Professor's Notes:

The black and blue text are those of the student. Black text signifies the text found in the professor's downloaded assignment document, except for student's references. The blue text signifies the student's responses to each of the subtopic questions within each topic.

The **green text** in capital letters are the professor's grading comments

Andrea P.
Geology 100
Assignment #4

Assignment #4 – Crustal Deformation, Earthquakes and Mountain Building

TOPIC #1 – DEFINE AND COMPARE CRUSTAL STRESS VERSUS CRUSTAL STRAIN (5 points for each section – 10 total)

a) **Provide a concise, yet brief, definition and comparison of both, crustal stress and strain, including the following:**

- Stress: the force per unit area acting on any surface within a solid area. The magnitude of stress is not simply a function of the amount of force applied but also relates to the area on which the forces act.
- Strain: an irreversible change in the shape and size of a rock body caused by stress. **NOTE THAT SOME TYPES OF STRAIN ARE REVERSIBLE, E.G. ELASTIC STRAIN.**
- What are the three general types of regional crustal stresses, and what ultimately perpetuates each of them, in terms of plate tectonics?
    - Compressional Stresses associated with plate collisions tend to shorten and thicken Earth's Crust by folding, flowing, and faulting. Horizontal

Compressional Stress causes rock bodies to shorten horizontally and thicken vertically.

- Tensional Stresses at divergent plate boundaries tend to lengthen rock bodies by displacement along faults in the upper crust and ductile flow at depth. Horizontal tensional stress causes rock bodies to lengthen horizontally and thin vertically.
- Shear Stresses at transform plate boundaries tend to produce offsets along fault zones. Shear stress causes displacements along fault zones or by ductile flow.

- What are the major types of regional-scale deformation (strain) structures? Make sure to include folds, and the three basic types of faults.
  - Rock Structures- Strike , Dip
  - Folds- Anticline, Synclines, Monoclines, Domes and Basins
  - Faults- Dip-slip faults, Low angle reverse faults, Normal faults
  - Joints- columnar joints

b) Describe how a specific type of crustal stress produces specific types of deformation structures.

- Tensional stresses produce what sorts of deformation structures?
  - Tensional stress leads to the hanging wall moving down with respect to the footwall which leads to the formation of normal faults.
- Compressional stresses produce what sorts of deformation structures?
  - Compressional stress leads to the formation of folds, reverse faults, and thrust faults.
- Shearing stresses produce what sorts of deformation structures?
  - Horizontal movement along strike-slip faults forms due to shear stress.
- Make reference in each case as to whether there is a) crustal thickening+shortening, b) thinning+extension, or c) neither (only translation).
  - Compressional Stress: Causes rock bodies to shorten horizontally and thicken vertically.
  - Tensional Stress: causes rock bodies to lengthen horizontally and thin vertically.
  - Shear Stress: causes displacements along fault zones or by ductile flow.
  -

(Course textbook, pgs.66-86, Figure 3.15, www.terrasonics.com, Crustal Deformation PowerPoint; Earth Geology and Structure lecture outline,

RESPONSES TO SECTIONS A) AND B) ARE CORRECT AND COMPLETE - 0 POINTS

TOPIC #2 – DEFINE AND EXPLAINING WHAT AN EARTHQUAKE IS AND WHERE AND WHY THEY OCCUR. (5 points for each section – 10 total)

a) Provide a concise, yet brief, definition of an earthquake and related faulting dynamics, including the following:

- What is an earthquake exactly?
    - An earthquake is the vibration of earth produced by the rapid release of energy. Most often, earthquakes are caused by slippage along a fault in Earth's crust. The energy released radiates in all directions from it's source called the focus or hypocenter in the form of waves.
- How are earthquakes related to faults?
    - The movements that produce a destructive earthquake are usually associated with large fractures in earth's crust called faults. Typically earthquakes occur along preexisting faults. Motions along faults are explained by plate tectonics theory. These mobile plates interact with neighboring plates, straining and deforming the rocks at their margins. It is along faults associated with plate boundaries that most earthquakes occur.
- Define focus, epicenter, and seismic waves.
    - Focus: The same as the earthquakes center. That is the location inside the Earth's crust where the earthquake originates; however, the term is used to mean the point at which the earthquake originated. It is directly below the epicenter at a depth known as the focal depth. It is the position where the energy stored in the strain in the rock is released.
    - Epicenter: is the point on the Earth's surface that is directly above the point where an earthquake or other underground explosion originates or focus. The epicenter

is directly above the hypocenter (dot number 3), the actual location of the energy released inside the earth and usually suffers the maximum destruction.

    - Seismic Waves: is a wave that travels through the Earth, most often as the result of a tectonic earthquake, sometimes from an explosion. Seismic waves are also continually excited by the pounding of ocean waves and the wind.
- Where do most of the world's earthquakes occur, in terms of plate tectonics?
    - They occur in the tectonic or crustal plates. On these active plate boundaries about 95% of all the world's earthquakes occur. California, Alaska, Japan, South America, and the Philippines are all on plate boundaries. Only 5% are in areas of the plates far away from the boundaries. These are called mid-plate or intra-plate earthquakes.

b) Describe and explain the Elastic Rebound Theory.

- Elastic Rebound Theory: A theory which attributes faulting to stresses (in the form of potential energy) which are being built up in the earth and which, at discrete intervals, are suddenly released as elastic energy; at the time of rupture the rocks on either side of the fault spring back to a position of little or no strain.
- The relationship between stress and strain.
    - Both stress and strain are a cause of deformation. To describe the forces that deform rocks, structural geologist use the term stress which is the amount of force applied to a given area. Stress can also cause an irreversible change in the shape of a rock body referred to as strain.
- The release mechanism of stored strain energy.
    - Elastic Rebound
- The 4-step process that culminates in the release of strain energy.
    - Original position
    - Build up strain
    - Slippage (earthquake)
    - Strain released
- Provide a practical example of this 4-step process.

- As rock is deformed it bends storing elastic energy. Once strained beyond its breaking point the rock cracks releasing the stored up energy in the form of earthquake waves.

(Course textbook, pgs.92-117, Figures 5.15-18; www.terrasonics.com, Earthquake PowerPoint; Earthquake and Structure lecture outlines.

RESPONSES TO SECTIONS A) AND B) ARE CORRECT AND COMPLETE - 0 POINTS

TOPIC #3 – HOW DO YOU DETERMINE THE EPICENTER AND MAGNITUDE OF AN EARTHQUAKE? - (5 points for each section – 10 total)

a) Provide a concise, yet brief step-by-step instructions of how to determine the epicenter of an earthquake.

- How many seismic recording stations needed? –
  - 3 or more
- What sort of seismic data needed?-
  - The differences in velocities of P and S waves provides a method for locating the epicenter.
- What do you do with the seismic data?-
  - Determine the distance separating the recording station from the earthquake. Then determine the direction.
- Where and how do you plot the data? –
  - By drawing a circle around each seismic station. Each circle represents the epicenter of each distance for each station.
- How does the plotted data pinpoint the epicenter? –
  - Triangulation, the point where the three circles intercept.

EXACTLY

b) Provide a concise, yet brief step-by-step instructions of how to determine the magnitude of an earthquake.

- How many seismic recording stations needed?-
  - One

- What sort of seismic data needed?-
    - based on the amplitude of the largest seismic wave.
- What do you do with the seismic data?-
    - Measure the logarithm and amplitude of the seismic wave by using a logarithmic scale.
- Where and how do you plot the data? –
    - You account for the decreased in wave amplitude with increased distance.
- How does the plotted data pinpoint the magnitude?-
    - a logarithmic scale is used to express magnitude where a tenfold increase wave amplitude corresponds to an increase of 1 on the magnitude scale.

USE OF TALLEST S-WAVE FROM A SEISMOGRAM AND PLOT ON A RICHTER CHART ALONG WITH THE DISTANCE TO EPICENTER – THE LINE CONNECTED BETWEEN THE TWO POINTS CROSSES OVER THE CORRESPONDING RICHTER MAGNITUDE.

(Course textbook, pgs.118-123, Figures 5.19-21; www.terrasonics.com, Earthquake PowerPoint; Earthquake and Structure lecture outlines.

RESPONSES TO SECTIONS A) AND B) ARE CORRECT AND COMPLETE - 0 POINTS

TOPIC #4 – DESCRIBE IN SOME DETAIL A RECENT LARGE EARTHQUAKE THAT YOU FIND MOST INTERESTING (5 points for each section – 10 total)

a) Provide a concise overview description of the recent, large earthquake, including the following:

- The time and place (epicenter).-
    - 06/14/2005, 07:50:54 PM (PDT), 06/15/2005 02:50 (UTC). 146 km West of Cresent City, CA
- Earthquake magnitude-
    - 7.2
- Depth of earthquake (focus)-

- 10.0 Km

- The name fault rupture occurred on-
  - Strike Slip Fault. **WHAT WAS THE FORMAL NAME OF THIS FAULT? - THE SAN ANDREAS?**
- The type of fault that the rupture occurred on-
  - Strike Slip Fault.
- Any statistical data on how often large quakes occur on this fault?
  - Earthquakes occur as often as every week on this fault. As for the size of the earthquakes which occur were not mentioned.
- Describe the general plate tectonic setting: Convergent = subduction or continental collision?; Divergent – seafloor spreading or continental rift?, Transform – oceanic or continental?
  - Convergent Subduction - **IF IT WAS A STRIKE FAULT, THEN I WOULD GUESS THAT IT WAS PART OF THE SAN ANDREAS TRANSFORM BOUNDARY SOUTH OF THE CASCADE CONVERGENT BOUNDARY**
- Name the specific plate boundary where rupture occurred. (Which plates involved?)
  - Subduction zone **DIDO**

b) List and describe the major earthquake hazards and associated seismic damage generated by the quake.

- Types of hazards associated with quake
  - Tsunami Warning
- Severity of each of the hazards, including ground shaking.
  - Tsunami warning was canceled after a preliminary tsunami watch was issued for this event by the Alaska and West Coast Tsunami Warning Center. The watch and warning were cancelled as soon as NOAA confirmed normal water levels at coastal sites.
- The types of seismic damage that occurred.
  - This quake was widely felt along the northern California - southern Oregon coast line, although only light shaking occurred.
- Description of the various types of quake damage.
  - None noted

- The severity of the quake damage, including both life and property.
    - None noted
- The regional extent of the quake damage
    - None noted

(Course textbook, pgs.125-130, Figures 5.23-24; www.terrasonics.com, Earthquake PowerPoint; USGS website. http://earthquake.usgs.gov/.

RESPONSES TO SECTIONS A) AND B) ARE CORRECT AND COMPLETE - 0 POINTS

TOPIC #5 –DESCRIBE AND EXPLAIN THE PREDOMINANT TYPE OF REGIONAL-SCALE CRUSTAL STRESS AND STRAINS AT EACH TYPE OF TECTONIC PLATE BOUNDARY. - (5 points for each section – 10 total)

a) Provide a concise, yet brief description and explanation for the dominant type of regional crustal stress regime at each type of plate boundary:

- Crustal stress regime at a Divergent boundary?
    - Where new crust is generated as the plates pull away from each other. This would be classified as horizontal tensional stress.
- Crustal stress regime at a Convergent boundary?
    - Where crust is destroyed as one plate dives under another. This would be classified as horizontal compressional stress.
- Crustal stress regime at a Transform boundary?
    - Where crust is neither produced nor destroyed as the plates slide horizontally past each other. This would be classified as shear stress.
- Make reference to how relative motion (direction and speed) between plates plays central role in controlling the stress regime.
    - Each of the motions within the plated defines a certain type of stress within the stress regime. This shows that the regime is a valid analysis for the deformation of earth's crust caused by tectonic forces and associated stresses resulting from the movement of lithospheric plates.

b) Provide a concise, yet brief description and explanation for the dominant type of regional-scale deformation structures occurring at each type of plate boundary:

- Deformation structures at a Divergent boundary?
    - Tensional Stresses at divergent plate boundaries tend to lengthen rock bodies by displacement along faults in the upper crust and ductile flow at depth. Horizontal tensional stress causes rock bodies to lengthen horizontally and thin vertically.
- Deformation structures at a Convergent boundary?
    - Compressional Stresses associated with plate collisions tend to shorten and thicken Earth's Crust by folding, flowing, and faulting. Horizontal Compressional Stress causes rock bodies to shorten horizontally and thicken vertically.
- Deformation structures at a Transform boundary?
    - Shear Stresses at transform plate boundaries tend to produce offsets along fault zones. Shear stress causes displacements along fault zones or by ductile flow.
- Make reference to how relative motion (direction and speed) between plates plays central role in controlling the orientation and scale of development of the deformation structures.
    - Depending on the direction or the speed of the motion is the type of deformation caused in result of stress and strain. For example there is elastic deformation, ductile deformation, brittle deformation, folds (synclines and monoclines), and faults (dip slip faults, low angle reverse faults, and normal faults).

(Course textbook, pgs.140 to 149, Figures 7.2-6; www.terrasonics.com, Earthquake and Mountain Building PowerPoints; Earthquake and Structure lecture outlines.

RESPONSES TO SECTIONS A) AND B) ARE CORRECT AND COMPLETE - 0 POINTS

TOPIC #6 – DESCRIBE IN SOME DETAIL A SPECIFIC MOUNTAIN BUILDING REGION THAT YOU FIND MOST INTERESTING (5 points for each section – 10 total)

a) Provide a concise overview description of the mountain building episode, including the following:

- Chose from any geologic time and place. It can be an extinct mountain belt, e.g. Appalachians, or a currently active one, e.g. Himalayas.
    - 45 million years ago, India/ Asia
- Name of the Mountain Belt
    - Himalayas
- Note the span of geologic time it was actively deforming/building.
    - Building - **SINCE 45 Ma TO THE PRESENT???**
- Describe the general plate tectonic setting: Convergent = subduction or continental collision?; Divergent – seafloor spreading or continental rift?, Transform – oceanic or continental?.
    - Convergent subduction zone - **NO – IT'S A CONTINENT-CONTINENT COLLISION ZONE – NO MORE SUBDUCTION ZONE – THAT WAS EXTINGUISHED MILLIONS OF YEARS AGO.**

b) List and describe the major geologic forces and deformational events that took during mountain building

- Predominant type of regional crustal stresses
    - Because both these continental landmasses have about the same rock density, one plate could not be subducted under the other. The pressure of the impinging plates could only be relieved by thrusting skyward, contorting the collision zone, and forming the jagged Himalayan peaks. This would be described as a horizontal compressional stress.
- Major sorts of regional deformation features, such as folds and faults. Be specific about which types of faults are found.
    - Main frontal thrust fault. Anticlines, synclines, monoclines and recumbent folds.
- Note which tectonic plates (by name) were involved in the mountain building event.
    - Convergent Subduction
- Any other significant geologic or tectonic features or events
    - Continuing subduction along Asia's margin created an Andean type plate margin that contained a well developed volcanic arc and accretionary wedge.

WHERE EXACTLY IS THIS OCCURRING TODAY? OR ARE YOU DESCRIBING WHAT HAD HAD TO OCCUR PRIOR TO THE CONTINENTAL MASSES COLLIDING?

- Some researchers suggest that extensive thrust faulting and folding within the upper crust as well as uniform ductile deformation of the lower crust and underlying lithospheric mantle produced the great crustal thickness that accounts for this extremely high plateau.

(Course textbook, pgs.145 to 158, Figures 7.5-8; www.terrasonics.com, Mountain Building PowerPoint; USGS website: http://earthquake.usgs.gov/learn/topics/plate_tectonics/rift_man.php

RESPONSES TO SECTIONS A) AND B) ARE CORRECT AND COMPLETE - 0 POINTS

ALL TOPIC REFERENCE LISTS ARE VERY GOOD - 0 POINTS

TOTAL SUBTRACTED POINTS = - 0 POINTS
TOTAL POINTS EARNED = 60 OUT OF 60 POINTS

EXCELLENT RESEARCH AND WRITING, ANDREA
LOOK FORWARD TO YOUR NEXT PAPER!