Eruptions 18.2

Making Magma

•The type of eruption (explosive vs nonexplosive) depends on the type/composition of the magma.

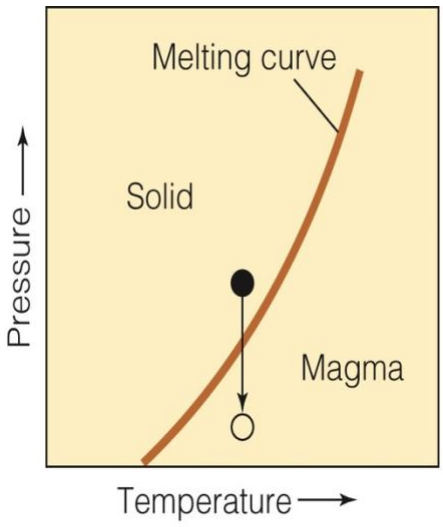
- Formation of magma is affected by:
    1) Temperature
    2) Pressure
    3) Water content
    4) Dissolved gases
    5) Chemical composition: main factor that determines type of eruption

•**Temperature:** most rocks will melt between 800ºC - 1200 ºC (1500 ºF - 2200 ºF) at atmospheric temperatures.

- at greater depths, you need more heat to melt the rocks.

•**Pressure:** upper mantle rock is around 1000 ºC

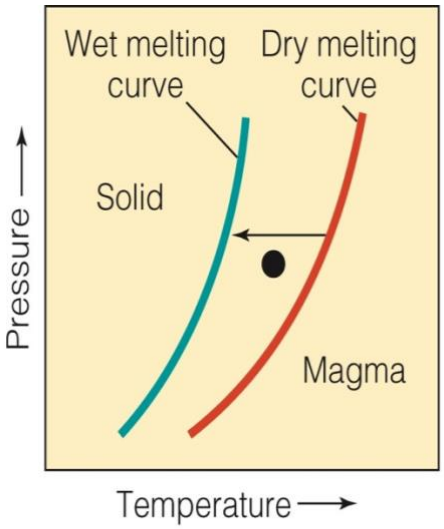
- Why is it not melted? Because it is under pressure!
- This explains why the Earth's rock in the lower crust and upper mantle is not melted
- Take the pressure off this mantle rock, it will melt without any additional heat added to it.
- This is how magma it created at divergent boundaries



a As pressure decreases, even when temperature remains constant, melting takes place. The black circle represents rock at high temperature. The same rock (open circle) melts at lower pressure.

•**Water:** water lowers melting point of magma.

- instead of melting at 1000 ºC, it may melt at 900 ºC if water is added
- this addition of water occurs at subduction zones and at divergent boundaries
- if magma has lots of water in it, the lava at the surface tends to be explosive because of the escaping water vapor



b If water is present, the melting curve shifts to the left because water provides an additional agent to break chemical bonds. Accordingly, rocks melt at a lower temperature (green melting curve) if water is present.

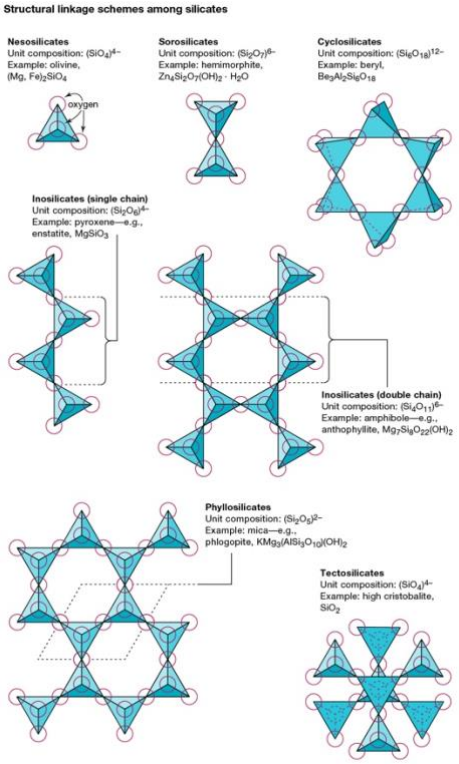
•**Dissolved gasses:** increases the explosivity of the volcanoe's eruption
- 50 to 80% is water vapor, carbon dioxide, nitrogen, sulfur dioxide, hydrogen sulfide, carbon monoxide
- gases contained in rising magma expand and contribute to violent explosions

USE Toxic Volcanic Gas at Papandayan Volcano 2:16 min
https://www.youtube.com/watch?v=YSeaRWK9QFA
USE Killer Lakes: about CO2 gas 3 min
https://www.youtube.com/watch?v=JITGEPP6evo

a This fumerole called the Black Growler is in Norris Geyser Basin in Yellowstone National Park, Wyoming.

b Gases Billowing from Halema 'uma'u Crater on Kilauea Volcano in Hawaii Volcanic gases are mostly water vapor, but carbon dioxide, sulfur dioxide, and several others are emitted, too. Sulfur dioxide produces a haze and the unpleasant odor of sulfur, or what people in Hawaii call *vog*.

•**Chemical composition:** mainly the amount of **silica** content
- How silica effects behavior of magma
  - silica tends to form large molecules from smaller molecules: therefore, they will be thicker and will not flow easily
- **Viscosity:** physical property that describes a material's resistance to flow
  - formation of silica tetrahedra networks controls viscosity
  - silica rich = <u>rhyolitic</u> magma/lavas are thick, viscous and resist flow
  - silica poor = <u>basaltic</u> magma/lavas are thinner, have a lower viscosity and don't resist flow
    - -higher viscosity = higher silica
      - thicker
    - lower viscosity = lower silica
      - thinner



- higher viscosity tends to trap gases and produces explosive eruptions
- higher viscosity magma doesn't flow easily, more force = more explosive

- temperature will also affect viscosity
    - high temperature = lower viscosity
    - low temperature = higher viscosity

- composition is a more important control of viscosity

J.D. Griggs/USGS/VHP

a A mafic lava flow in 1984 on Mauna Loa Volcano in Hawaii. These flows move rapidly and form thin layers.

G. Iwatsubo/USGS

b The Novarupta lava dome in Katmai National Park in Alaska. The lava is felsic and viscous, so it was extruded as a bulbous mass. This image was taken in 1987.

Which test tube has the highest viscosity?

Which test tube has the lowest viscosity?

Types of Magma

•The silica content of magma determines not only its explosivity and viscosity, but also which type of volcanic rock it forms as it cools

•Three types of magma

1) Basaltic = low silica
2) Andesitic = intermediate silica
3) Rhyolitic = high silica

•**Basaltic Magma**

- Usually forms from rock in the upper mantle
- Less than 50% silica – low viscosity
- Gases escape easily: 1-2 % water, usually not very gassy
- Quiet eruptions
- usually rise to surface

Examples – Mauna Loa, Kilauea, Surtsey

Basaltic lava flow from Kilauea in Hawaii

•**Andesitic Magma**

- 50-60% silica
- Found along oceanic-continental subduction zones
- Forms from oceanic crust or oceanic sediments
- Intermediate viscosity
- Intermediate explosivity
- creates composite volcanoes:
    - examples – Colima, Tambora, Mt Saint Helens

Colima in Mexico

Mt Fuji in Japan

•**Rhyolitic/Granitic Magma**

- Molten material that rises and is mixed with continental crust (rich in water and silica)
- More than 60% silica
- High viscosity
- Large amount of trapped gases
- Very explosive
- Rare
- Can create Supervolcanoes

Example: Chaiten in Chile
Photo taken of the 2008 eruption

Lava Flows

•**Pahoehoe:** relatively low viscosity magma. Top partially solidifies and magma continues to flow

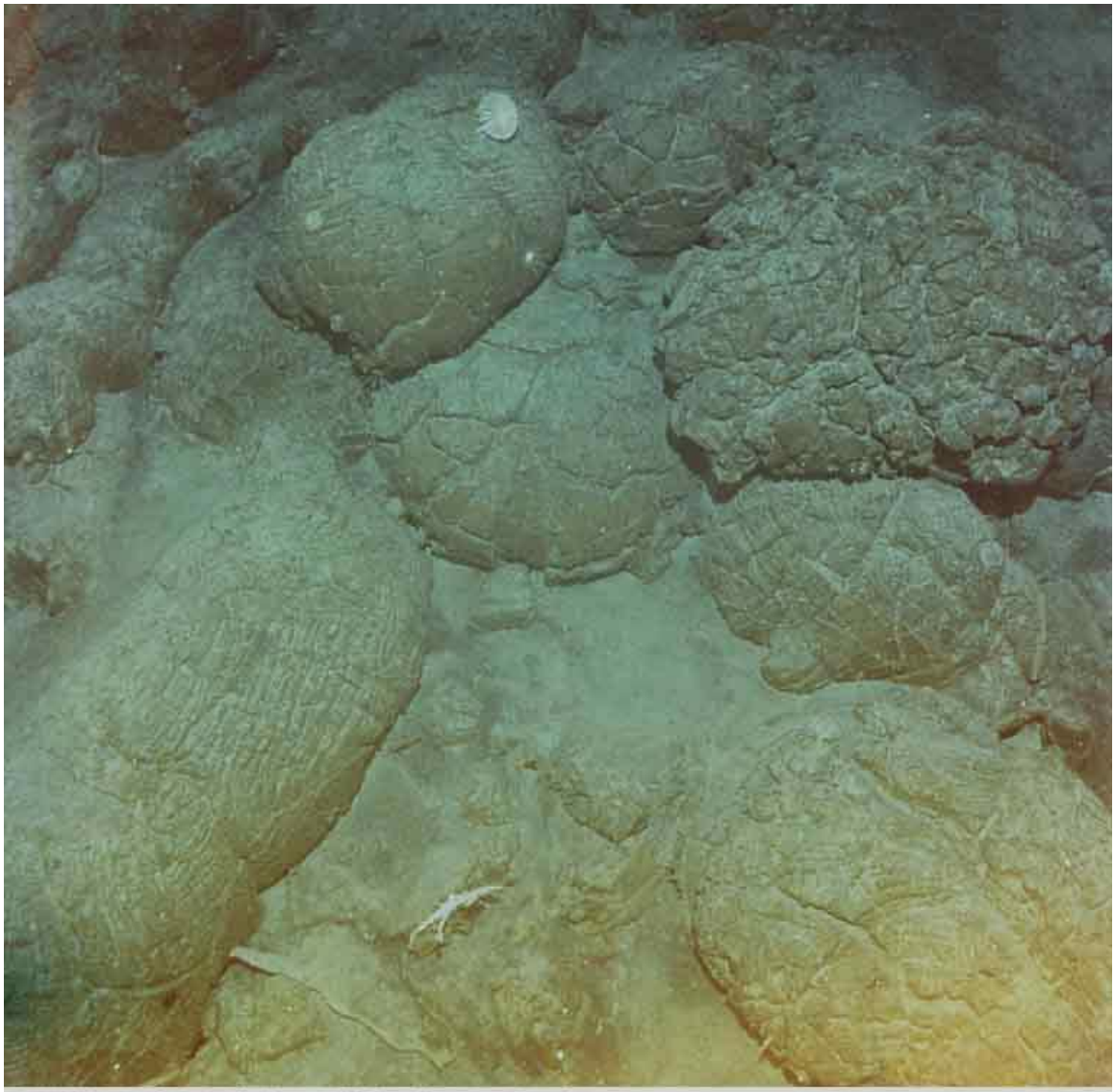
- glassy, wrinkled surface (ropy)

USE CSAV Hawaii: Lava Viewing 5 November 2009: pahoehoe 2:35 min
http://www.youtube.com/watch?v=gJpmtOTle_g
USE Kilauea Volcano lava crosses the highway 9 min
http://www.youtube.com/watch?v=HpNWLCmXyTE

•**aa:** magma is a mixture of solid rock and thick liquid lava
- jagged, broken surface

USE Kilauea a'a Shield Flow June 1, 2010 2:45 min
https://www.youtube.com/watch?v=bWswq8PmRII
Kilauea a'a Lava Flow 1:24 min
http://www.youtube.com/watch?v=iyIV5fd1Aww
CSAV Hawaii: Volcanic Eruption With Aa 2:08 min
http://www.youtube.com/watch?v=P8W6vAlcFxE

•**pillow lava:** fast cooling, happens under water
- sphere shaped



USE Pillow Lava - Lava Dive Hawaii 2:50 min
http://www.youtube.com/watch?v=gn_IW5Vsxaw
Pillow Lava | Nautilus Live
https://www.youtube.com/watch?v=g_r6CFQ7yaU
AMAZING UNDERWATER PILLOW LAVA - Lava Dive Hawaii 3:24 min
http://www.youtube.com/watch?v=xsJn8izcKtg

Explosive Eruptions

•When lava is too viscous to flow freely from the vent, pressure builds up in the lava until the volcano explodes

•There are two major effects from these types of eruptions
1) tephra
2) pyroclastic flows

•**Tephra/pyroclastic material** – erupted materials given off by the volcano; can be pieces of solidified lava or pieces of crust
- classified by size
- smallest – ash
  - can rise very far in the air
  - threatens aircrafts: Iceland volcanic eruptions
  - can affect weather: Mount Tambora 1815; year without a summer 1816
- largest – blocks/bombs
  - can be as large as a car

Sizes	
.06 mm .002 in	Fine ash; glassy
.06-2mm .002-.079 in	Coarse ash
2-64mm .079-2.52 in	Cinders (lapilli)
+64mm +2.52 in	bombs


scoria
tuff
bomb
scoria

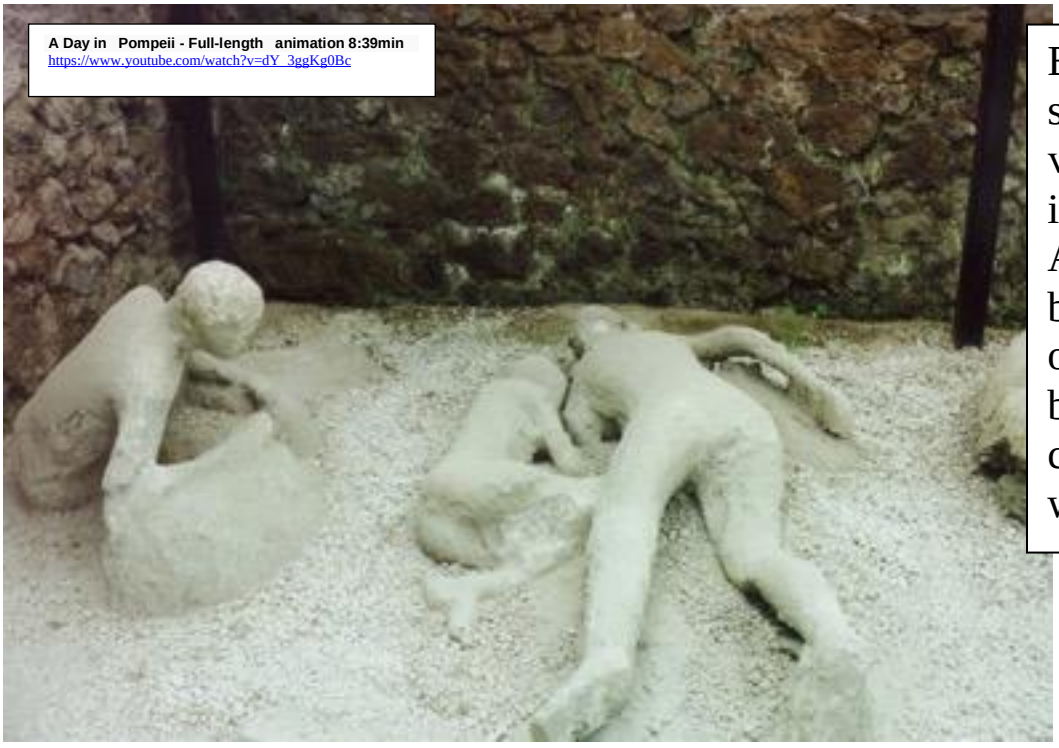
•**Pyroclastic flow** – rapidly moving clouds of tephra mixed with hot, suffocating gases
•Can reach temperatures of 1000°C
•Can move at more than 700 km/h

Pyroclastic flow rushes downside of Mayon Volcano, Philippines

Stromboli Composite 55sec
https://www.youtube.com/watch?v=RY44HWeFcow

Japan volcano small pyroclastic flow 2:15 min
https://www.youtube.com/watch?v=aQtkoLxqUNQ

Unzen Volcano 1:15 min
https://www.youtube.com/watch?v=Cvjwt9nnwXY



A Day in Pompeii - Full-length animation 8:39min
https://www.youtube.com/watch?v=dY_3ggKg0Bc

Body casts of some of the volcano's victims in Pompeii. About 2,000 bodies in this city of 20,000 have been found, but certainly far more were killed.

Recap

Basaltic	- High Density - High Melting Point - Low Viscosity - Thin Magma - Dark Color - Low silica (45-52%) - Degasses Easily - Quiet Eruptions - Shield Volcanoes - Lava Flows (pahoehoe, aa, pillow lava) - Low Water Content
Andesitic/ Rhyolitic	- Low Density - Low Melting Point - High Viscosity - Thick Magma - Light Color - High silica (53-64%) (+65%) - Degasses Poorly - Explosive Eruptions - Composite Volcanoes - Pyroclastic Material (ash, cinders, bombs) - High Water Content

	Shield	Composite
Picture		
Magma Type? Why?		
Location? Why?		
Viscosity? Why?		
Shape of Volcano? Why?		
Rock Type? Why?		
Eruption type? Why?		