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G201 – 4/12/10 Notes

What mineral is characterized by :

a) A red-brown streak - Hematite

b) Fizzing (effervescence) in dilute HCl - Calcite

c) Has striations on cleavege planes – plagioclase feldspar

How do you determine the hardness of a mineral?
- It's MOH's scale – numbered 1-10 – we determined it in lab by harder or softer than a penny or a plate of glass.

Igneous Rocks – rocks formed by the solidification of magma (molten rock)
Lava = magma that reaches the Earth's surface.

Reminder:
liquid vs. amorphous solid vs. crystalline solid (water vs. ice)
Molecules still connected, but in an irregular arrangement
Obsidian is glass – amorphous solid – atomic structure similar to liquid

Melting involves breaking of bonds – function of temperature and pressure
Heat causes atoms to move – hotter they are, the more they move, the more the bonds break and "chunks" break off – pieces of mineral
Pressure tends to keep bonds together.

Phase diagram – compare pressure (or depth) to temperature to decide whether a substance will be in a specific phase (solid, liquid, gas).
Triple point – where all 3 phases coexist.
Critical Point – gas/liquid no longer exist – "critical fluid" which is neither and both.

Phase diagram is a bit more complicated for a polymineralic rock.
Each mineral is a different substance – its properties (luster, color, hardness, cleavage, density, and melting/crystallization, temperature) are unique and depend on its structure and chemistry.
As minerals are not pure substances, they generally melt or solidify over some range of temperatures (at a given pressure), rather than one unique temperature.

Example:
In a plagioclase feldspar, it takes a bit more energy to break the bonds involving Ca (2+ charge) than bonds involving Na (1+ charge).
At 1atm pressure, pure Ca-rich plagioclase feldspar goes from solid to liquid (or liquid to solid) at 1553 degrees C.
For Na-rich plagioclase feldspar the temp is 1118 degrees C.
Composition in between contain both Na and Ca and melt over a range of temps.

Olivine – Isolated tetrahedral silicate – abundant in the upper mantle.
If you forget about all other components of the rock, there is still a 300 degree range where there will be solid olivine crystals floating in pure olivine melt.

Minerals In Nature are Never Pure

KEY POINTS:

Each mineral has a different melting/crystallization temperature
Because minerals allow site substitution – example, Olivine – their melting/crystallization temps are actually a range of temperatures at any given pressure (such as 1atm), except for a "pure" end member.

Bowen's Reaction Series :
Isolated, then single chain, double chain, sheet
In general the abundance of silica – more silica requires lower temps to melt – less silica requires higher temps to melt.

Magmas between 600°C and 1200°C – to melt mantle, has to be hot enough to melt at least pyroxene and some of the feldspars (between 900° and 1200°C)

As minerals begin to form there is a period of time during which a crystal-rich magma exists. Called **PARTIAL MELT**. (melt + solid)
Eventually it will get hot enough to melt the entire rock.
Until then, grains will be left floating in the melt and the melt is not the same composition as the original rock.
Most of the time when you melt the mantle, the melt is not going to be the same composition as the original rocks because you are leaving behind a portion of the rock that did not get melted.

Classification of Igneous Rocks:

Minerals can crystallize from magma underground:
Plutonic or Intrusive
Texture: **Phaneritic** (coarse – grained)
If they crystallize underground they will **cool slowly** and form **big grains**.

Minerals can crystallize from magma aboveground:
Volcanic or Extrusive
Texture: **Aphanitic** (fine-grained)
If they crystallize above-ground they will **cool quickly** and form **fine grains**.

Minerals can begin to crystallize from magma at depth, and then magma can move higher, where more minerals crystallize.
Texture: **Porphyrtic** (two grain sizes)
Minerals begin to crystallize deep down, then it rises and cools faster as it rises, so grains are different sizes.

Minerals can crystallize from a dilute melt:
Texture: **Pegmatitic** (Rock= pegmatite)
It breaks the rule! Grain size is going to correlate with the rate of cooling. Pegmatite breaks that rule, it can cool quickly and have large grains.

Magma can solidify without growing minerals.
Glassy Texture (Obsidian)

Magma (or resulting rocks) can break into fragments – Pyroclastic Rocks (Pyro – fire; Clastic - fragments) – Fire Fragments.
Rocks created by magma break into fragments.

Faster the cooling, smaller the grain, slower the cooling, bigger the grain.

Crystalline igneous rocks are classified on the basis of their texture and chemistry.
Felsic – lots of silica, potassium, aluminum - Rhyolite
Felsic/intermediate – Dacite (dome at Mt St Helens)
Intermediate - Andesite
Mafic - Basalt
Ultramafic
These refer to the abundance of silica

PHANERITIC vs APHANITIC – Texture terms
Coarse grain vs Fine grain

Classification of crystalline igneous rocks – Chart p. 82

Phaneritic (coarse – grained) rocks
Felsic – higher silica content (like quartz, some feldspars)
Usually going to be lighter colored than mafic.
Granite – sometimes pink or white, more light than dark
Diorite – about ½ feldspar and about ½ hornblend amphibole (salt & pepper rock)
Gabbro – pyroxene and calcium-rich plagioclase feldspar – tends to be darker

Ultramafic Phaneritic Rock
not always green – could be closer to black. Lots of olivine. Peridotite – coarse grain.

Aphanitic (fine grained) rocks
Rhyolite
Andesite – mixture of intermediate comp feldspars and amphiboles – more commonly porphoritic
Basalt – generally dark

Ultramafic aphanitic rock (very rare)
Komatite

Pegmatite – very coarse crystals. Muscovite + feldspar; biotite + feldspar + quartz – Dilute, water-rich magma - likely to get a pegmatite. Pegmatites are sources of gems & ore. (Aquamarine inside quartz)

Glassy Texture – Obsidian – no minerals here. This is a glass. Pure clear glass is pure SiO_2. A little impurity will change the color.
Can be any composition. Most often felsic. No minerals, so not light colored!

Fragmental and vesicular/frothy rocks – vesicular means it has holes. Has minerals. Frothy rocks are glass around holes.

Volcanic Breccia – rock made out of rock fragments that are angular and a certain size (able to be seen).
Ash-Fall Tuff – fragments are so small you cannot see them. Hard to recognize the diff between this and an aphanitic rock. No minerals. Made out of ash.
Scoria – mafic or basaltic in composition, but no minerals. (Also called basaltic cinders) Will not float on water.
Pumice – intermediate to felsic, will float on water.

Textures: (also see p.93 in lab book – similar chart)
Phaneritic – Granite, Diorite, Gabbro, Peridotite
Aphanitic – Rhyolite, Andesite, Basalt, Komatiite (rare)
Porphyritic – precedes any of the above names whenever there are appreciable phenocrysts
Glassy – Obsidian (compact glass)
Pyroclastic (Fragmental) – Tuff (fragments less than 2mm), Volcanic Breccia (fragments greater than 2mm)
Frothy Rocks (Sub-category of pyroclastic) – pumice (felsic to intermediate), scoria (mafic)

Chemical Composition:
Felsic – Granitic
Intermediate – Andesitic
Mafic – Basaltic -
Ultramafic – Olivine, calcium-rich plagioclase feldspar

PREFERRED CHART – Igneous rocks are ID'd on the basis of 2 things – TEXTURE and COMPOSITION

	Felsic	**Intermediate**	**Mafic**	**Ultramafic**	
Aphanitic (fine grained; volcanic; extrusive)	Rhyolite	Andesite	Basalt	Komatiite (Rare!)	
Phaneritic (coarse grained; plutonic; intrusive)	Granite	Diorite	Gabbro	Peridotite (mantle)	
Glassy (no minerals; no holes)	OB SIDIAN →	→	→		
Pyroclastic (Fragmental; no holes)	Tuff – Small Fragments	Volcanic Breccia – large Fragments	→		
Pyroclastic (FROTHY!; with holes; vesicular)	Pumice →	→	Scoria		

Magma Formation – 3 ways to melt rocks
The interior of the Earth is hot – mantle rocks are only near melting temperature in region near surface known as the asthenosphere.
Magma comes from asthenosphere (or crust if melting crustal rocks) – Partial melting of ultramafic (mantle) rocks.

There are 2 ways to melt mantle rocks - Both cases are changing pressure on the rocks

1 – Decompression Melting
Don't change the temperature – take hot rock and somehow change the pressure – Melting by pressure release – occurs at mid-ocean ridges, and other areas where lithosphere is being stretched (such as Basin & Range)
a.) remove some of the weight on the top of the rocks. Most common at a divergent plate boundary where the lithosphere is being pulled apart. Eruptions of magma at mid-ocean ridges. Thinning of the Lithosphere.
Magma will ALWAYS be mafic – basaltic.

b.) take hot rock from down low and bring it up without cooling it significantly. Rapidly transporting hot rock from depth without giving it time to cool off. – Changes the pressure, but not changing the temp.
Hot Spot Volcanoes Columns of hot rock rise quickly, and when they get high in the asthenosphere you get a volcano.
Magma will ALWAYS be mafic here as well.

Example - Hawaiian Islands: Hot column of rock – does not start to melt until it gets to the edge of the asthenosphere. When it gets there it melts and spreads out and then you get volcanic islands.

2 – Melting by Addition of Water (Flux Melting)
Occurs at Subduction zones – can get Basalt → Rhyolite. When you add water you don't get a single composition, you get a whole spectrum of felsic, intermediate and mafic – mostly at the surface is intermediate.
The water acts like a flux and lowers the melting temperatures for different minerals, but not all at the same rate.

3 – Heat Transfer
Transfering heat from hot magmas to low continental crust
The only place you get Magma not from the Aesthenosphere is where you're running a Basalt through the Contintntal Crust and it creates Rhyolitic Magmas. The magma is Basalt, but because it gets stuck in the Continental crust it creates this Rhyolitic Magma which IS explosive – Big change in density – goes sideways and through fractures -

15min presentation – power point – presented as a group in lab.

Topic:
New Madrid Misssouri Earthquake
History of Cascade Volcanism
Chile – recent vs 1960's (largest EQ ever recorded)
Hatai EQ
Supervolcanoes + Yellowstone Hotspot
Birth of a Volcano
Volcanoes in antiquity – Thera/Atlantis + Vesuvius/Pompeii/Herculaneum
History of Columbia Gorge basalt eruptions and ideas on origin
Cascadia Region Earthquakes
Good Friday EQ in Anchorage AK
San Francisco EQ – 1906
Tsunamis in Hawaii
Geology of Himalayas
Geology of Grand Canyon
Life at mid-ocean ridges
Compare ophiolites – Josephine/Oman
Giant Crystal caves in Mexico – what mineral and why so big