Volcanoes and Rocks

Volcanoes

Vocanoes are an opening in the cust through which magma, molten rock and ash are erupted. There are explosive (material gets catapulted) and effusive (material flows out) volcanoes. The ash particles release can produce lightnings as they friction. Ring of Fire: ¾ of the world's active volcanoes which lie along the pacific.

Mount St. Helena, USA: Very strong eruption, 400m of the mountain got blasted away and 700m^2 was covered in ash.

Why do Volcanoes erupt?

Because magma liquid magma is less dense than its rock, it begins to float upward through the lithosphere. It can do that by finding a path by fracturing the lithosphere along zones of weakness or by melting it way towards the surface. Some of the magma reaches the surface and erupts as lava. A volcano is a hill or mountain constructed from the accumulation of lava or other erupted materials. The entire sequence of events from melting to eruption is considered a volcanic geosystem. The geosystem can be viewed as a chemical factory that processes magma from the asthenosphere and transports the end product, lava, to the surface by a plumbing system.

1. Rocks melt to Magma due to pressure
2. Magma rises and gathers in a magma chamber
3. While raising it gains chemical components
4. This chamber periodically empties through a pipe-like feeder channel to a central vent (Lava can also erupt through vertical cracks and other vents)

Lava gets to the surface and Gaseous constituents get released in the atmosphere and ocean if an eruption occurs. By looking at them we can extract clues of the chemical composition and physical state of the upper mantle.

Lava and other volcanic deposits

Lavas of different types (chemical composition, gas content, temperature of the lava) produce different landforms. High silica content and low temperature → viscous and slow. A lot of gas → violent eruption. Lava solidifies to ingenious rocks; basalt, andesite or rhyolite.

Basaltic Lavas

Has high level of magnesium, iron and calcium. It has the lowest silica level. Basaltic Magma is the most common magma type. It is produced along mid-ocean ridges, continental rift valleys and hot spots. Basaltic Lava erupts when hot, fluid magma fills up the plumbing system and overflow (Eruption temperature 1000° – 2000°). Basaltic eruptions are rarely explosive. On land it creates steams that can engulf everything in their path. They are extremely fluid and flow downhill fast and far (a few km/h - 100 km/h). If the lava cools down it gets black or dark gray.
A single downhill basaltic flow commonly forms pahoehoe and farther downstream Aa, where the lava already cooled down more.

Pahoehoe - Hawaii

Forms when a highly fluid lava spreads in sheets and a thin, glassy, elastic skin congeals (erstarren) on its surface as it cools. The molten liquid below still flows and therefore drags the skin into coiled (spiralwendig) fold. It looks like a rope.

Aa - Teneriffa

Looks like clumps of moist, freshly plowed (gepflügt) earth. Aa forms when lava loses its gases and flows more slowly than pahoehoe. A thick skin forms which breaks into rough block as it continues flowing. The blocks pile up. Aa is truly difficult to cross.

Pillow lavas

If basaltic Lava cools underwater, it forms pillow Lava: Piles of ellipsoidal, pillowlike blocks of basalt. Indicator that regions of dry land, was once underwater. The pillows interior develops a crystalline texture because they cool down more slowly. The quickly chilled skin solidifies to a crystal-less glass.

Rhyolitic Lavas

Rhyolite is high in sodium and potassium with a silica content of 68% +. It is light in color, often a pretty pink. Rhyolitic magmas are produced in zones where heat from the mantle has melted large volume of continental crust (today the Yellowstone volcano). Rhyolite its melting point is 600° - 800°. Rhyolite lava is the most viscous. A rhyolitic flow moves 10 times more slowly and it tends to pile up in thick, bulbous (knollig) deposits. Gases are easily trapped beneath. Rhyolitic volcanoes produce the most explosive eruptions.

Texture of Volcanic Rocks

Textures reflect the conditions under which they solidified.

- Coarse-grained (grobkörnig) with visible crystals → lava cooled slowly
- Fine-grained → lava cooled quickly
- Obsidian (volcanic glass) → silica-rich and rapidly cooled

Volcanic rocks often contain bubbles due to gases released during an eruption. Just as the carbon dioxide in the soda forms bubbles when the pressure is released, the water vapor and gasses escaping from lava as it erupts create gas cavities. (Pumice: extremely vesicular rock, rhyolitic in composition)

Volcanic Ejecta

Finest fragments are **volcanic ash**. Eruption can spread ash high into the atmosphere. Fragments that are ejected as blobs and cool as blobs are called volcanic bombs. These fragments will fall to the Eart and build their largest deposits near the sources. As they cool, they become welded (geschweisst) together. Rocks from smaller fragment are called tuffs, those formed from larger fragment breccias.

Eruptive styles of Landforms

Surface features produced by a volcano as it ejects depends on:

- Properties (Eigenschaften) of the magma (gas content and chemical composition)
- Type of material (lava, pyroclast)
- Environmental conditions (land, sea)
- Rate in which lava is produced

- Plumbing system

Central Eruption

Discharge lava or pyroclasts from a central vent, an opening a top from the magma chamber the earth's surface. They create volcanic mountain, shaped like a cone.

Shield Volcano – Mauna Loa, Hawaii (10 km high from seafloor, diameter 120km)

Lava cone is built up by successive flows from a central vent. If the lava is basaltic it flows easily and spreads widely. If it flows copious and frequent, a shield volcano form. (2+ km high and any km circumference) It has gentle slopes. Shield volcanoes are typical for hotspots.

Volcanic Domes

Produced by rhyolitic and andesitic lava. A volcanic dome is a bulbous (knollig), step-sided mass of rock. They look like lava has been squeezed out of a vent like toothpaste. They often plug vents and trap gases. This can lead to an explosion.

Cinder Cones (Aschekegel)

When vents discharge pyroclasts, they can build up to cinder cones. The profile depend of the angle of repose (Schüttwinkel) → the maximum angle that the fragments will remain stable. The larger fragments form steep but stable slopes. Finer particles form gentle slopes at the base. The concave-shaped volcanic cone develops this way.

Stratovolcano (Mount Fuji, Japan; Mount Etna and Vesuvius, Italy; Mount St.Helen, Washington)

When a volcano emits lava and pyroclasts, the alternating flows and beds of pyroclast form a stratovolcano. They are common above subduction zones.

Craters

A bowl-shaped pit at the summit of volcanic mountains. During an eruption the lava overflows the crater walls. The lava that remain in the crater sinks back into the vent and solidifies. Because crater walls are steep, they may cave in (einfallen) or erode away overtime. In this way, a crater gains diameter and deepness. (Carter of Mount Etna – 300m diameter)

Calderas

When great volume of magma are discharges rapidly from the magma chamber, the chamber cannot longer support its roof. The volcanic structure can collapse, leaving a large, steep-walled, basin-shaped depression. They can have sizes from a few km to 50 km or more in diameter. The yellow stone volcano has a caldera.

Diatremes

When magma escapes explosively, the vent and the feeder channel are often left filled with breccia. Shiprock is a diatreme in Mexico.
The kinds of minerals and rocks in a diatreme could have formed only depths within the upper mantle. Gas-charged magmas force their way up by fracturing the lithosphere and exploding into the atmosphere, ejecting gases and solid fragments from the deep crust and mantle. Such an eruption would look like an exhaust jet in the ground blowing rocks and gases into the air.

Minerals

What are Minerals?

Minerals are the building block of rocks. Mineralogy is the studies of those composition, structure, appearance, stability, occurrence, and associations of minerals. Rocks can be separated to their minerals. Limestone for example consists mainly of calcite. Minerals are defined as a naturally occurring, solid crystalline (solid with an orderly, repeating, 3D array) which have a chemical composition and are usually inorganic.

The Formation of Minerals

Atomic structure

The bonding of carbons in a diamond are covalent. Under high pressure and temperature, the bonds bind in tetrahedar building up a regular 3D array. with a specific 3D array. As it grows, it extends its tetrahedral structure in all directions by adding new atoms. As the minerals grow, they maintain their crystal faces () as long as they have enough room. If they don't have enough space, they will grow over one another and become a solid mass of crystalline particles or grains

Crystallization

It starts with microscopic single crystals. The boundaries of crystals are naturally flat surfaces called crystal faces. The faces are the external expression of the internal atomic structure.

Conditions

The temperature must be lower than a mineral's freezing point or melting point.
Crystallization can also occur as liquids evaporate from a solution. Salt-water solution is saturated (can hold no more salt as water evaporates) and the salt will drop out/precipitates (Niederschlag).
Pressure and heat can affect the crystal structures and appearance. Polymorph – Diamond and graphite

Physical Properties of Minerals

Hardness

The measure of the ease needed to scratch the surface of a mineral. There is a scale called Mohs scale of hardness. The hardness depends on the strength of the chemical bonds and other factors that can affect bond strength (size, charge, packing, binding kind).

Cleavage

The tendency of minerals to split along defined planar surfaces. Cleavage varies with bond strength: strong bonds produce poor cleavage while weak bonds produce good cleavage. Bond strength varies along the different planes. Cleavage is classified according to the number of planes, pattern of cleavage, quality of Surfaces and ease of cleaving.

Fracture

The tendency of a crystal to break along irregular surfaces. Fracture may be conchoidal or fibrous.

Luster

The way a surface of a mineral reflects light. Tends to be glassy for ionically bonded crystals and more variable for covalently bonded.

Density

Weight of a mineral divided by the weight of water with the same volume. Depends on atomic weight and their closeness of packing. Can be affected by pressure and heat.

Color

We look if the light is transmitted or reflected. If the minerals have only one color, or a range of color etc. **Streaks:** The color of fine deposit of mineral powder on an abrasive surface, when you scratch it.

Rocks

Properties of Rocks

A rock is a naturally occurring solid aggregate of minerals or non-minerals solid matter (Coal is also a rock). Minerals are joined in that way that they remain their individual matter. The identity is determined by its mineralogy and by its texture (size, shape, the way they're put together). Rocks are separated in coarse-grained and fine-grained (not visible by eye). The most found rocks contain minerals of silica, because the continental crust contain it. Oceanic crust is denser and darker – basaltic.

Why can be knowing properties be useful?
What items should a geologist bring along an excursision?

Igneous Rocks

- Form by crystallization from magma
- **Plutonic/Intrusive**: Crystals cool down slowly and therefore have more time to grow before the whole rock crystalizes, producing coarse-grained rocks → deep in the earth's crust
- **Volcanic/Extrusive**: Crystals cool down fast and therefore have no time to grow before the whole rock crystalizes, producing fine-grained rocks → eruption
- Most minerals are silicates because silicon is the most abandoned in the earth's crust
- Quartz, feldspar, micas, pyroxenes, amphiboles, and olivine

Sedimentary Rocks

- Layers of loose particles (originating from weathering etc.) on the surface
- **Siliciclastic sediments**: Physically deposited particles (*weathering* - physical and chemical process that break up rocks into fragments, *erosion* – process that loosen soil and rock and moves them downhill or downstream, the transport) and the gravity push it together
- **Chemical sediments**: new chemical substances that form by precipitation. Weathering dissolves some of the Rock's component which are carried to the ocean.
- Sediment → Rock

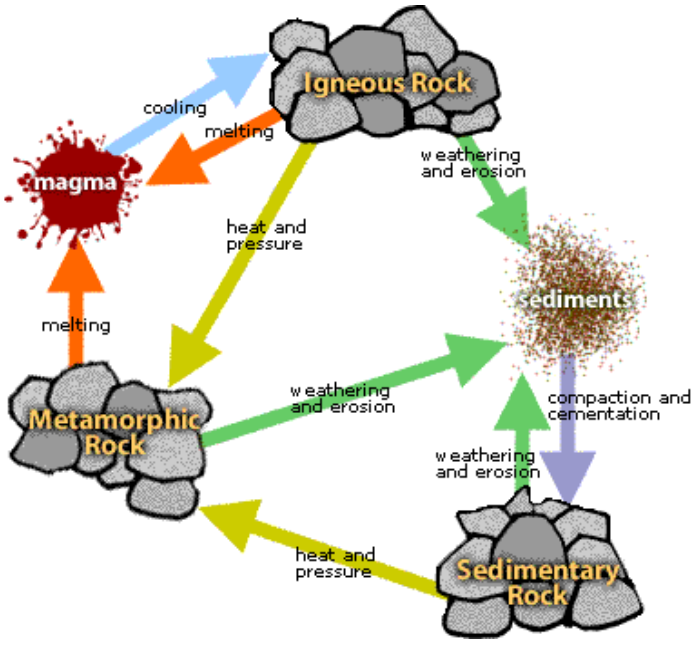
  - Particles are squeezed together (compaction)
  - Mineral precipitate around deposited particles and bind them together (cementation)
- Characterized by bedding, the formation of parallel layers
- **Common Minerals**: Quartz, feldspar, clay, calcite, gypsum, halite

Metamorphic Rocks

- Produced when high temperatures and pressures deep down cause changes in the mineralogy, texture, chemical composition - of any kind of preexisting rock – while staying solid
- Below melting point of the rock but high enough for crystallization and reactions (250°-700°)
- **Regional metamorphism**: high pressure and temperature extend over a large region. E.g. collisions of two plates
- **Contact metamorphism**: high temperature is restricted to a small region. E.g. near contact with magmatic intrusion
- **Common Minerals**: Quartz, feldspars, micas, pyroxene, amphiboles, **kyanite, staurolite, garnet**
- Calcite are metamorphosed limestone

The Rock Cycle

All 3 types of rocks can evolve to one another. The rock cycle is known to be the result of interactions of two global geosystems: The plate tectonic system and the climate system. The plate tectonic causes formation of magma as subduction zone. A change in climate influences the rate of weathering, which there influences the rate of sediments are returned to the interior. Those interactions drive transfers of materials and energy among Earth's interior, the land surface, ocean and the atmosphere.



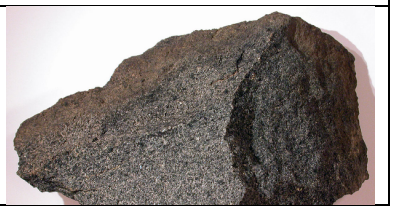
Example: Igneous rock is produces at a mid-ocean ridge. The two plates will at some point collide again. The igneous rock drives beneath each other and eventually start to melt and form magma. The intrusion of the igneous rock and the heat and temperature from going deeper causes the igneous rock to turn into a metamorphic rock. Those rock than gets uplifted to a mountain. Weathering and erosion than forming loose materials and strips them away. Those than deposit as sediments. Under successive layers of sediments, the sediments slowly lithify to sedimentary rock.

List of Minerals

• Most common on surface • Contains silica and oxygen • Mohs 7 • Colorless and shiny	Quartz	
• Hard minerals • Clear and light or cloudy in color • (Pearly luster)	Feldspar	
• Common mineral but usually in small quantities • Olive color • We need a magnificent glass to see the mineral	Olivine	 
• Red to brownish • Glass like • Often locked igneous rock	Garnet	
• Black or green • Hard • Shiny • Builds shorter columns than Amphiboles	Pyroxene (group of minerals)	 
• Black, brown or green • Shaped like a blade or longer columns	Amphibole	

• Black (biotite) or white (muscovite) • Easily peeled into layer → foliated structure • Between layer VdW • Shiny • Flat shaped	Mica	
• High density and heavy • Contains iron • Looks golden or yellowish • Metallic luster	Pyrite	
• Similar to quartz but different angles • Calcium carbonate • Stalagmites and stalactites are partly composed of it	Calcite	 

List of Rocks

• Buff to pink • Fine textured • Silicate rich – contains feldspar and quartz • Light • Volcanic	Rhyolite - Igneous	
• Many colors • Hardness 7-8 • Plutonic • Contains Feldspar, Mica, Quartz	Granite - Igneous	
• Pink and gray • Hardness 7.4 • Volcanic • Coarse • intermediate	Andesite - Igneous	
• Plutonic • Coarse • Darker than Granite • Richer in dark minerals	Diorite - Igneous	
• Poor of quartz and feldspar • Dark • Very solid • Fine grained • Volcanic – very small minerals (ocean)	Basalt - Igneous	
• Dark • Formed deep within the earth's crust • Plutonic • Same composition as basalt	Gabbro - Igneous	

• Has garnets • Formed in the earth's mantle • Plutonic • Similar structure as granite	Peridotite - Igneous	
• Volcanic glass • Shiny with shape edges • Almost black • Same composition as basalt but shock cooled (e.g. in the ocean)	Obsidian - Igneous	
• Volcanic glass • No minerals • Gas trapped as it cooled down → bubbles	Pumice and Scoria- Igneous	
• Term for sediment stone with visible layers • Typical for surface • Foliated structure	Shale - Sedimentary	
• Formed by compressed igneous rock grains • Has carbon glue • Was ocean floor first	Sandstone - Sedimentary	
• Along mountain rivers – rolling down caused round shape • With sand and pebbles compressed	Conglomerate - Sedimentary	
• Similar to Conglomerate but without round shapes	Breccia - Sedimentary	

• Loose or crumbling deposits with amount of calcium carbonate	Marl - Sedimentary	
• Compression of shells and sea animals • Bottom of the ocean	Limestone – Chem/Bio Sedimentary	
• Black or brownish black • Formed by vegetable matter without free access to air under influence of moisture, pressure, temperature	Coal - Chem/Bio Sedimentary	
• Shale compressed underneath the earth's surface	Slate - Metamorphic	
• Igneous or sedimentary rocks compressed in layers	Schist - Metamorphic	
• Large layers of rocks (granite, quartz, pegmatite most common)	Gneis - Metamorphic	

• Limestone compressed under high pressure	Marble - Metamorphic	
• Metamorphed sandstone	Quartzite - Metamorphic