Homework 2: Plate Boundaries, Minerals, and Igneous Rocks

GEOL2205: Solid Earth S2024
Name: Ryan Nielsen

________/ 200 points

Part 1: Plate Boundaries

1. List the three plate boundary types, and the "subtypes" of each plate boundary. (10 points)

Convergent:

-Ocean-Ocean

-Continent-Continent

-Ocean-Continent

Divergent:

-Continental Rift

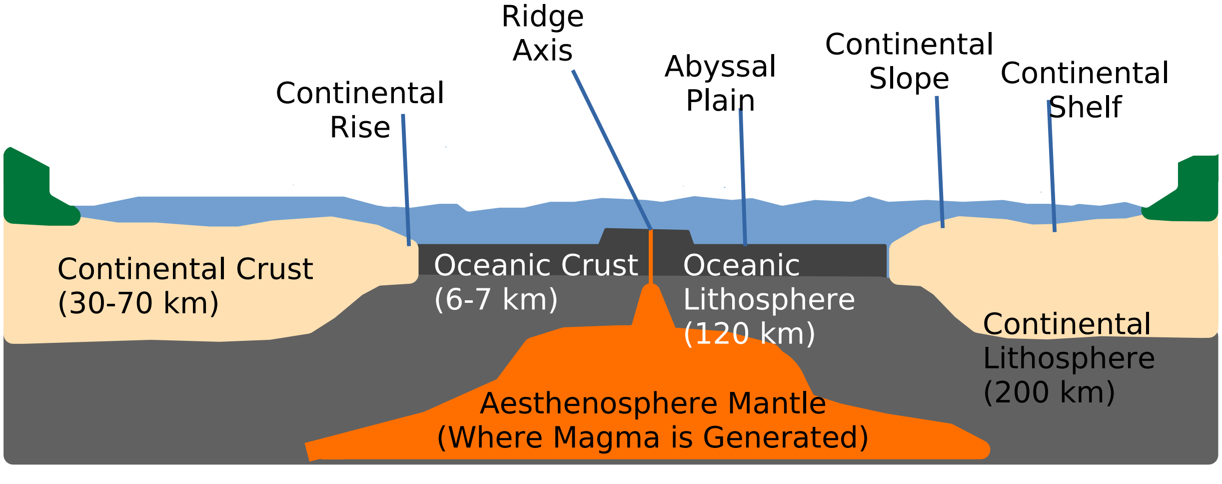
-Oceanic Spreading Center

Transform:

-Fracture Zones

-Plate Boundaries

2. In the space below, draw a sketch of a divergent boundary that transitions into a continental passive margin. Include and clearly label the following things in your sketch: oceanic crust, oceanic lithosphere, continental crust, continental lithosphere, the asthenosphere, the ridge axis, where magma is generated, abyssal plain, continental rise, continental slope, continental shelf. Also label the thickness (in km) of crust(s) and lithosphere(s). (12)

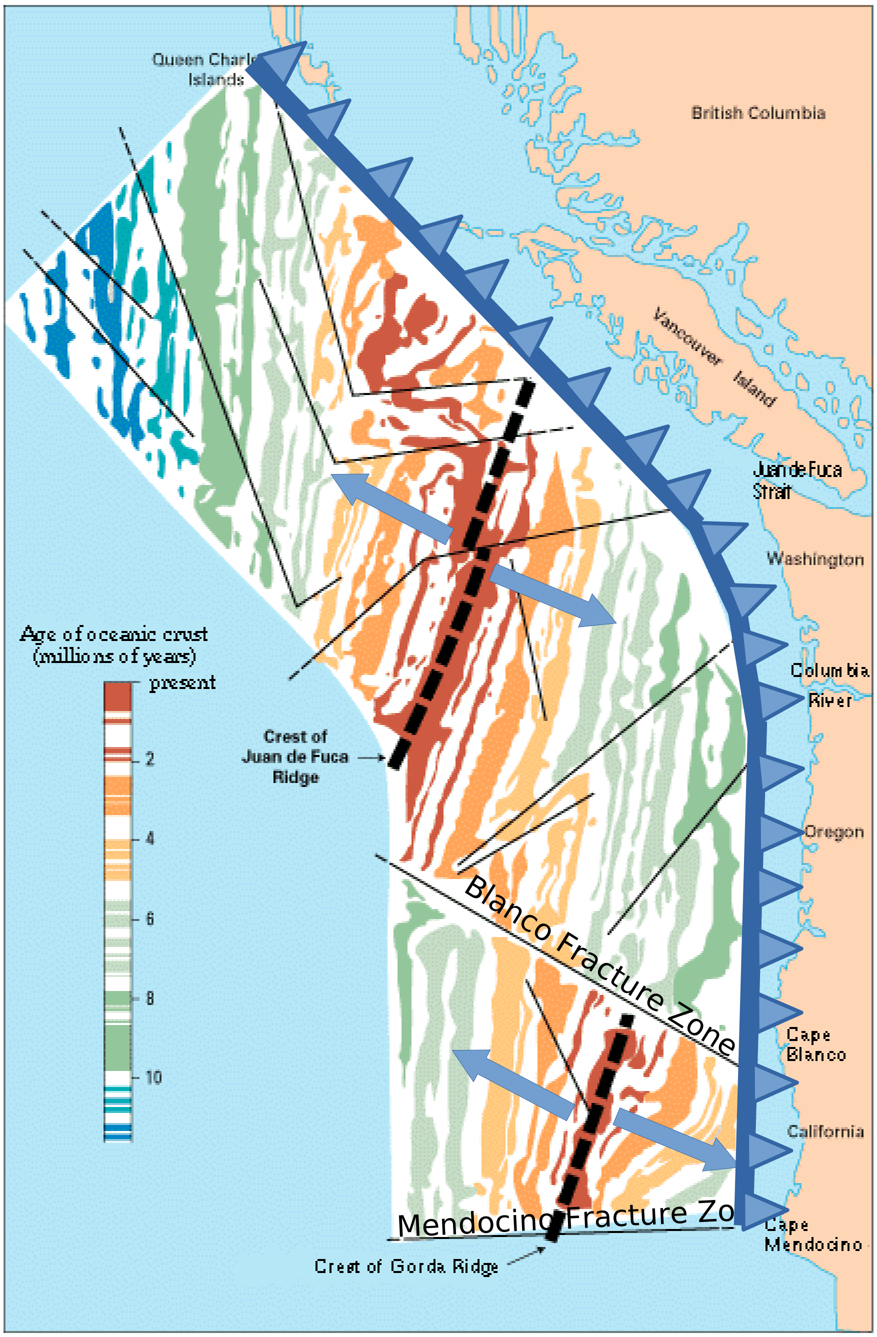


3. On the following page is a map view of the Pacific Northwest of North America. You will use this map for a few things. The black dashed lines are the spreading ridges (the Juan De Fuca and Gorda spreading ridges), the colored stripes are the magnetic chrons of the sea-floor on the plate. The legend to the left shows the ages of the different in Millions of Years before present (Ma). The diagonal lines that disrupt the pattern of magnetic striping are transform faults. The most are is the Blanco Fracture zone (the diagonal line oriented toward Cape Blanco), and the Mendocino Fracture zone (the line oriented toward Cape Mendocino). Do the following things outlined below.
   a. First, label the Blanco Fracture zone and Mendocino Fracture zone (2 points)
   b. Add motion directions the plate is moving on both sides of the spreading ridges (Gorda and Juan de Fuca Ridge) (4 points)
   c. The plate boundary between the Juan de Fuca plate and North American plate is not shown here. Draw the approximate location of the plate boundary between these two plates, and use the correct symbol. It should be a line with triangles or “teeth” on it. The “teeth” go on the side of the overriding plate (6 points)
   d. Fill in the table below by following these directions: The age of the magnetic reversals are labeled on the legend on the map in 2 million year increments. Some will be easy to determine, others you will have to estimate to the nearest 0.1 Ma. To measure distance, use a ruler. On the map 1 cm = 50 km. When you measure a distance on the map in cm, multiply it by 50 to km. Measure distances out from the center of the ridge to the boundary of the edge of the color zones listed below, avoid crossing the black transform fault lines in your measurements. Rate of the plate is a speed, so you just need to divide distance the plate traveled by time (km/Ma). Converting to mm/year is simple 1 km/Ma is the same as 1 mm/year. (40 points)

Magnetic anomaly color boundary (corresponds to a magnetic reversal)	Age (Ma)	Distance west of center of ridge crest (km)	Distance east of center of ridge crest (km)	Plate velocity (mm/year)
Red begins (center of ridge)	0.0	0	0	0
Red ends	2	45	45	22.5
Orange begins	2.5	50	50	0.1
Orange ends	3.5	83	83	9.43
Yellow begins	4	100	100	34
Yellow ends	5	120	120	4
Light green begins	5.7	125	125	7.14
Light green ends	7.3	175	175	31.3
Dark green begins	7.9	200	200	62.5
Dark green ends	9.8	270	280	5.26

e. Answer this question: Is plate velocity steady through time? (2 points)
No, plate velocity is not steady through time.

f. If it is not steady through time, describe how it has changed (6 points)
Between now and 6 Ma ago, the plate velocity was higher. This can be seen in the wider spread of green and blue lines in the graphic. That means that in a shorter amount of time, the plate went further.



Part 2: Minerals

4. Describe the difference between crystal habit and cleavage/fracture (4 points).

   Crystal habit is the way a mineral "wants" to form its crystals, but this can be impeded by other objects, impurities, et cetera. Cleavage and fracture have to do with what shape the mineral breaks into. Because of the way the molecules align, the mineral will break along the path of least resistance. For some minerals there is cleavage along strict angles, but other minerals fracture conchoidally instead of cleaving along planes.

5. Describe how can you recognize cleavage in a mineral vs. fracture (4 points).

   Cleavage is recognizable from the elements breaking along straight planes all facing the same direction (for each direction of cleavage). Fracture usually takes a circular or shell-like form that is especially recognizable in fine-grained and integral samples.

6. What are two easy ways to tell the difference between quartz and plagioclase feldspar (4 points)?

   Quartz fractures conchoidally, while plagioclase feldspar has bidirectional cleavage. Quartz is usually clear (colorless or sometimes tinted), while plagioclase is opaque and gray.

7. List the notable nine minerals, and their chemical formulas (18 points):

   Quartz - SiO_2

   Muscovite - $(KF)_2(Al_2O_3)_3(SiO_2)_6(H_2O)$

   K-Feldspar - $(K, Na)AlSi_3O_8$

   Biotite - $K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$

   Plagioclase Feldspar – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$

   Hornblende - $(Ca,Na)_2(Mg,Fe,Al)_5(Al,Si)_8O_{22}(OH)_2$

   Pyroxine - $(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$

   Olivine - $(Mg,Fe)_2SiO_4$

   Calcite - $CaCO_3$

8. List the main mineral classes we discussed in lecture and what defines them. Why are silicate class minerals the most common (10 points)?

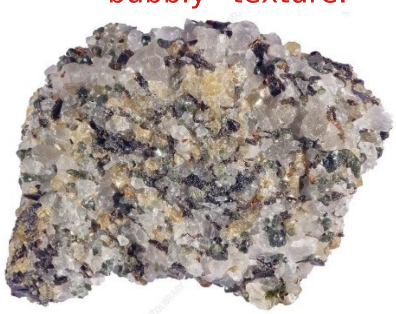
   The mineral classes we discussed in lecture are silicates, oxides, sulfides, sulfates, halides, carbonates, and native metals. Silicates are the most common on Earth's surface because they are the least dense. The denser minerals sink toward the center of the earth while the lighter minerals like silicates rise to the outside of the earth.

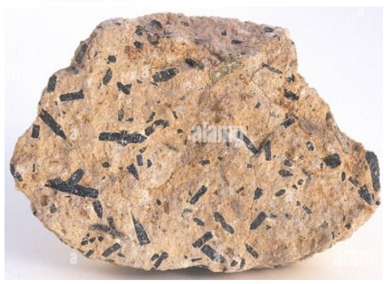
<u>Part 3: Igneous Rocks</u>

9. What are the 4 main igneous rock/melt compositions and how do we define them (8 points)?

   The 4 main rock/melt types are felsic, intermediate, mafic, and ultramafic. These are defined by silica content and iron/magnesium content. More silica-rich rocks are felsic, and more iron/magnesium rich rocks are mafic to ultramafic.

10. Describe the texture of the igneous rock to the right of each picture. Use the proper texture term (e.g., fragmental, phaneritic, glassy, etc.) and then interpret the cooling history or other important details from the texture (2 points each)
    a. Phaneritic – This rock cooled inside the earth slow enough for large crystals to form.
    b. Aphanitic – This rock cooled outside of the earth quick enough that only tiny crystals could form.
    c. Porphyritic – This rock started out cooling slowly inside the earth, then was exposed and cooled off the rest of the way pretty quickly.
    d. Pegmatitic – This rock was cooled super slow and developed huge mineral crystals
    e. Glassy – This rock cooled so slowly that crystals didn't have a chance to form.
    f. Fragmental – This rock was formed from hot ash that blasted out of a volcano and welded to other rocks and then cooled very quickly.
    g. Vesicular/Scoria – This rock was blasted out of a volcano with a lot of expanding gas that pushed the molten rock out of the way, thus the "bubbly" texture.



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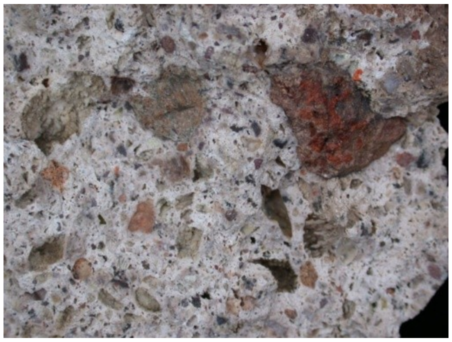
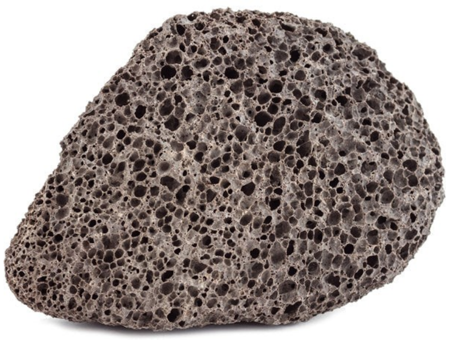
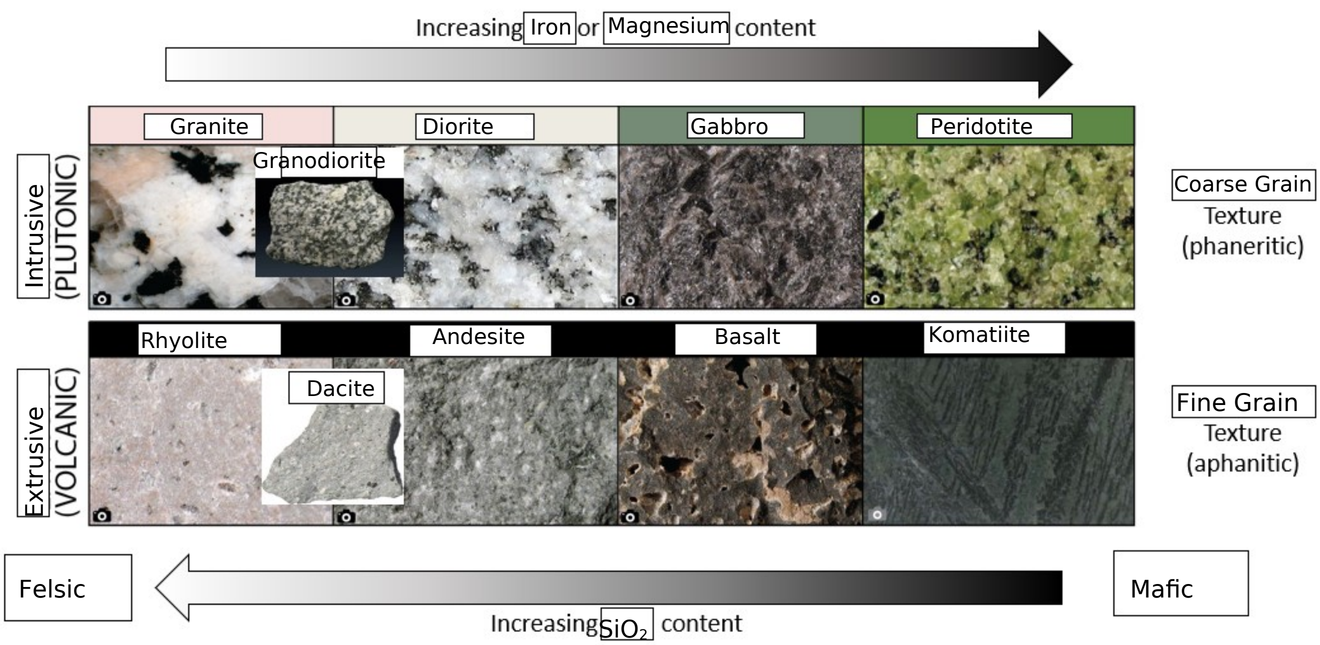
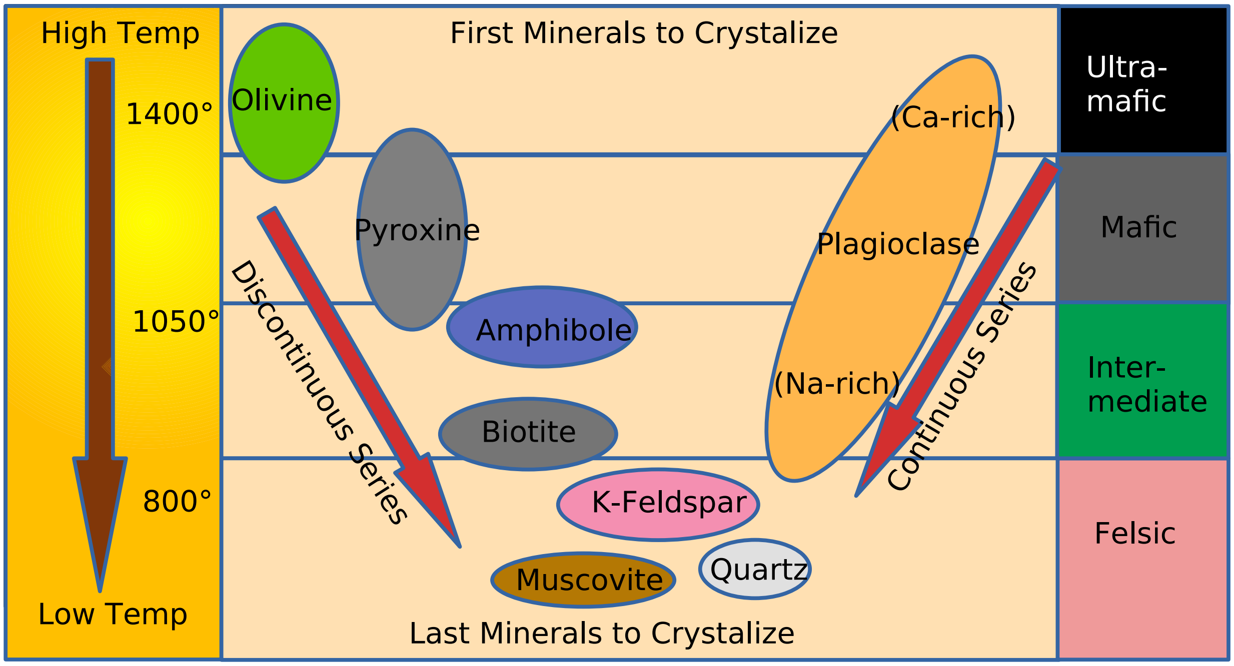




11. Complete the chart by filling in all the white boxes (20 points)



12. Draw the Bowens Reaction Series (like it is depicted on the lecture slides). (21 points)



13. Describe what the Bowens Reaction series is, and how does it help us understand igneous rocks (15 points)?

The Bowens Reaction series shows the sequence in which different minerals form and crystalize from high to low heat. It shows the continuous and discontinuous series and in what order their elements react with the silica in the mixture. Once all the silica is used up, no more silicate rocks can be formed. It helps us understand the activation energies needed to form different types of rocks/minerals. Just by identifying a rock or mineral, you can tell how hot the magma was and what its composition was.