and as it cooled down it won't change the direction anymore. That causes the magnetic direction in the rocks to be normal and reversed again.

MID-ATLANTIC RIDGE



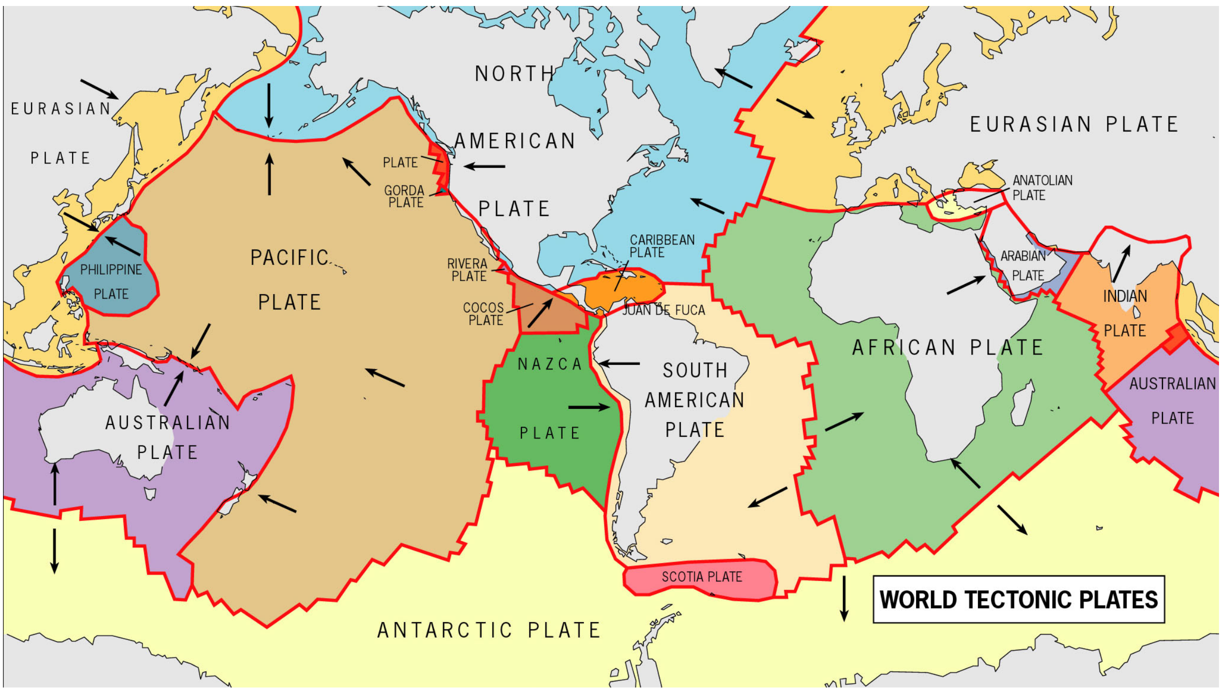


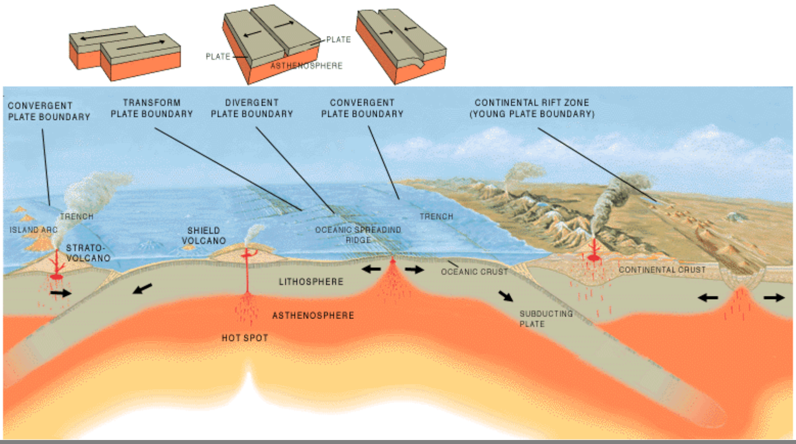
The Mid-Atlantic Ridges are record of magnetic field on the ocean floors. They represent places where molten material from the mantle is rising. As it reaches the surface the material heaps up from the ridge and moves out sideways. At the ridge the material is magnetized, depending on the magnetic field. New rocks from the range spread over the sea floor. As the motion goes in one direction sideways. The sea floor becomes larger. Older rocks, volcanoes and islands move always further away from the ridge. The stripes are parallel to the ridges and if you go further away from the ridge the magnetism gets weaker.

PLATE TECTONICS

A set of theories which describe and explain the distribution of earthquakes, volcanoes, fold mountains and continental drift. It states that the earth's core consists of semi-molten magma and that the earth surface or crust moves around on the magma. *The cause of the movement is radioactive decay in the core. This creates huge convection currents in the magma, which rises towards the earth's surface, drag continents apart, and cause them to collide.*

PLATE BOUNDARIES





Type of Boundary	Processes
Constructive margins (spreading or divergent plates)	Two plates move apart from each other; new oceanic crust is formed and creating mid-oceanic ridge – volcanic activity is common
Destructive margins (Subduction zone)	Oceanic and continental crust collide, and the oceanic crust sinks due to greater density; deep sea trenches and island arcs are formed; volcanic activity is common
Collision zone	Two continental crusts collide, and neither can sink; they are folded up into mountains
Conservative margins (passive margins or transform plates)	Two plates move sideways past each other

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TECTONIC PROCESSES

DIVERGENT

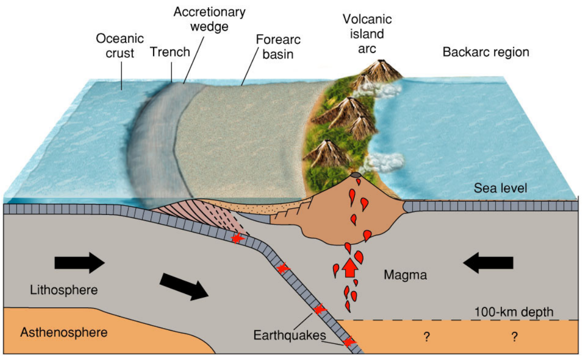
Two plates are moving apart at ocean ridges or continental drifts → splitting of the crust. Through this gap the lava can easily escape (→ lava flow or volcanic eruption). The lava creates new crust & forms a mid-ocean-ridge. Example: Island (reason for volcanic eruptions & earthquakes on island).

Because of the opening up of a continent a continental rift zone is formed. It is a long, narrow fissure (=Spalt) in the earth.

CONVERGENT

Two plates are moving together & one plate is forced beneath another forming ocean trenches or mountain building. This process leads to a subduction of the crust → **destructive** plate boundary. The zone of friction (=Reibung/Spannung) is called benoiv. Right at the shore of the continent an accreationary wedge (=Keil) forms. Volcanoes are present along the coastal mountain range because the diving of one plate beneath another causes a rise in pressure of the magma. The mountain range is often folded/deformed due to enormous pressures. Therefore, in many cases the rocks there are metamorphic (rocks that change because of pressure & heat, minerals tend to become greener & increase in size).

OCEANIC AND OCEANIC

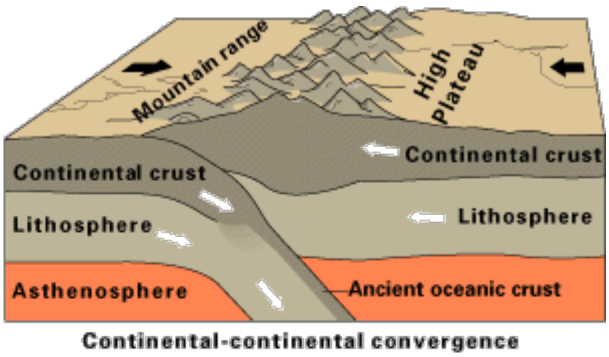


If one plate is warmer than the other, the colder one is diving underneath it. Further away from the coast a deep ocean trench occurs due to the downward bend of the crust. This tectonic process isn't causing a big mess because these plates are lighter.

The descending mantle current tends to drag (=mitreissen) the crust down with it, forming a **deep ocean trench** or piling up young mountains. At the same time, the continental crust tends to ride over the oceanic crust, because it is the lighter one.

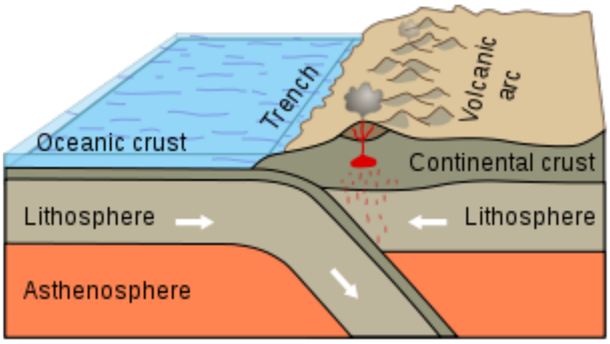
Accretionary wedge: The sediments from the ocean falls down producing a layer of sediments on the basalt. The older it is the thicker it gets. A part comes from the scratching of.

CONTINENTAL AND CONTINENTAL



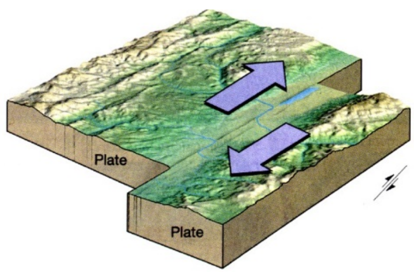
Because neither of the two plates can sink they are folded up into mountains. Example: As the Indian Plate collided with the Eurasian plate the Himalayas were formed.

OCEANIC AND CONTINENTAL



The denser oceanic plate dives underneath the less dense continental plate. Further away from the coast a deep ocean trench occurs due to the downward bend of the crust. Volcanic activity is common. Example: Nazca sinks under the South American plate.

TRANSFORM AND TRANSCURRENT



Two plates are moving past each other & are neither constructive nor destructive (→ no volcanic eruptions). The pressure builds up & when it is released earthquakes occur. Only example: San Andreas fault in California.

MORE INFO

VOLCANIC ISLAND FORMING

Plates move together → causes magma to squeeze out because plate shift under the other causing high pressure. Plates move away from each other → the density causes that some lighter magma tend to go up.

HOT SPOT AREAS

Hawaii and Canary Islands is a hot spot/hot area. An area with a hot type of magma. Because the plates are moving, the volcanoes tend to shift. South east active but north west not active because they are away from the hot spot which remains the same.

VOLCANOES / HOT SPOTS

Most volcanoes & earthquakes are found along plate boundaries. There are a number of volcanoes that sit in the middle of plates. These volcanoes have formed above a hot spot - a single plume of rising mantle. Hot spots are found in the ocean & on continents.
Hot spot volcanism is unique because it doesn't occur at the boundaries of Earth's tectonic plates, where all other volcanism occurs. Instead it occurs at abnormally hot centers known as mantle plumes.

HIMALAYA AND ALPS

Because two continents drifted against each other and piled up to the alps (Africa plate, European plate and oceanic plates) and Himalaya (Indian peninsula into Asian plate)

Swiss alps rise 1 mm per year and gets eroded 1 mm per year - it stays the same as long as they are rising.

EARTHQUAKE

FORMATION

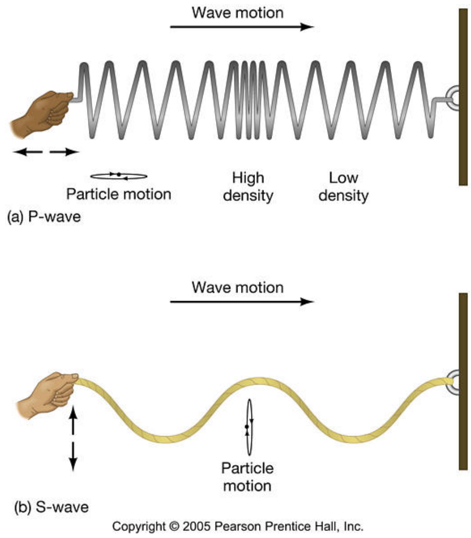
If energy is released in the earth's crust, the surface vibrates which causes an earthquake. This energy can be generated by a sudden dislocation of segments of the crust, by a volcanic eruption or by manmade explosions. In the process of breaking (if the crust is 'snapping' to a new position), vibrations (shock waves) are generated. These waves travel outward from the source of the earthquake along the surface & through the earth at varying speeds depending on the material on which they move.

Earthquakes tend to reoccur along faults, which reflect zones of weakness in the earth's crust (a fault is the result of a transform plate boundary). Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur. Relieving stress along one part of the fault can also increase stress in another part.
The **focal depth** of an earthquake is the depth from the earth's surface to the region where an earthquake's energy originates (=> the **focus**). The foci of most earthquakes are concentrated in the crust & upper mantle. The **epicenter** of an earthquake is the point on the Earth's surface directly above the focus. The location of an earthquake is described by the geographic position & its focal depth. The further away from the ocean, the deeper are the foci of earthquakes because the contact zone of the two plates is deeper.

Liquefaction (= Verflüssigung) causes major damage during earthquakes. This happens when loosely packed, water-logged sediments lose their strength because of the strong shaking.

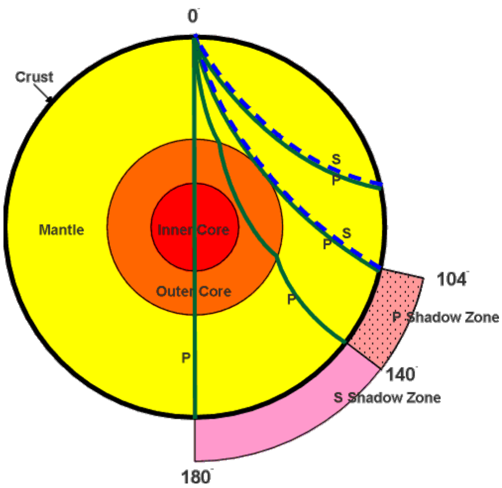
MEASUREMENT

The vibrations produced by earthquakes are detected, recorded & measured by **seismographs**. The **seismogram** (the lines made by a seismograph) reflects the changing intensity of the vibrations by responding to the motion of the ground surface beneath the instrument. From data expressed in seismograms you can determine the time, epicenter, focal depth & the type of faulting of an earthquake. You can also estimate how much energy was released (→ **magnitude** of the earthquake).



There are two general types of vibrations:

- **surface waves**: They travel along the earth's surface & have usually the strongest vibrations & probably cause most of the damage.
- **body waves**: They travel through the earth (from the focus to the distant points on the surface) & can move in all three directions. They can travel through solid rock.
  - **P waves** (compressional waves): They can travel through the Earth's outer molten core & are faster than S waves. P waves push tiny particles of earth material directly ahead or displace them behind their line of travel.
  - **S waves** (shear waves): They don't travel at the speed of P waves & displace material at right angles to their path. S waves are electromagnetic waves.



The first indication of an earthquake is often a sharp thud (=dumpfer Schlag), signaling the arrival of compressional waves. This is followed by the S waves & then the 'ground roll' caused by the surface waves. The severity (=Schwere) can be expressed in several ways. The **Richter Scale** is a measure of the amplitude of the seismic waves & usually expresses the *magnitude* of an earthquake. The magnitude can be estimated from seismographic readings. This scale is logarithmic so that f.e. a recording of 7 indicates a disturbance with ground motion 10 times as large as a recording of 6. The scale is open, but there was never an earthquake with a magnitude of 10.

The **Mercalli Scale** is a subjective measure that describes how strong a shock was felt at a particular location → expresses the *intensity* of an earthquake. This scale ranges from I to XII.
Earthquakes of large magnitude do not necessarily cause the most intense surface effects. The effect depends on local surface & subsurface geological conditions: An area underlain by unstable ground (sand, clay,…) is likely to experience much more noticeable effects than an area equally distant from an earthquake's epicenter but underlain by firm ground (granite) → the intensity may be higher & the destruction bigger, but the earthquake isn't stronger!).

PREDICTION

Scientists estimate earthquakes in two ways: studying the history of large earthquakes in a specific area & the rate at which strain (=Spannung) accumulates in the rock.

1. They study the past frequency of past earthquakes in order to determine the future likelihood of similar large shocks. But in many places the assumption of random occurrence with time may not be

true, because when strain is released along one part of the fault system, it may actually increase on another part.

2. Another way is to study how fast strain accumulates. When plate movements build the strain in the rocks to a critical level, the rocks will suddenly break & slip to a new position. Scientists can measure how much strain accumulates along a fault segment each year, how much time has passed since the last earthquake along the segment & how much strain was released in the last earthquake. With this information they can calculate the time required for the accumulating strain to build to the level that results in an earthquake. Problem: such detailed information about faults is rare (only San Andreas fault).

Both of these methods are being tested along the part of the San Andreas fault.

TSUNAMI

Tsunamis are caused by large undersea disturbances that contain a strong vertical motion. Such quakes often occur where one of earth’s tectonic plate dives/’subducts’ beneath another. Sometimes they are also caused by landslides or volcanoes.
As waves spread from the epicenter in a typical arc-shaped pattern, their energy also spreads out. The extreme wavelength of tsunamis distinguishes them from ‘normal’ waves. Tsunamis slow when the lower part of the wave encounters the upward-sloping ocean floor. But while the front of the wave slows, the wave behind is still moving faster, causing a giant pile-up at the front. The kinetic energy that was spread through the ocean depth concentrates in a towering wave at the surface.
Like all waves, tsunamis have a rising & a falling motion. If you see the water retreating, you should immediately head away from the shore. Another quirk: Tsunami waves can be spaced as much as one hour apart, so subsequent (=folgende) waves can kill those who return to help victims of earlier waves.