LECTURE #4: Rocks & the Rock Cycle

Date: 22 January 2025

I. Rock Types

- we want to know: how do the major minerals and mineral classes form into rocks?

- *why do we care about rocks for a course in Natural Disasters!?*
  - certain minerals, rock compositions, and rock textures can tell a geologist a lot about the hazardous conditions present in the past, for example:
    - the explosive potential of a nearby volcano
    - the ability of rocks/soil to absorb water during a flood
    - the composition of rocks and their orientation as potential landslide locations

- what is a rock?
  - rock: a naturally occurring solid made of one or more minerals *or other solid substances*
    - this is a simpler and more open definition than we had for a mineral

  - examples: a sandstone that is made of only quartz sand mineral grains and a limestone that is made up of only fossils *(living matter)* are both rocks
    - is coal a rock?? _____
    - why/why not?

- there are 3 rock types

1. Igneous Rocks
   - form when molten (melted) rock cools and solidifies either under or on the Earth's surface
     - solidifies slowly underground: large mineral crystals form
     - solidifies quickly on the surface: small mineral crystals form
     - solidifies *very* quickly on the surface: glass forms
     - solidifies slowly (but only partially) underground *and then* erupts large mineral crystals in a smaller-grain matrix (that cooled quickly)
       - known as a *porphyritic* texture

     - if there is a large amount of water present in the magma
       - explosive volcanoes

     - with little water present in the magma
       - effusive *(non-explosive)* volcanoes

- range of igneous rocks
  - from light to dark minerals
  - from extrusive *(on the surface)* vs. intrusive *(underground)*
    - ➢ intrusive: slow-cooling rock with many large grains
    - ➢ extrusive: fast-cooling rock with many small grains

  - granite *(intrusive)* / *rhyolite* (extrusive)
    - ➢ average composition of the continental crust
    - ➢ generally, more light-colored minerals

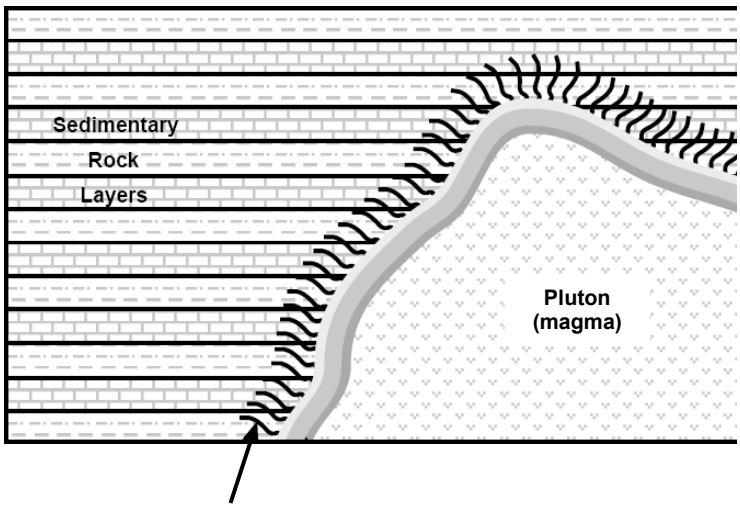
  - gabbro *(intrusive)* / *basalt* (extrusive)
    - ➢ average composition of the oceanic crust
    - ➢ generally, more dark-colored minerals

granite
(slow cooling, larger mineral grains)

2. Metamorphic Rocks
   - form when an existing rock of *any* of the three types re-crystallizes (but does **not** melt)
   - it experiences elevated temperatures and/or pressures
     - known as a "solid-state transformation"

   - a rock that is metamorphosed starts as a "parent" rock first
   - *parent rock:* *metamorphic rock*
     - limestone → _____
     - shale → _____
     - sandstone → _____

   - contact metamorphism
     - happens with high temperature (T), low pressure (P)
     - occurs where a hot magma intrudes colder, older rocks
     - "cooks" the surrounding parent rocks *(aka, country rocks)*
     - no foliation (banding) present in these



Contact metamorphosed rocks

- regional metamorphism
  - happens with <u>high</u> T and <u>high</u> P
  - occurs where continental collisions form mountain belts
  - deep core of the mountains experiences much higher temperatures and pressures
  - results in light/dark bands of minerals
    - called “foliation”

gneiss

3. <u>Sedimentary Rocks</u>
   - form on/near the Earth's surface or under the oceans
   - lithification *(transforming into rock)* of fragments of other rocks *(e.g., sandstones)*
   - fragments of organic remains *(e.g., fossil plants, shells, bones)*
   - solids precipitated from liquids *(e.g., salt, limestone)*

   - mechanical formation style
     - lithification of sediments/rock fragments
     - examples:
       - sandstones
       - mudstones
       - shales
       - breccia

   - chemical formation style
     - evaporation, precipitation of minerals from a liquid like seawater
     - examples:
       - limestone ($CaCO_3$)
       - gypsum ($CaSO_4 \cdot 2H_2O$)
       - salt ($NaCl$)

     - $CaCO_3$ → very important when it comes to carbon-cycle!
     - *why?*

- recycling of rocks (occurs from weathering and Plate Tectonics)
  - we will examine Plate Tectonics next week
  - there is a difference between the rocks of the oceanic and continental crust
    - age and composition are two important distinctions
    - oldest continental rocks are 3-4 billion and found in areas known as *cratons*
    - cratons:

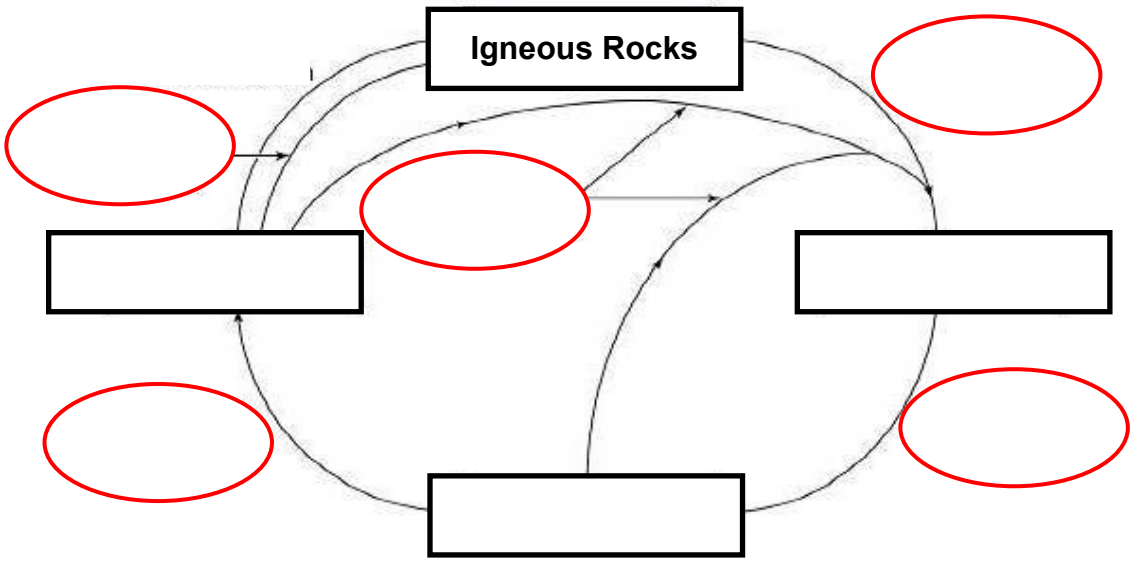
- located in the continental interiors
- the earliest crust (proto-continents)
- new material constantly being added to the cratons: *from volcanoes and continental collisions*
- material constantly being removed from the cratons: *from weathering and erosion*

II. The Rock Cycle

- processes: each and every rock, no matter how dull looking, came into existence as the result of some process
  - deciphering the rock allows us to recognize that process, and therefore:
    - how it worked in the past
    - and how the Earth works today
  - because each mineral forms under specific conditions
    - geologists use the minerals to identify the rocks
    - and the rocks origin story

- the rock cycle describes pathways of the rock-formation process
  - consequence of Plate Tectonics
    - estimated time of about 100 million years per cycle
      - much longer than the times of atmosphere or ocean cycles
      - takes even longer at continental interiors *(cratons)*
    - not a completely closed loop
      - new input and exit pathways for rock material
    - most material has been recycled many times from continent to the mantle
      - nearly complete crustal replenishment every 2-3 billion years

- *we will fill in the missing blanks in the Rock Cycle below during lecture:*



III. Informal Homework:

- What two rock types do you see when entering the Cathedral of Learning?