2020 Camas Invite GeoLogic Mapping

Answer Key

This test is fairly long, so be efficient with your time (I would suggest having each person start from opposite ends of the test to ensure complete coverage). It will be helpful to have a scientific calculator (non-graphing) for a few problems, but answers will not require significant figures. Please round answers as requested in each question. Show work the best you can for any math questions by writing out key equations used.

Example for how to write an inverse trig function: arcsin(x) or sin^(-1)(x).

Be sure to use parentheses and brackets as necessary for clarity.

You might need a ruler or straight edge for some problems.

Notes from the Test Writer/Grader:

- In addition to answers, I provided some common mistakes made by students
- I noticed that many students who correctly answered the math questions didn't show work which resulted in a substantial loss of points for work that they had already done. I clearly stated at the beginning of the test that work was necessary. In the future, remember that it is beneficial to read the instructions at the beginning of a test.
- There were also many students who incorrectly answered the math questions and didn't show work. Had they shown work, partial credit may have been earned.

Disclaimer: Many of the questions on this test have several correct answers, so you may have noticed you received points for an answer not specifically listed in the answer key

Earth Structure and History:

1. How old is the Earth? (1)
   a. 4.5 million yrs
   b. 9 million yrs
   c. 4.5 billion yrs
   d. 9 billion yrs

2. List the chemical layers of the earth and provide an approximate composition of each (6)
Crust: silica rich minerals (silicon and oxygen)
Mantle: silicate minerals with iron and magnesium
Core: mostly iron and other heavy metals
(1 pt for each correct layer, 1 pt for each correct composition)
Remove one point for any extra layers

Fun fact: these are also called the classical layers of the Earth because they were determined before more precise seismic measurements were taken.

3. List the physical layers of the Earth and describe their states (10)
Lithosphere: hard solid
Asthenosphere: “soft” solid (plastic)
Mesosphere (or lower mantle): hard solid
Outer Core: liquid
Inner Core: solid
(1 pt for each correct layer, 1 pt for each correct physical state)

Fun fact: these are also called the modern layers of the Earth

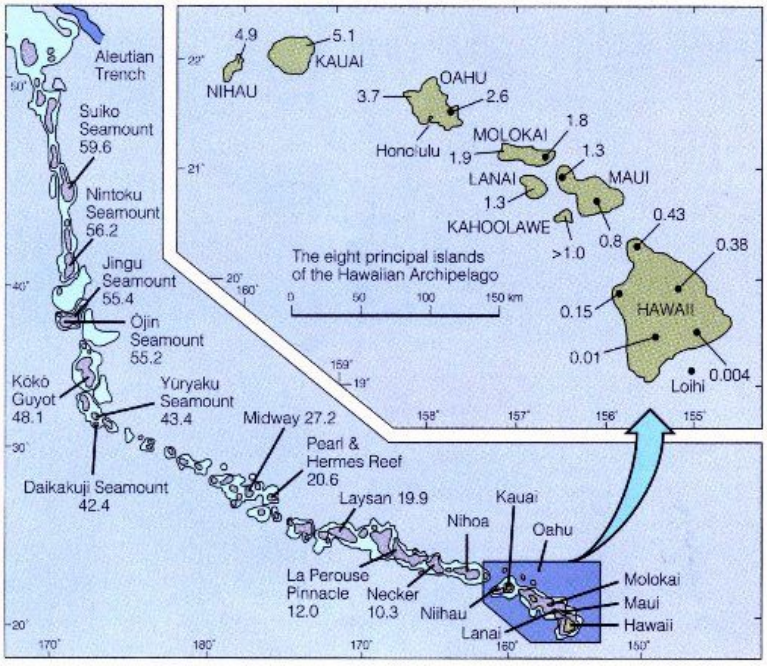
4. We know a lot about the Earth’s interior because of seismic waves. Use knowledge of these waves to describe how we know the outer core is liquid and the inner core is solid. (5)
Seismic body waves, (P and S) travel through the Earth’s interior when an earthquake occurs (1). P waves can travel through both liquids and solids (1), but S waves can only travel through solids (1). When the waves hit the outer core, the S wave disappears, and only the P wave travels through (1). When the P wave hits the inner core, it generates a small earthquake which brings back the S wave which can travel through because it is solid, and disappears again when it reaches the outer core (1). Mention of how P waves travel slower in the liquid outer core versus the solid mantle and inner core can also earn a point.

Plate Tectonics:

5. What are five pieces of evidence for plate tectonics? (5)
Fit of continents, fit of mountain ranges, fit of glacial deposits, same fossils on different continents, paleomagnetism, SLR (satellite laser ranging), age of the seafloor, reversal of magnetism along the seafloor, locations of volcanoes and other geologically active regions along plate boundaries, etc.

Note: no points are received for answers like "volcanoes", "earthquakes", "fossils". The students must specify what about those hinted at plate tectonics because without recognizing the patterns, those by themselves don't say much by themselves.

Use the following map to answer questions 6-10:



6. How were Emperor seamounts and the Hawaiian islands formed? Explain in detail. (4pts)
They were created by a **stationary** hotspot below the crust (1). Volcanoes formed above the hotspot (1), so as the Pacific plate moved, those volcanoes were moved away from the hotspot and became dormant and eventually eroded back beneath sea level (1). New islands continue to form as the Pacific plate continues to move. (1)

7. What direction was the Pacific plate moving 60 million years ago? (1)
North

8. Around 43 million years ago, the plate direction changed to what? (1)
Northwest

9. Using Hawaii and Oahu, calculate the average speed of the Pacific plate in centimeters per year (note that the ages of the volcanoes are in millions of years on the map). (3pts)
Distance: 210km, Time: 2.59million years
210km/2.59million years x 100000cm/1000000yrs (2)
8±0.5cm/yr (1)

Note that you could have used different locations on Hawaii and Oahu to calculate the speed. I did the calculation with several pairs and all the speeds were within 0.5 cm/yr of 8 cm/yr

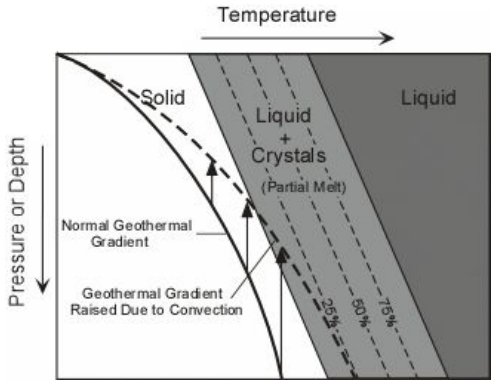
10. Is this relatively fast, slow, or average compared to other parts of the oceanic crust? (1pt)
Fast

11. Is continental crust denser or less dense than oceanic crust? How does this affect what happens when two plates converge? Based on this, is continental crust generally older or younger than oceanic crust? (4 pts.)
Continental crust is less dense (1) which means that when it converges with an oceanic plate, the oceanic plate will be pushed under and be destroyed (1). Since continental crust will not be pushed under like oceanic crust, it is not readily destroyed or created (1). This means that continental crust is generally much older than oceanic crust. (1)

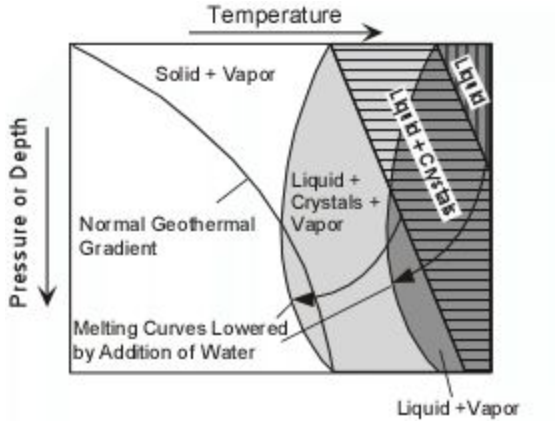
Rock Formation:

Use the following two diagrams to answer questions 12-15:

a.



b.



12. What kind of partial melting is shown in graph A? (1)
Decompression melting

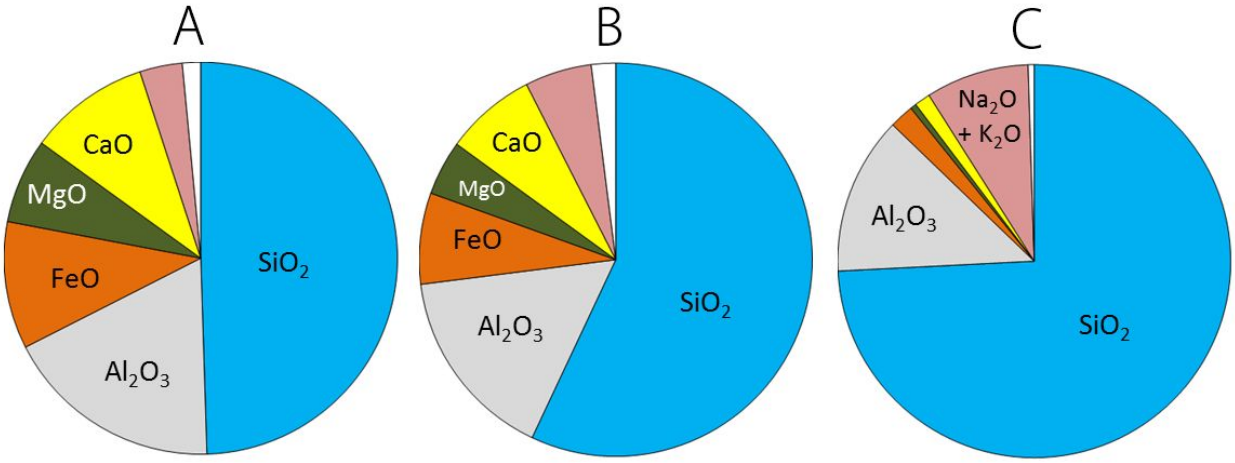
13. What kind of partial melting is shown in graph B? (1)
Flux melting

Several teams mentioned equilibrium/fraction fusion/crystallization for questions 12-13, but that has to do with the cooling of magma into rocks, not the melting of rocks into magma

14. Which kind of melting occurs at mid oceanic ridges? (1)
    a. A
    b. B

15. Which kind of melting occurs a oceanic/continental convergent boundary (1)
    a. A
    b. B

Use the following pie charts to answer questions 16-20:



16. Identify which of the above is most like the composition of andesite? (1)
    a. A
    b. B
    c. C

17. Identify which of the above is most like the composition of basalt? (1)
    a. A
    b. B
    c. C

18. Identify which of the above is most like the composition of rhyolite? (1)
    a. A
    b. B
    c. C

19. **TB4**: Magma in a shield volcano is most likely to have a composition like which of the above? (1)
    a. A
    b. B
    c. C

20. Magma in a composite volcano is most likely to have a composition like which of the above? (1)
    a. A
    b. B
    c. C

21. Which one of the following minerals does not contain silica tetrahedra? (1)
    a. Clay
    b. Quartz
    c. Calcite
    d. Olivine
    e. Feldspar

22. If a basalt were heated up until it melted thoroughly (no crystals left) and then was cooled very very slowly you would most likely get: (1)
    a. Gabbro
    b. andesite porphyry
    c. Obsidian
    d. Granite
    e. Diorite

23. Which mineral below is extremely unlikely to occur in a basaltic rock? (1)
    a. Pyroxene
    b. Plagioclase
    c. Olivine
    d. Amphibole
    e. Quartz

24. A very dense, very fine-grained metamorphic rock suggests metamorphism primarily as a result of (1)
    a. high pressure and high temperature
    b. high pressure and lower temperature
    c. low pressure and low temperature
    d. low pressure and high temperature
    e. migration of chemical fluids

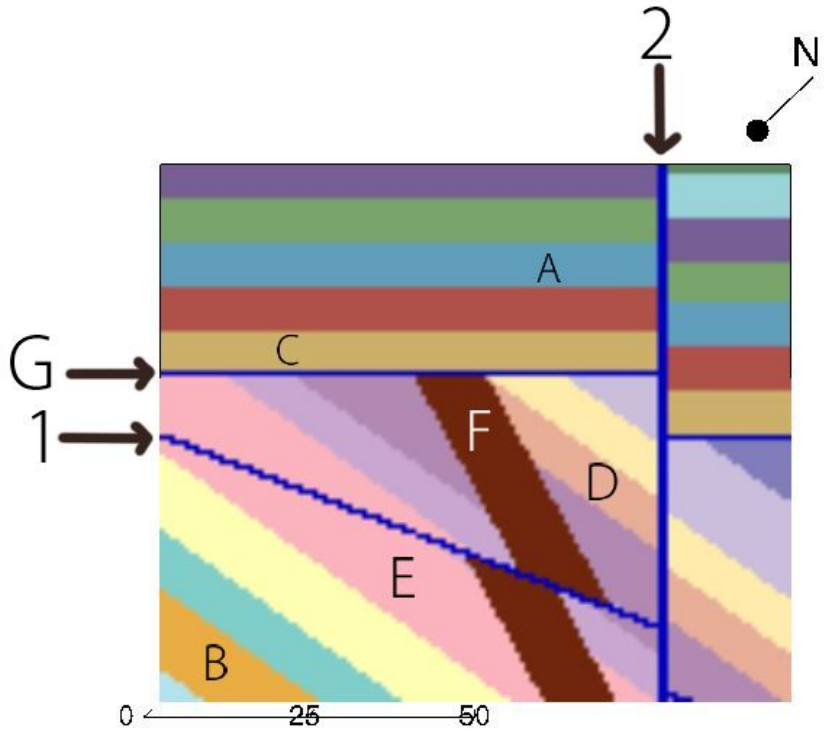
25. The best evidence that a rock has a metamorphic origin is: (1)
    a. finding mica in the rock
    b. presence of different-colored layers in the rock
    c. a foliated texture
    d. finding garnets in the rock
    e. finding phenocrysts in the rock

26. Many granites are thought to originate by

a. deep burial, melting, and recycling of continental material (especially sedimentary rocks) where two lithospheric plates are colliding
b. melting of the tops of downgoing lithospheric slabs (in trenches) together with contamination by continental material as the melt rises through the crust
c. partial melting of the upper mantle
d. settling out of quartz and feldspar from peridotite
e. metamorphism of andesitic rocks

Geological Principles:

Use the following block diagram to answer questions 27-30:



Note: The letter N is specifying North and is not pointing at anything in the diagram.

27. Determine the order of events (A B C D E F G 1 2) and explain using Steno's three laws as necessary. Assume that no beds were overturned. (10)

B E D F (1 G or G 1) C A 2 (5 pts) remove 1 pt for every event out of order. Note that we can't tell from this diagram whether 1 or G occurs first, so accept either order.

Superposition: (B E D), (C A) used to determine the order of these beds assuming they weren't overturned. (2)

Original Horizontality: (B E D) was originally horizontal (1)

Law of Cross Cutting Relations: (1, 2, F) used to determine relative dating for the igneous intrusion and the faults (cross-cutting relations must be younger than the beds they cut through) (2)

28.What kind of unconformities exist and between which layers? (2)
Angular unconformity (between B E D and C) and nonconformity (between F and C). (1 pt for each correctly identified unconformity/location)

29. What kind of fault is fault 1? (1)
Normal

30. What kind of igneous intrusion is F? (1)
Dike

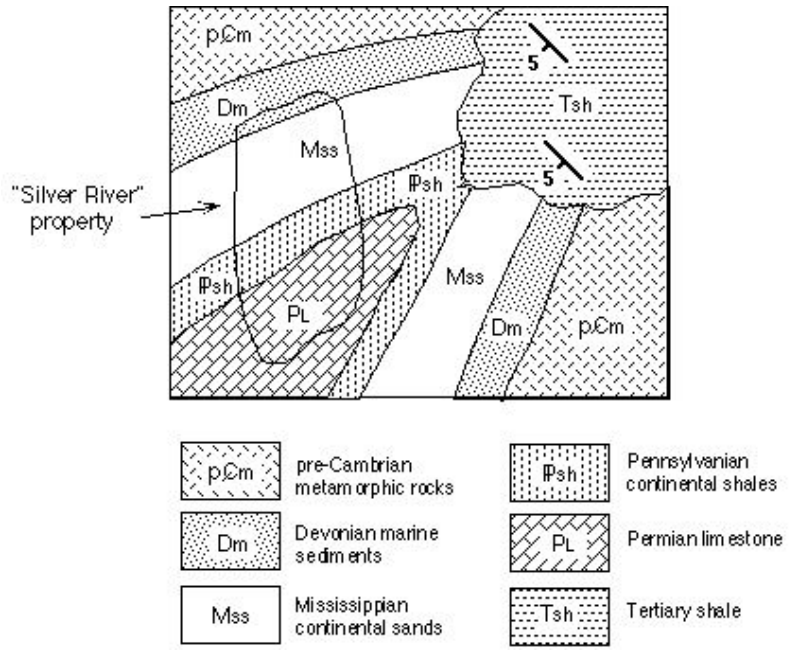
31. Explain uniformitarianism and provide one piece of evidence for it. (3)
the theory that the same natural laws and processes that operate in the universe now have always operated in the universe in the past and apply everywhere (2). It is the idea that “the present is key to the past,” and that the laws of nature are constant through time and space. Evidence: layers in the Grand Canyon etc. unconformities in rock layers, the cycle of sedimentation and erosion (1 pt for a correct piece of evidence)

32. Explain catastrophism and provide one piece of evidence for it. (3)
the theory that changes in the earth's crust during geological history have resulted chiefly from sudden violent and unusual events (2). This idea was greatly influenced by the Bible (ex. Great flood). Evidence: mass extinctions, volcanic eruptions, asteroids, misplaced fossils/missing layers (1 pt for a correct piece of evidence)

33. Based on current geologic knowledge of the Earth and its history, which of the above is correct? (or both?) Explain. (3)
Each individually is not entirely correct (1). While it is true that for the most part the Earth goes through continuous, fairly uniform cycles (ex. Wilson cycle, sedimentation/erosion) (1), sudden catastrophic events (ex. Missoula, Krakatoa) also have immense effects on the Earth’s geologic evolution (1).

Geologic Map Interpretation:

Use the following geologic map to answer questions 34-39:



34. Which of the beds is the oldest? (1)
    a. pCm
    b. Tsh
    c. Psh
    d. Mss
    e. PL
    f. None of the above

35. Which of the beds is the youngest? (1)
    a. pCm
    b. Tsh
    c. Psh
    d. Mss
    e. PL
    f. None of the above

36. Name the two kinds of unconformities that exist in the above map and which layers they are between. (4)

Angular unconformity: between Tertiary shale and the other layers

Nonconformity: between pre-Cambrian metamorphic rocks and Devonian marine sediments

(note the gap in time between pCm and Dm, nonconformity because metamorphic and sedimentary)

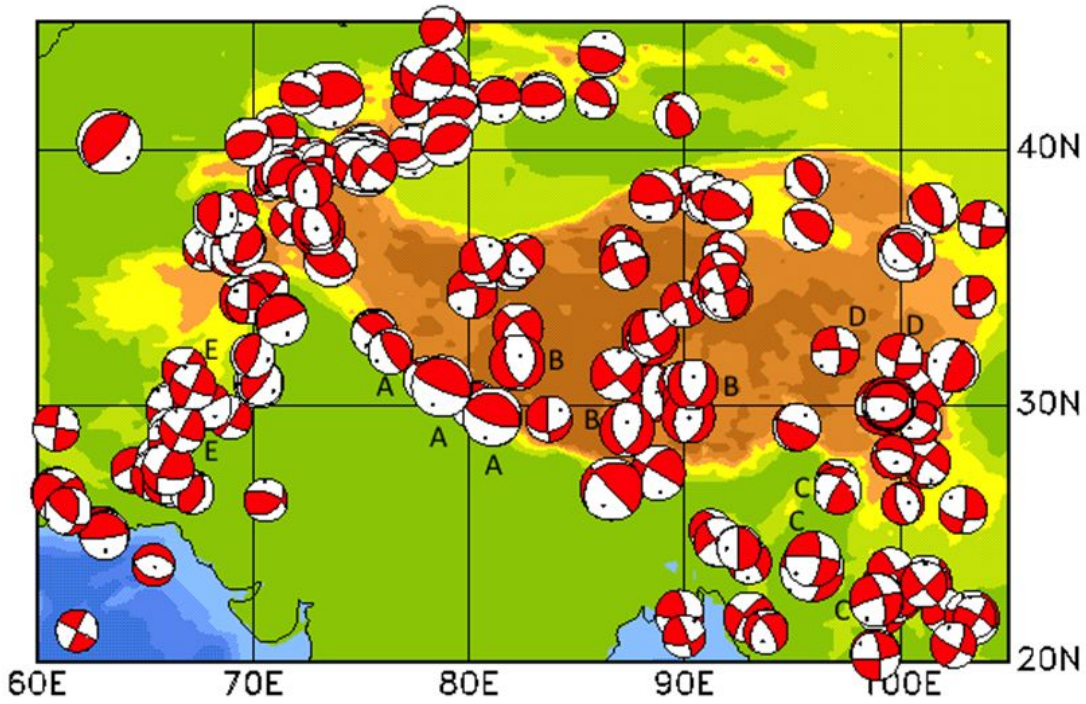
37. What kind of geologic structure is present? (1)
Plunging syncline

38. What direction does the structure plunge? (1)
Southwest

39. Do you think the Silver River property labeled in the map would be a good place to find oil? Explain the likelihood by describing possible source and reservoir rocks, and traps. (5)
No (1), The Devonian marine sediments are a possible source rock (1), and the Mississippian sandstones are a possible reservoir rock (1). However there is no trap: a syncline won't trap the oil (1), and there is also no caprock in the Silver River area (1).

Faults:

Use the following map to answer questions 40-47:



40. What kind of faults are those labelled A? (1)
    a. Normal
    b. Thrust
    c. Reverse
    d. Strike slip

41. What kind of faults are those labelled B? (1)
    a. Normal
    b. Thrust
    c. Reverse
    d. Strike slip

42. What kind of faults are those labelled C? (1)
    a. Normal
    b. Thrust
    c. Reverse
    d. Strike slip

43. What kind of faults are those labelled D? (1)
    a. Normal
    b. Thrust
    c. Reverse
    d. Strike slip

44. What kind of faults are those labelled E? (1)
    a. Normal
    b. Thrust
    c. Reverse
    d. Strike slip

45. **TB3**: What is the strike direction for Group A? Describe the dip qualitatively (i.e. steep, shallow, near 45 degrees ...). What is the most likely fault plane? Explain. (4)
Strike: northwest/southeast (1)
Dip: shallow (1)
The northeast fault plane is more likely (1) knowing that the Indian plate is converging with the Eurasian plate (1).

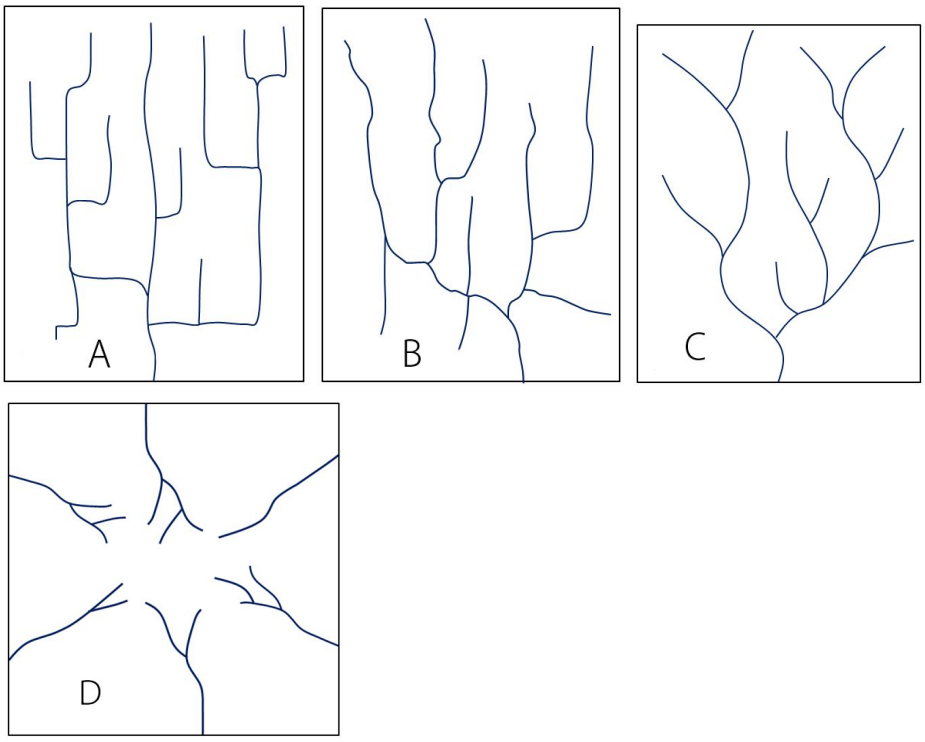
46. What kind of plate boundary most likely exists near faults labelled A? (1)
Convergent

47. Explain why the different types of faulting occur in this region. (5)
The shallow dipping reverse faulting occurs closer to India due to the convergence with Asia which creates thrust faults (1). The region of Tibet experiences strike/slip faulting and normal faulting as a result of the material moving out of the way of the incoming Indian plate (1). The squeezing applies a force on the middle region which produces north-south striking normal faults that stretch the land laterally (1). To result in lateral motion, there needs to be a system of many normal faults (1). The lateral motion of the region also results in east west striking strike slip faults. Since the strike is the same direction as the land movement, these faults occur along the length of Tibet as opposed to the normal faults which occur along the width.

1 pt for explaining thrust faults come from convergence, 2 pts for explaining the normal faulting, 2 pts for explaining the strike-slip faulting

Erosional patterns:

Use the following diagrams to answer questions 48-52:



48. What kind of stream drainage pattern is A and what kind of geology does it correspond to? (2)
Rectangular - from highly jointed bedrock (little topography, system of bedding planes, fractures, faults)

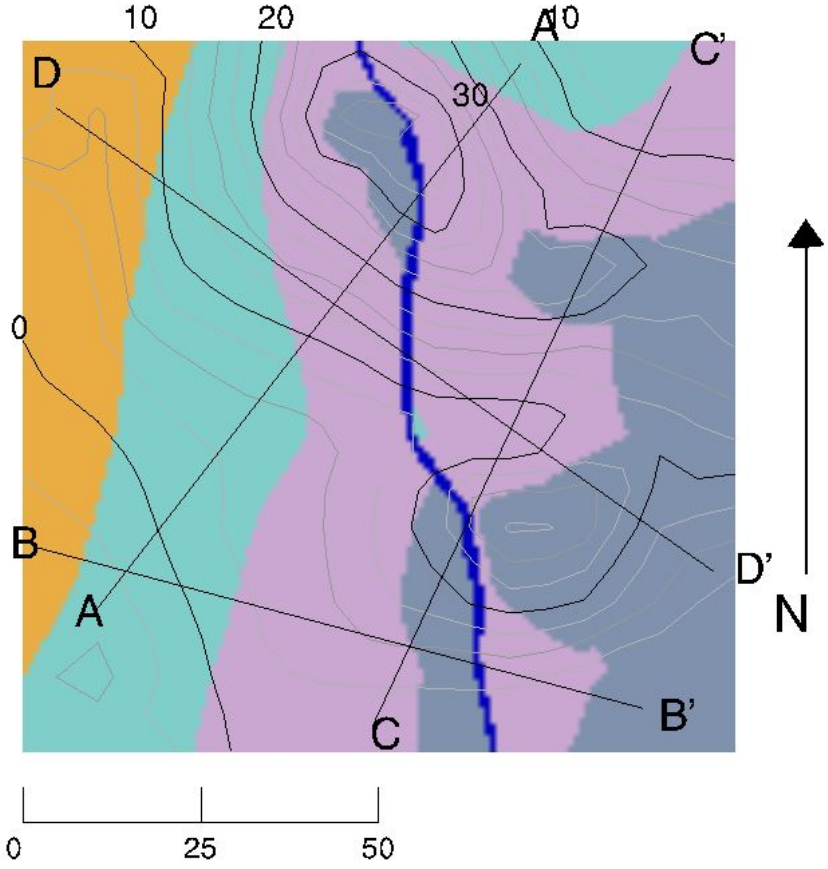
49. What kind of stream drainage pattern is B and what geology does it correspond to? (2)
Trellis - alternating weak and resistant bedrock

50. What kind of stream drainage pattern is C and what geology does it correspond to? (2)
Dendritic - from relatively uniform bedrock, no particular structure that can be eroded equally in all directions

51. What kind of stream drainage pattern is D and what geology does it correspond to? (2)
Radial - from isolated volcanic cones or domes

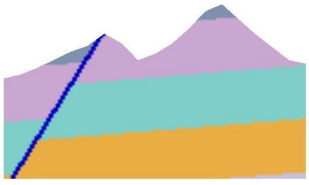
52. The Great Basin region probably has which of the above stream patterns? Why? (2)
B (trellis) (1), series of parallel mountains and valleys (horsts and grabens) (1)

Use the following Topographic map and profiles to answer questions 53-57:

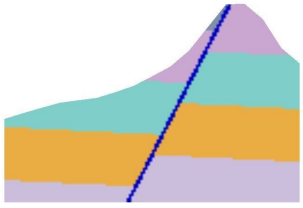


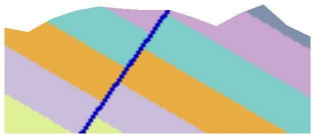
Here are the unlabeled profiles of the above lines:

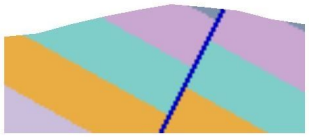
a.



b.



c. 

d. 

53. Which profile corresponds to A-A'? (1)
    a. A
    b. B
    c. C
    d. D

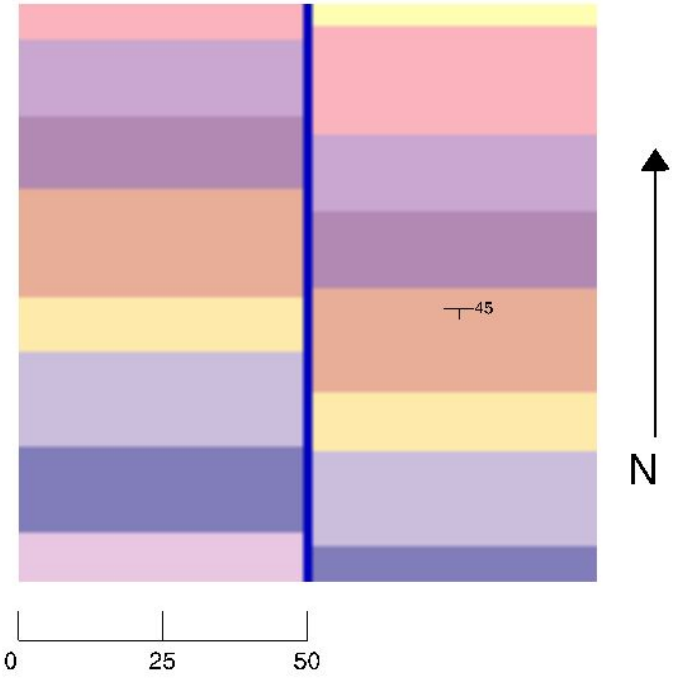
54. Which profile corresponds to B-B'? (1)
    a. A
    b. B
    c. C
    d. D

55. Which profile corresponds to C-C'? (1)
    a. A
    b. B
    c. C
    d. D

56. Which profile corresponds to D-D'? (1)
    a. A
    b. B
    c. C
    d. D

57. What kind of fault exists in the above map? (1)
    a. Normal
    b. Thrust
    c. Reverse
    d. Right lateral strike-slip
    e. Let lateral strike-slip

Use the geologic map below to answer questions 58-59:

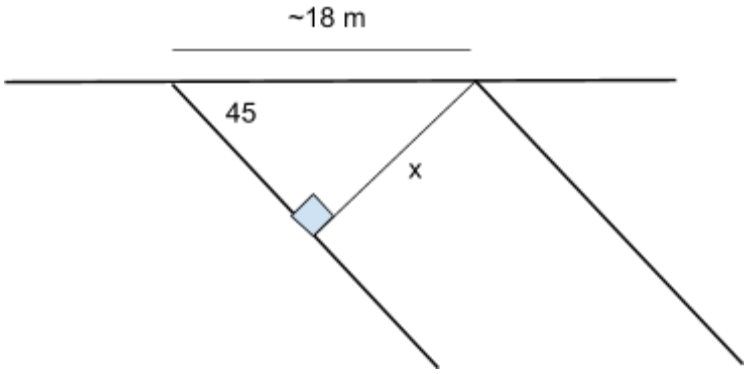


58. What kind of fault is shown in the diagram above? (note, meters) (1)
    a. Normal
    b. Thrust
    c. Reverse
    d. Right lateral strike-slip
    e. Left lateral strike-slip

59. **TB2**: Calculate the thickness of the orange bed (assume the ground is flat) (3)
Measured thickness: 1.8 cm,
using the scale, 2.5 cm = 25 m
2.5 cm/ 25 m = 1.8 cm/ x m
x= 18 m (1 pt)

sin(45 degrees) = x / 18 (1 pt for correct set up)
x=12.7 m thick (1 pt for correct answer), if work was shown and the measured thickness was close, I gave the point, however, if work wasn't shown and the answer was close, I gave no point

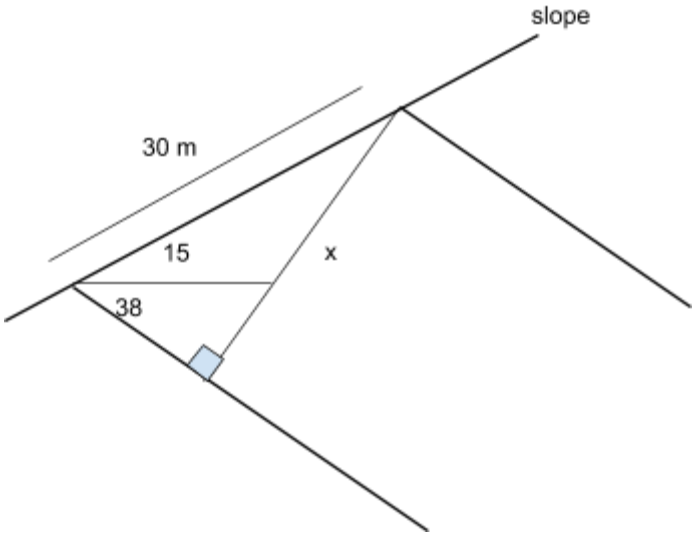
Drawing not to scale:



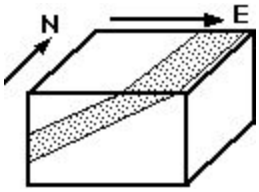
60. Calculate the thickness of a bed (to the nearest meter) given the following:
The distance between the lower and upper contacts is 30 meters measured perpendicular to the strike.
The true dip is 38 degrees.
The slope has a grade of 15 degrees.

1. Find the angle between the ground and the bed: true dip + slope grade = 38 + 15 = 53 degrees (1)
2. sin(53) = x m / 30 m (1 for correct setup)
3. x = 24 m (1 pt for correct answer, must be rounded correctly, 0.5 if not)

Drawing not to scale:

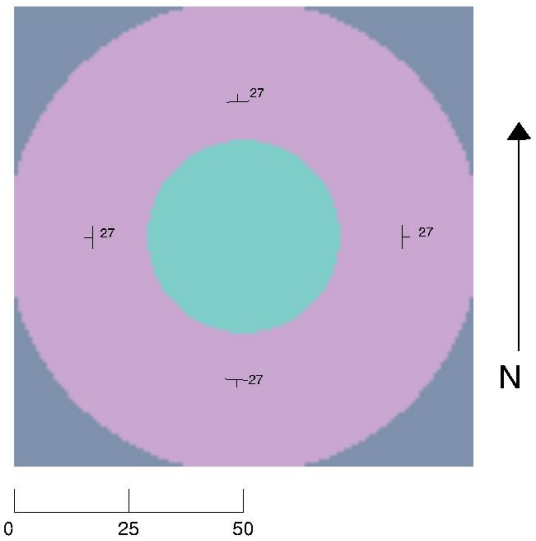


61. Given the following block diagram, what directions are the strike and dip? (1)



a. E-W, N
b. E-W,S
c. N-S, E
d. N-S, W
e. N, S

62. Identify the structure in the map below and describe how you know what it is: (2)

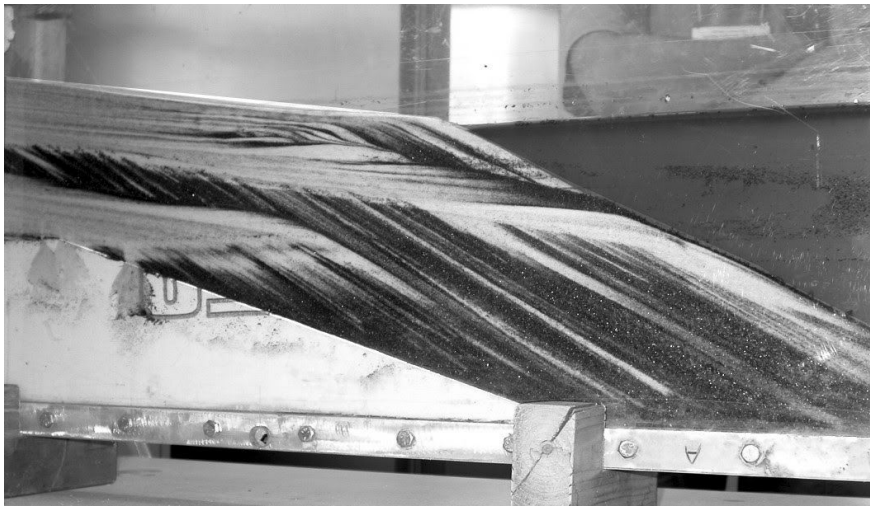


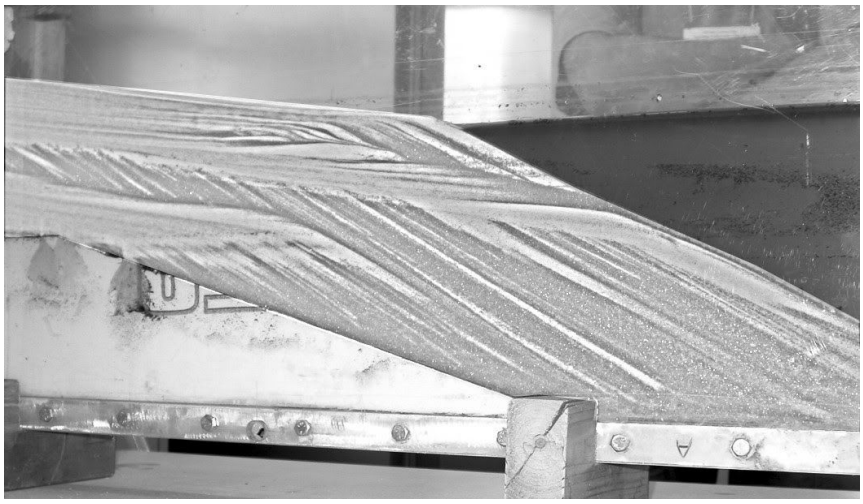
Dome (1), layers dip away from the center (1)

Depositional Environments:

Note: depositional environments are not my area of expertise, however, I had a geology major who just took a class on sedimentology write this section, so it should be good. I was a lot less lenient on answers in this section.

Pictured below is a cross section of a model fluvial-dominated delta depositional sequence. Use the images to answer questions 63-64:





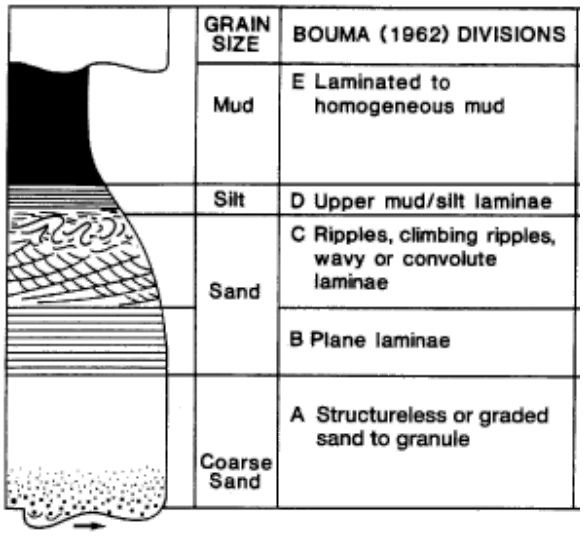
63. Based on the depositional sequence, how many transgressions and regressions have occurred at this location? (4)

This depositional sequence shows two transgressions and one regression, 2 points for the correct number of transgressions, 2 points for the correct number of regressions.

64. At what water level do topset beds form? (2)

2 point for saying topsets form at shallow water levels

Use the following diagram to answer questions 65-67:



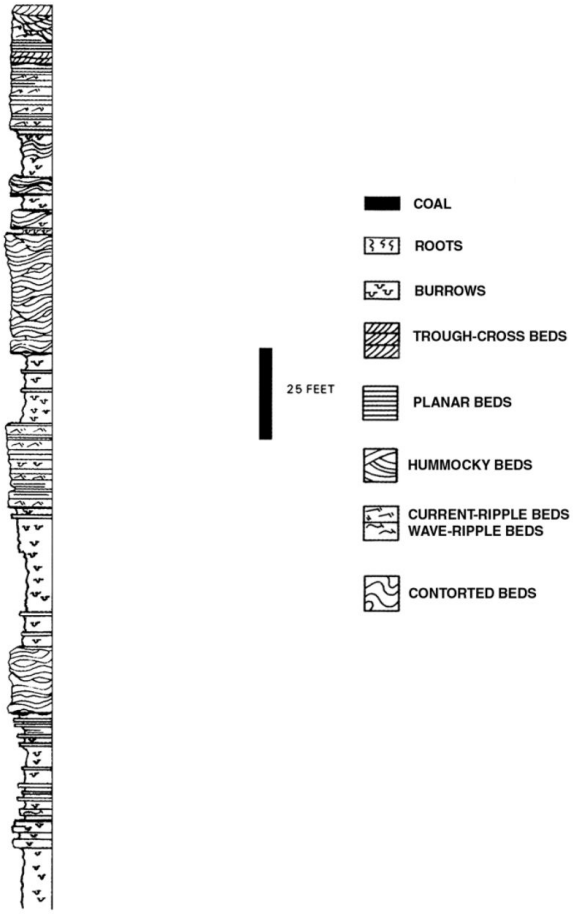
65. The above depositional sequence is characteristic of what sedimentary process? (1)
Turbidity current

66. Describe how normal graded bedding forms (3)
1 point for saying sediment becomes suspended in water
1 point for describing a loss of energy of the sediment flow as the flow reaches flat ground
1 point for saying larger sediments settle out first

67. List one event that can trigger the sedimentary process that produces the sequence above (1)
1 point for any of the following: large storm, earthquake, collapsing slopes, any other high energy event that could dislodge a large amount of sediment into a turbidity current

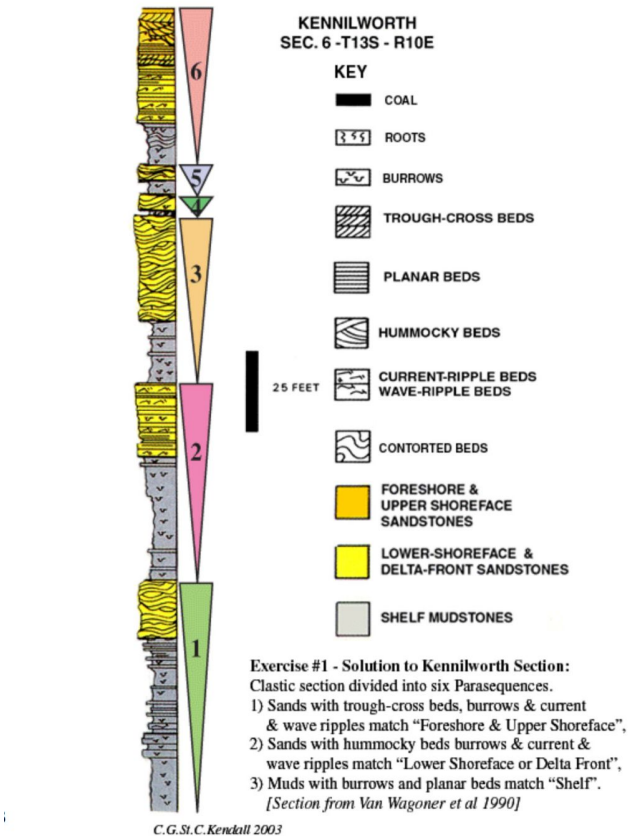
Though several teams answered turbidity current, this question was asking for an event that could cause a turbidity current

68. Identify how many transgressional sequences exist in the cross section below. (2)



2 points for either 5 or 6

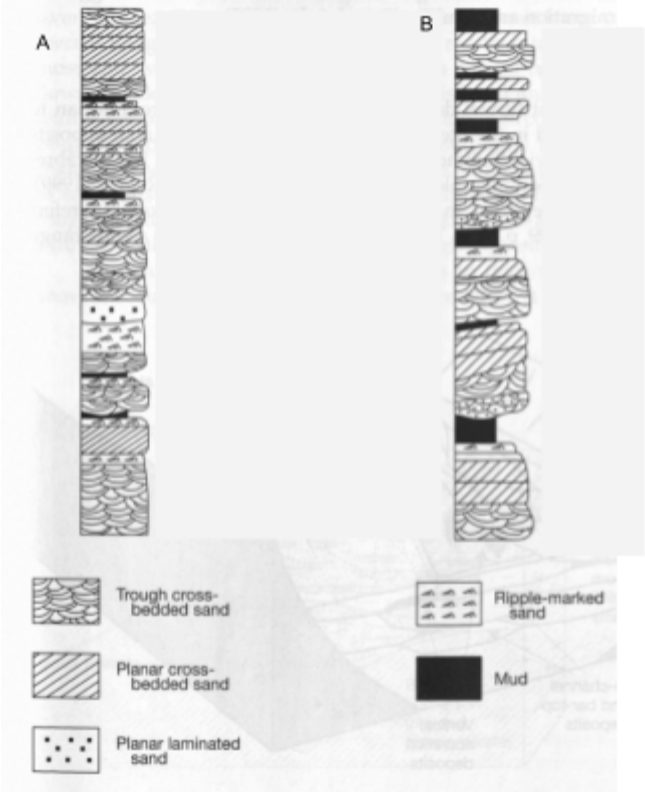
We accepted either 5 or 6 because if a class of third year geology majors identified 5 and not 6, it would be unrealistic to expect high schoolers to identify 6.
See the diagram on the next page for the locations of all the transgressional sequences.



69. How are hummocky beds formed? (1)

1 point for an explanation similar to: Hummocky beds are formed by storm waves, which disturb sediments at deeper depths than regular waves due to the amount of energy in storms

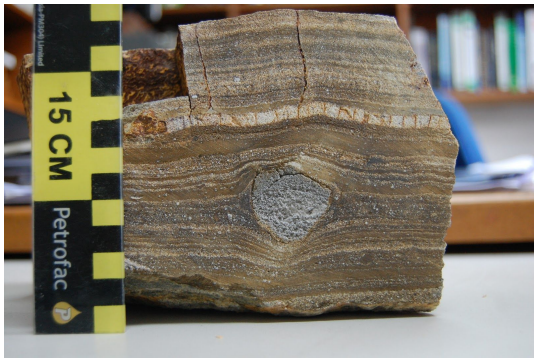
Use the following diagram for questions 70-71:



70. The two cross sections above represent a standard depositional sequence from a braided river and a meandering river. Which column represents each river? (2)
2 points for saying A represents braided river, B represents meandering river

71. How does the depositional environment of planar cross beds differ from the depositional environment of trough cross beds? (1)
1 point for saying planar cross beds are formed in lower energy/lower flow velocity environments than trough cross beds

Use the following image for questions 72-73:



72. **TB1**: What is the name of this sedimentary feature? (1)
1 point for dropstone

73. What causes this feature to form? (2)
1 point for mentioning glaciers
1 point for mentioning stones carried on icebergs and melt out, dropping on the fine sediment below

74. Rank the following sedimentary structures in order of flow velocity of the depositional environment in which they form, from lowest flow velocity to highest: (5)

Antidunes
Ripples
Dunes
Varves
Cross bedding

1 point for each structure in the correct order
Lowest flow velocity
-Varves
-Ripples
-Cross bedding
-Dunes
-Antidunes
Highest flow velocity

Use the following image for questions 75-76:

75. What sedimentary structure is visible in the sample above? (1)
1 point for cross bedding

76. Suggest an environment where this sample could have formed (be specific about energy of the environment) (1)
1 point for a valid sedimentary environment, examples include desert, medium flow velocity river, shoreface beach environment, etc