GS104 Lab 3 Key - Introduction to Plate Tectonics

Pre-Lab Reading Questions

1. Lithosphere - comprised of the upper part of the mantle and the crust, above the asthenosphere.

2. Asthenosphere - the upper region of the mantle, below the lithosphere, that is semi-molten, or "plastic", upon which the lithospheric plates ride.

3. Divergent Plate Boundary - tectonic plate boundary in which the plates are pulling apart, spreading, or moving away from one another (spreading center).

4. Convergent Plate Boundary - tectonic plate boundary in which the plates are colliding together, or moving towards one another (subduction zone).

5. Transform Plate Boundary - tectonic plate boundary in which the plates are horizontally sliding past one another, neither converging or diverging (transform fault).

6. Oregon is located at a convergent plate boundary, in which the Juan de Fuca plate is being subducted beneath the North American Plate.

7. Southern California is located at a transform boundary, the San Andreas Fault System, in which the Pacific Plate is sliding to the northwest, and the North American plate is sliding to the southeast.

8. Elements of the earth's interior include the crust (continental, oceanic), moho (boundary between the crust and mantle), upper brittle mantle (crust + moho + upper brittle mantle = "lithospheric plate"), asthenosphere (ductile silly putty), lower solid mantle, liquid outer core, solid inner core.

Map-Based Questions (Earth's Fractured Surface)

1. Most divergent plate boundaries occur in oceanic crust at the Mid-Ocean Ridge. The Red Sea is an example of ongoing Continental Rifting and the beginning of an oceanic spreading center.

2. Volcanoes are most associated with subduction zones (e.g. the Andes Mtns of S. America, the Cascades of OR-WA), and also with seafloor spreading.

3. Yes - Hawaii and other volcanic islands occur away from plate boundaries. Yellowstone N.P. is another example of a volcanically active terrane away from a plate boundary.
4. PNW is associated with a convergent boundary / subduction zone. The plates include the Juan De Fuca being subducted beneath North America (over-riding plate).

5. The "Ring of Fire" refers to the occurrence of numerous subduction zones, and active volcanic arcs that circumscribe the Pacific Ocean basin.

6a. The Hawaiian Islands and Emperor Seamount chain represent a set of linear volcanoes that have sequentially formed over the Hawaiian Hot Spot.

6b. Yes the Hawaiian Islands and Emperor chain are related, but they show a different orientation. The Hawaiian Is. are oriented Southeast-Northwest, while the Emperor chain in more north-south.

6c. Reasoning: the Big Island of Hawaii is currently located over the hotspot with volcanic rocks forming right now! The Midway Island volcanic rocks are 27,000,000 yrs old and have sequentially moved northwest away from the active hotspot. To calculate the rate of plate motion, we need to know the distance from the Big Island to Midway Island and the amount of plate travel time (27 m.y.):

Plate Rate = Distance / Time

Distance from Big Island of Hawaii to Midway Island = 2.4 in (758 mi/in) = 1819 mi =
1819 mi (5280 ft/mi) (12 in/ft) = 115264512 in

Time = 27,000,000 yr

Rate = 115264512 in / 27,000,000 yr = 4.27 in/yr

The Pacific Plate has been moving on average 4.27 in/yr over the past 27 million years!!! This motion is slightly faster than fingernail growth, but comparable overall.

6d. Based on the hotspot track, the Pacific Plate appears to have changed direction from travelling "North" to more "Northwest", with the change in direction starting about 65 million years ago. Most of the other sea mount chains are oriented northwest like the Hawaiian Islands, but they are positioned much closer to the seafloor spreading center, and hence, are much younger than the Emperor Chain. The northwest Pacific Plate is located farthest away from the spreading center in the Pacific (and the farthest of any seafloor on the planet!), thus it represents the oldest record of ocean crust on earth (i.e. the closer to the spreading center, the younger the crust; the farther from the spreading center, the older the crust).

7a. Most of the historic volcanic eruptions have occurred at subduction zones / convergent plate boundaries.

7b. Iceland is located on a seafloor spreading center / divergent boundary / mid-oceanic ridge. It just so happens that sea level is such that the volcanic pile, represented by Iceland, is above water right now.

8. Most of the largest magnitude earthquakes have occurred at subduction zone boundaries. The S. CA quakes of course are associated with the San Andreas transform boundary.

Map Questions - Living on the Edge

1. Most quakes have been associated with Mt. St. Helens and with the Mendocino Triple Junction in N. CA.

2. Cascadia subduction hypotheses: a) the plate is subducting at such slow rates that the frequency of earthquake occurrence is low, and we have not experienced many quakes historically., b) the plate is hot and ductile, and does not tend to generate many earthquakes.

3. seems like my hypotheses are compatible with the map text.

4. Based on the reading, Mt. Rainier, Mt. Hood, and Mt. St. Helens are all active volcanoes with historic records of activity.

5. Long Valley Caldera is associated with an active magma chamber beneath it... it is an active volcanic center.

Questions Related to Figure 1 on p. 3.6

1. The San Andreas is a "right-lateral" fault system, with the sense of displacement, looking across the fault, moving to the right (i.e. Berkeley is moving southeast and Santa Barbara is moving northwest).

2. Rate of fault movement (match up the outline of the "M" rocks on both sides of the fault, and measure the distance of offset)

   Distance = 340 km (1000 m/km) (100 cm/m) = 34000000 cm
   Time = 25,000,000 yrs
   Rate = 34000000 cm / 25,000,000 yrs = 1.36 cm /yr

3. Southern CA is under constant threat of earthquake activity. This is an average rate over 25 m.y., it is not necessarily the constant rate of motion. Some earthquakes could be associated with more offset, others not as much. Plus, the San Andreas "fault" is not one single fracture, but a zone of faults the cut across southern CA.

4. Total Fault Displacment in 25 m.y. = 340 km (1000 m/km) = 340000 m (from 2 above)

   Offset per quake = 5 m/quake (according to 1906 event)

   No. of Quakes in 25 m.y. = 340000 m (1 quake / 5 m) = 68,000 quakes

   Frequency of quakes, on average, over 25 m.y. = 25,000,000 yrs / 68,000 quakes = 368 years / quake

   This calculation suggests that on average, making some simple assumptions which are not true, that a 1906-style earthquake would be generated every 368 years, with 5 m of offset, over 25 m.y., resulting in a net displacement of 340 km along the fault zone.