Introduction to Physical Geology (GEOL I)



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100 or so million years later, First (and giant) stars form

After the first 20 minunets of the big bang

H, He, Li, Be





Type of H Deuterium

Fusion

Tritium **Type of H**

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Ejected neutron

Helium



Supernovas, Kilonovas





- 1. Forming the Solar System, according to the nebular theory: A nebula forms from hydrogen and helium left over from the Big Bang, as well as from heavier elements that were produced by fusion reactions in stars or during explosions of stars.
 - 6. Gravity reshapes the proto-Earth into a sphere. The interior of the Earth differentiates into a core and mantle.
 - 7. Soon after the Earth forms, a protoplanet collides with it, blasting debris that forms a ring around the Earth.

2. Gravity pulls gas and dust inward to form an accretionary disk. Eventually a glowing ball—the proto-Sun—forms at the center of the disk.

> 5. Forming the planets from planetesimals: Planetesimals grow by continuous collisions. Gradually, an irregularly shaped proto-Earth develops. The interior heats up and becomes soft.

8. The Moon forms from the ring of debris.

3. "Dust" (particles of refractory materials) concentrates in the inner rings, while "ice" (particles of volatile materials) concentrates in the outer rings. Eventually, the dense ball of gas at the center of the disk becomes hot enough for fusion reactions to begin. When it ignites, it becomes the Sun.

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9. Eventually, the atmosphere develops from volcanic gases. When the Earth becomes cool enough, moisture condenses and rains to produce the oceans. Some gases may be added by passing comets.

4. Dust and ice particles collide and stick together, forming planetesimals.





Why is the composition of the Earth so different on the crust?



Crust Only

Entire Earth









Earth by structure

180×

Mantle Fe. Density = 3.3 – 5.7 g/cm³)

Core

(Fe and Ni alloy. Density = 10 - 13 g/cm³)

Earth by composition



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Compositional layers in pictures









Kola superdeep borehole

12 KM Deep

Center of Earth: 6,400 KM deep



Crust Only



Entire Earth

How do we know the composition of Earth?



Chondrites and Meteorites

Solid

Melting Freezing

Phases of mater

Liquid Evaporation Condensation

Building the earth, a bit like cooking

Basic ingredients

Each dish

Full meal

Atoms (elements)

Minerals

Rocks

Earth electron cloud

Charge (geology always adds to zero) Blue = Positive, Red = Negative

Size

How do scientists measure ingredents?

Thinking Diversity

In cooking: How do we measure ingredients in the United States? How do they measure ingredients in Europe?

Our solar system

Talking geology in terms of atoms

Since most of geology deals with Blue = Positive, Red = Negative

Chemical formula (A bit like a recipe for cooking)

Na = 0.00 O = pe

 $Na = 0.00 \quad O = pe$

 $Na = 0.00 \quad O = pe$

Na = 0.11 O = pe

Na = 0.00 O = no

eak	Periclase: AI = 0.00	Mg = 0.49	Si = 0
eak	Corundum AI = 0.33	Mg = 0.00	Si = 0
eak	Spinel $AI = 0.28$	Mg = 0.14	Si = 0
eak	Jadeite AI = 0.09	Mg = 0.00	Si = 0
peak	Galena AI = 0.00	Mg = 0.00	Si =

.00

.00

.00

.21

0.00

Minerals

Covalent (Strongest)

Bonding in minerals lonic

Van der Waals (Weakest)

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4 Strong bonds

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3 Strong bonds

Bonds have energy: In order to break or make, there is an energy cost

Bonds have energy: In order to break or make, there is an energy payout

Size, bond, composition

Sodium 2.1% Other <1% Oxygen 46%

By definition a mineral is: Naturally occurring Inorganic Solid Crystalline Ordered internal structure Definite chemical composition

(Rock = a solid aggregate of minerals + other thigns)

Ordered structure (crystalline)

Silicon tetrahedron

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Silicon tetrahedron







How is this used to make minerals? Red spheres = -2Blue spheres = +4

What is the charge on the silicon tetrahedron?



-2



-2

Total? -4

We need more + atoms



Total? - 8





New total?

42



Total? -14 + 8 = -6

Olivine



Quartz



The Silicon tetrahedron is a basic building block













No extra!



Red spheres = -2Blue spheres = +4 If it is touching a grey sphere, count it as half

Sheet silicates

Type of Silicate Struc

Independent Tetrahedra

Double Tetrahedra

Ring Silicates

Single Chains

Double Chains

Sheet Silicates

Framework Silicates

ture	Formula	Si:O Ratio
	SiO ₄	0.25
	Si ₂ O ₇	0.29
	Si ₆ O ₁₈	0.33
	SiO ₃	0.33
	Si ₄ O ₁₁	0.36
	Si ₂ O ₅	0.40
	SiO ₂	0.50







How do we ballance them out?



Which silicates need the most other elements?









Experience with Cleavage?

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Cleavage: I plane







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No cleavage, only fracture



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But pretty looking crystal faces





Crystal growth (Adding layer by layer)

Outward crystal growth fills available space Open space – Good crystal faces grow Confined space – No crystal faces



Often the resulting crystal shape is governed by surroundings

Where do minerals grow and form?



Where do minerals grow and form?

Mineral growth with time = longer = larger

What do we need to cause "slow" mineral growth?

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Shorter? Too Short?

Geo-Glass: Where might it form?



Mayon volcano

Glass and amorphous materials



Basalt (a volcanic rock)



Libyan desert











Chemical Composition, Pressure, Temperature





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Johannes Kepler used a primitive form of thermodynamics to estimate the age of the Earth based on its current temperature (or current atleast in 1500s).

His idea was that if we could estimate how much heat would have been created during the formation of Earth, then we could use its current temperature and estimate how much it has cooled off.

His guess, Earth was formed in 3993 BC
How much heat he guessed Earth has was wrong.

What sources of heat can be found on Earth?



Fission (NOT Fusion)





Chemical Composition, Pressure, Temperature





Why didn't all the elements separate out?



Crust Only

Entire Earth

Water and Alcohol

