

GeoLogic Mapping

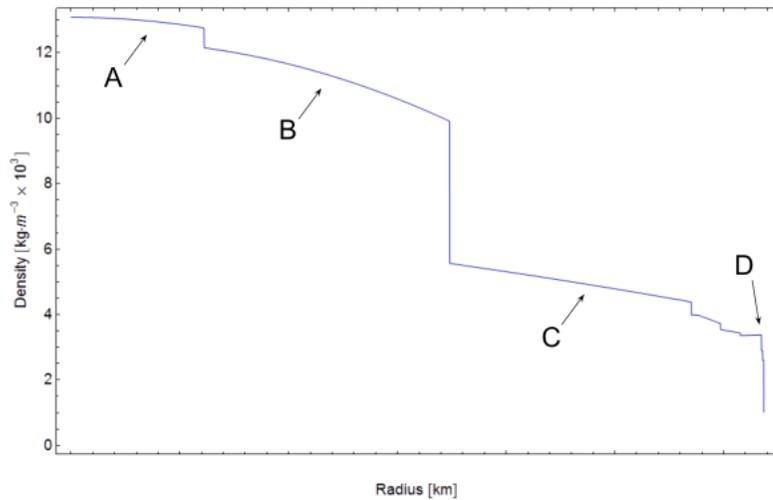


Hi everyone! I'm Vivek Vajipey from West Windsor-Plainsboro High School North in New Jersey. I wrote this test with my friends Yuchen Li, from Tesla STEM High School in Washington and Chloe Cheng, from Venice High School in Southern California. Here are some basic guidelines for the test:

- You and your partner will have 50 minutes to complete this test.
- Each partner may have a 2" binder and a stand-alone non-programmable, non-graphing calculator. Also, it is fine if you write on scrap paper with a pencil.
- Please do not access the internet or any additional resources during this test.
- This test has multiple-choice, multiple-select, and open-ended questions with a total of 80 questions and 125 points.
- Partial credit will be awarded for multiple-select questions and short answer questions so try your best on these questions.
- Tiebreaker questions are 50, 47, 48, 55, 13, in that order.
- For questions that ask for an exact number of words, make sure your answer is only that number of words (these questions are automatically graded).
- For any questions that ask you to identify or name something, please limit your answers to a few words or a short phrase (so grading goes quicker). Only write full sentences for explanation/justification questions.

Good luck and have fun! :^>

Using your understanding of Earth's interior, answer questions 1 to 4 about this graph of Earth's radial density distribution.



1. (1.00 pts) Which layer of the Earth is represented by section A?

- A) Crust
- B) Lithosphere
- C) Asthenosphere
- D) Inner Core
- E) None of the above

2. (1.00 pts) What is the approximate range of values represented by the x-axis of the graph?

- A) 1000 km
- B) 3000 km
- C) 4000 km
- D) 6000 km
- E) None of the above

3. (1.00 pts) Which discontinuity is labelled D?

- A) Gutenberg discontinuity
- B) Mohorovičić discontinuity
- C) Lehmann discontinuity
- D) Repetti discontinuity
- E) None of the above

4. (1.00 pts) The D'' region is found in which of the regions of the graph?

- A) A
- B) B
- C) C

- D) Between C and D
- E) None of the above

5. (1.00 pts) Which of the following was not used as evidence to support Continental Drift Theory?

- A) Shoreline fit of continents
- B) Mesosaurus fossil distribution
- C) Meteorite impact locations
- D) Paleoclimate data

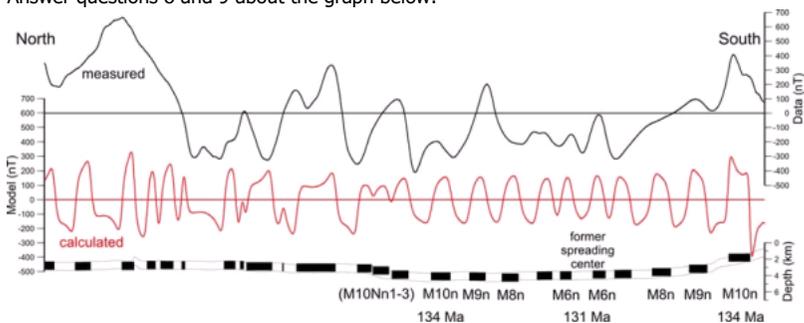
6. (1.00 pts) At a subduction zone, _____ lithosphere sinks because it has a _____ composition.

- A) oceanic, felsic
- B) oceanic, mafic
- C) continental, felsic
- D) continental, mafic

7. (1.00 pts) Generally, oceanic ridges are _____ and have _____ spreading rates than oceanic rises.

- A) steeply-sloping, slower
- B) gently-sloping, slower
- C) steeply-sloping, faster
- D) gently-sloping, faster

Answer questions 8 and 9 about the graph below:



8. (1.00 pts) Which of the following instruments likely collected the data displayed in this graph?

- A) Echo sounder
- B) Magnetometer
- C) Seismometer
- D) Psychrometer
- E) None of the above

9. (1.00 pts) What is the name of the event that causes the graph to change from positive to negative or from negative to positive?

Expected Answer: Magnetic reversal, polar reversal, geomagnetic reversal etc.

Refer to the Minecraft igneous rock samples below to answer questions 10 to 13.



10. (1.00 pts) Which of the rock samples would have formed at the highest temperature?

- A) Andesite
- B) Basalt
- C) Granite
- D) Diorite

11. (1.00 pts) Which of the following minerals would you expect to find in the granite sample?

(Mark **ALL** correct answers)

- A) Orthoclase feldspar
- B) Ca-rich plagioclase
- C) Na-rich plagioclase feldspar
- D) Augite (pyroxene)
- E) Muscovite
- F) Olivine

12. (1.00 pts) Which of the rock samples would have crystallized below the Earth's surface?

(Mark **ALL** correct answers)

- A) Andesite
- B) Basalt
- C) Granite
- D) Diorite

13. (1.00 pts)

The mineralogy of igneous rocks frequently contains many useful clues that may help determine its environment of formation. Which of the following statements regarding igneous environments is true?

(Mark ALL correct answers)

- A) Most Mid-Ocean Ridge Basalts (MORBs) evolve along the tholeiitic magma series
- B) The interbedding of pillow basalts and chert suggests an ophiolitic origin
- C) Plagioclase crystals in igneous rocks associated with convergent plate boundaries are often present as prominently zoned phenocrysts
- D) Chromite lenses are often associated with felsic intrusions
- E) Cumulates are almost always found interbedded with tuff

14. (1.00 pts) Which of the following igneous intrusions is discordant?

(Mark ALL correct answers)

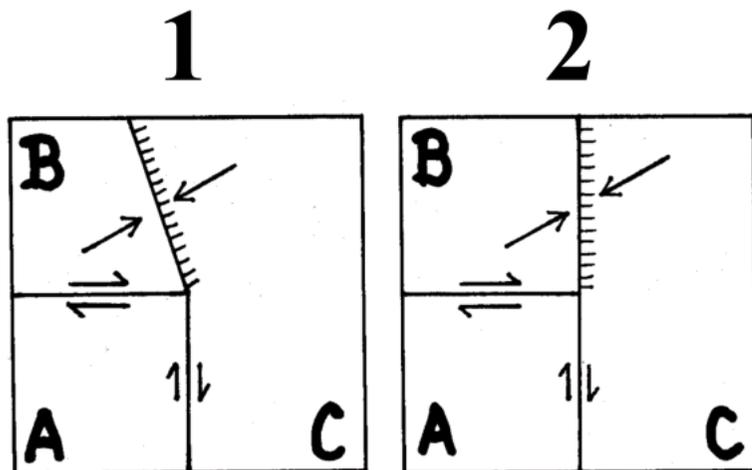
- A) Dike
- B) Batholith
- C) Laccolith
- D) Lopolith
- E) Phacolith
- F) Stock

15. (1.00 pts) Which of the following correctly identifies ways sills and normal lava deposits can be differentiated?

(Mark ALL correct answers)

- A) Sills alter the surrounding layers through contact metamorphism.
- B) Sills are more fine-grained than lava deposits.
- C) Sills lack theropy, blocky, and vesicular texture characteristic of extrusive rocks.
- D) Sills have a greater CaCO₃ content than normal lava deposits.
- E) Sills are mafic while normal lava deposits are felsic.

Refer to the two triple junction diagrams below to answer questions 16 and 17.



16. (1.00 pts) Configuration 1 represents a _____ triple junction and configuration 2 represents a _____ triple junction.

- A) TTT, TTR
- B) RRT, RRT
- C) TFF, TFT
- D) TRF, TFR
- E) FFT, FFT

17. (1.00 pts) Configuration 1 is _____ and configuration 2 is _____.

- A) stable, stable
- B) stable, unstable
- C) unstable, unstable
- D) unstable, stable

18. (1.00 pts) What is the correct order of these events from Earth's history (from oldest to most recent)?

I. Rapid cooling in the Younger Dryas

II. The Oxygen Catastrophe

III. Extinction of the dinosaurs

IV. Breakup of Pangaea

- A) I → IV → III → II
- B) II → IV → III → I
- C) II → I → IV → III
- D) IV → III → I → II
- E) III → IV → II → I

19. (1.00 pts) What is the name of the formation and breakup of supercontinents and the opening and closing of ocean basins?

- A) Wilson Cycle
- B) Calvin Cycle
- C) Wegener Cycle
- D) Hess Cycle
- E) None of the above

20. (1.00 pts) What is the correct order for the paleogeographic reconstructions shown below (from oldest to most recent)?



(V) Pangaea (W) Kenorland (X) Rodinia (Y) Pannotia (Z) Ur

- A) $V \rightarrow W \rightarrow X \rightarrow Y \rightarrow Z$
- B) $Z \rightarrow Y \rightarrow X \rightarrow W \rightarrow V$
- C) $Z \rightarrow W \rightarrow X \rightarrow Y \rightarrow V$
- D) $V \rightarrow X \rightarrow Z \rightarrow W \rightarrow Y$
- E) $W \rightarrow Y \rightarrow V \rightarrow Z \rightarrow X$

21. (1.00 pts) Which of the following best describes a synform fold?

- A) Linear strata dip away from the axial center, with the oldest strata in the center
- B) Linear strata dip towards the axial center, with the youngest strata in the center
- C) Linear strata dip away from the axial center, irrespective of age
- D) Linear strata dip towards the axial center, irrespective of age
- E) None of the above

22. (1.00 pts) Which of the following structures is generally not associated with thrust faults?

- A) Horst
- B) Klippe
- C) Nappe
- D) Horse
- E) Decollement

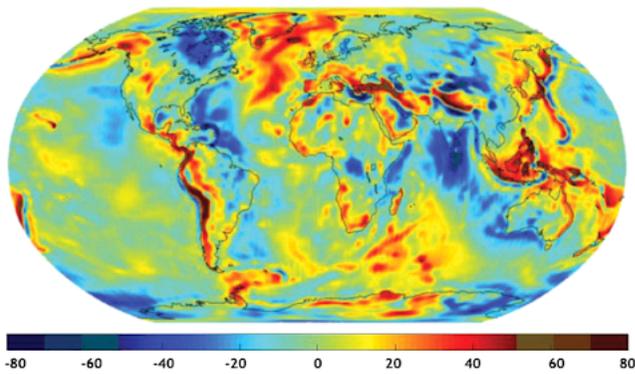
23. (1.00 pts) Which of the following may be a direct result from strike-slip faults?

- A) Deep-focus earthquakes
- B) Transpression
- C) Plutonic emplacement
- D) Shield volcanism
- E) Isostatic uplift

24. (1.00 pts) Which of the following statements regarding plutons is NOT true?

- A) Magma rises until it reaches the level of neutral buoyancy
- B) Solidified plutons form intrusive igneous rock
- C) Halite may form plutons due to its relatively low density and impermeability
- D) Plutons resemble Rayleigh-Taylor instabilities
- E) None of the above

25. (1.00 pts) What does the figure below show?

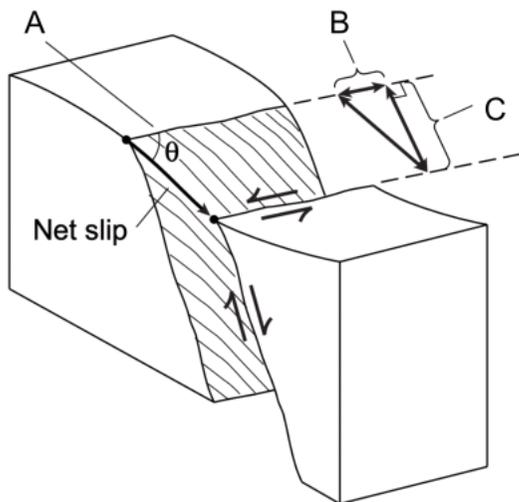


- A) Crust thickness anomaly
- B) Average annual surface temperature
- C) Surface elevation anomaly
- D) Mantle temperature anomaly
- E) Gravity anomaly

26. (1.00 pts) Which of the following incorrectly matches the fault type with the principle stress type?

- A) Thrust fault: compression
- B) Reverse fault: tension
- C) Normal fault: tension
- D) Sinistral strike-slip fault: shearing

Answer questions 27 and 28 about the diagram below:



27. (1.00 pts) What is the term describing the angle labelled A?

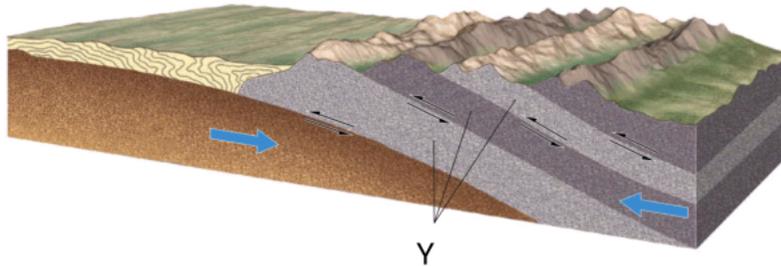
- A) Strike
- B) Dip
- C) Trend

- D) Plunge
- E) Rake

28. (1.00 pts) B is the _____ component and C is the _____ component of the net slip.

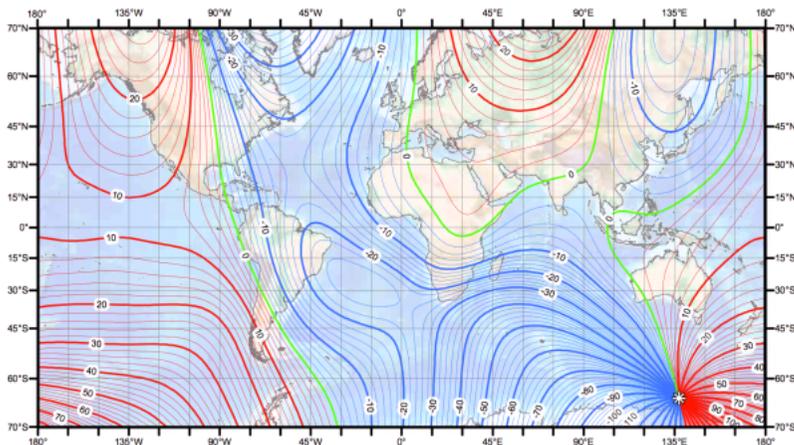
- A) strike-slip, dip-slip
- B) dip-slip, strike-slip
- C) trend-slip, plunge-slip
- D) Trend-slip, strike-slip
- E) Strike-slip, plunge-slip
- F) None of the above

29. (1.00 pts) What are the structures that bound Y in the diagram below?



- A) Ring faults
- B) Boudinage
- C) Overthrust faults
- D) Oblique-slip faults
- E) My fault

Refer to the diagram below to answer questions 30 to 32.



30. (1.00 pts) Which of the following is true for the location at 15°N, 135°W?

- A) The magnetic field lines dip 10° to the north
- B) The magnetic field lines dip 10° to the south
- C) The magnetic north pole is 10° east of the geographic north pole
- D) The magnetic north pole is 10° west of the geographic north pole

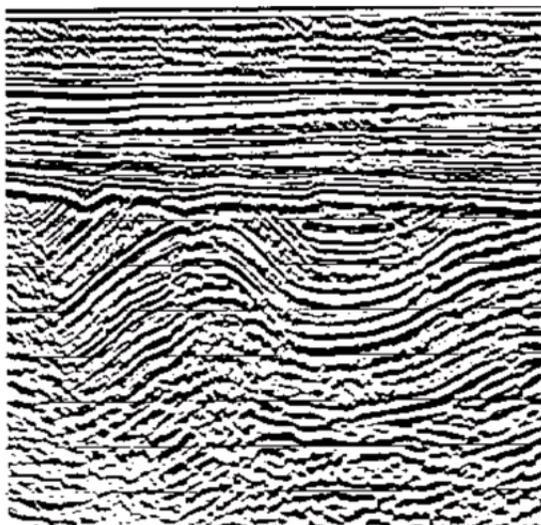
31. (1.00 pts) What value would be given to the interface between the red and blue isogonic lines in the lower right?

- A) 0
- B) -0
- C) 90
- D) 180

32. (2.00 pts) Explain why the range of latitudes is limited to $\pm 70^\circ$.

Expected Answer: This type of projection results in the geographic poles being represented by lines rather than points. It's not possible (or would be strange looking?) to create a single isogonic line of 180° between the magnetic poles and their respective geographic poles in the extreme latitudes.

33. (1.00 pts) Describe the technique used to create the image of the stratigraphic cross-section below.

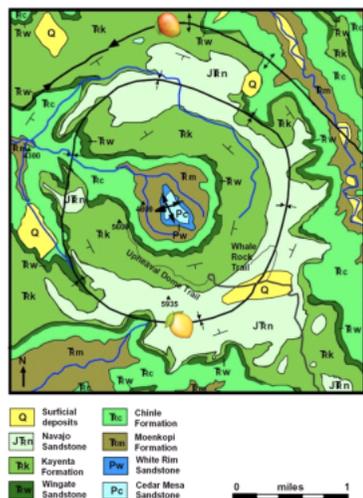


Expected Answer: Seismic reflection imaging involves the interaction of artificially generated seismic waves and differing media, which partially transmit the waves but also reflect some back to surface instruments.

34. (1.00 pts) Depending on the bearing of the cross-section, the folds in the diagram from question 33 may appear to have a _____ than in reality.

- A) Greater interlimb angle
- B) Smaller interlimb angle
- C) Greater amplitude
- D) Smaller amplitude

Refer to the following diagram for questions 35 to 38.



35. (1.00 pts) Which of the following features of the rock units in this geologic map can be used to determine their ages?

- A) Shape
- B) Color
- C) Size
- D) Strike and dip
- E) None of the above

36. (1.00 pts) What is the feature next to the mango emoji (🥝) represented by the two outward pointing arrows?

Anticline

37. (1.00 pts) What is the feature next to the lemon emoji (🍋) represented by the two inward-pointing arrows?

Syncline

38. (1.00 pts) The structure depicted in the geologic map is a _____ because the _____ rock is at the center.

- A) Basin, oldest
- B) Basin, youngest
- C) Dome, oldest
- D) Dome, youngest

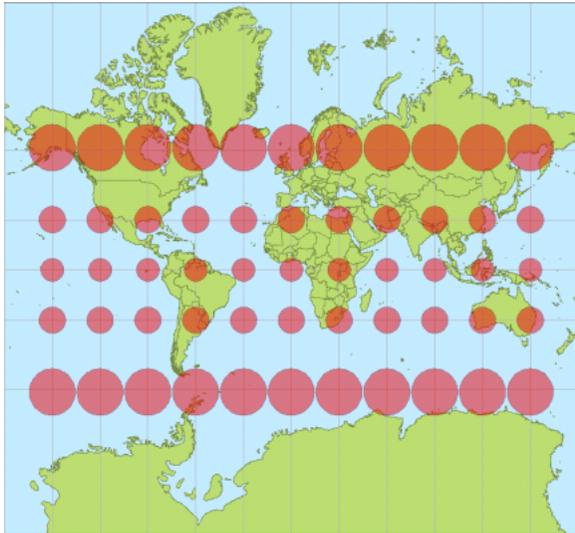
E) None of the above

39. (1.00 pts) Which of the following statements about map projections is true?

(Mark ALL correct answers)

- A) Conformal projections, such as the transverse Mercator, preserve angles locally.
- B) The Robinson projection preserves area measure, but it does not preserve angles locally.
- C) The Mollweide projection is an equal-area, pseudoazimuthal map projection.
- D) Cylindrical projections, such as the Gall-Peters, compress east-west distances.

40. (3.00 pts) What map projection is shown below? What is the name given to the red circles and what do they represent?



Expected Answer: Mercator projection. (1 pt). Tissot's indicatrix. (1 pt) Each indicatrix indicates the distortion of the map at the point. (1 pt)

41. (3.00 pts)

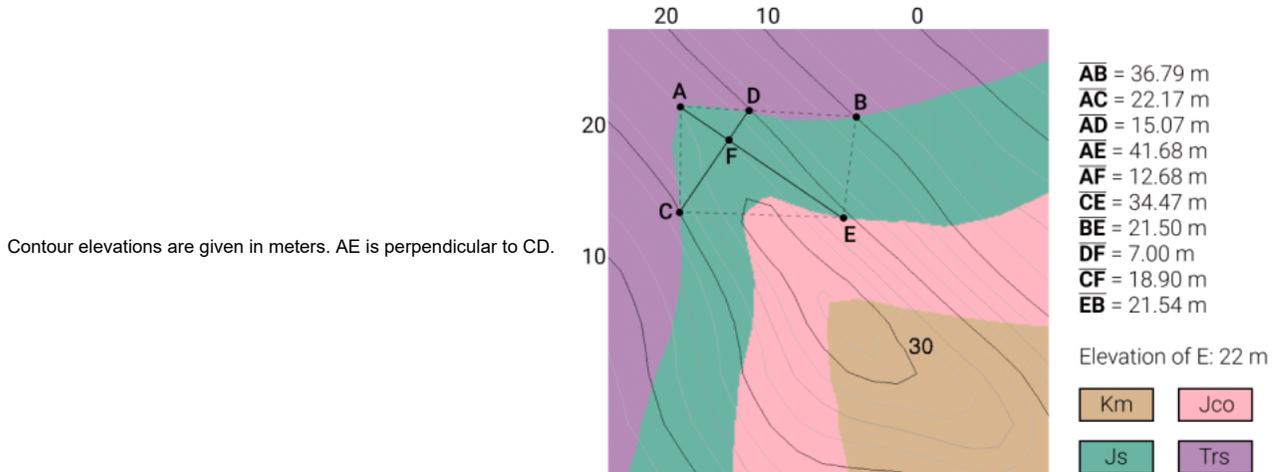
The apparent dip of a uniformly dipping limestone bed is 53 degrees. If the obliquity angle of this apparent dip measurement is 27 degrees from the direction of true dip, calculate the true dip, in degrees. Round your answer to one decimal place and describe your work.

Expected Answer: $\tan(\text{apparent dip}) = \tan(\text{true dip}) \cos(\text{obliquity angle})$ (1 pt for stating equation). We obtain a true dip of 56.1 degrees. (2 pts for answer)

42. (3.00 pts) Is the apparent dip always less than, greater than, or equal to true dip? Why?

Expected Answer: Apparent dip is always less than true dip (1 pt). Graphically, when there is an obliquity angle from the observed dip and the true dip, the right triangle formed by the dip angle is "squeezed down" as obliquity increases. Mathematically, cosine can never exceed 1, and thus, apparent dip will always be less than true dip. (2 pts for explanation)

Questions 44 - 49: Shown in the figure below is a geologic map of some uniformly dipping beds. The horizontal distances between the points are given on the side of the figure.



43. (1.00 pts) What topographic feature is shown in this map? (exactly one word)

Ridge

44. (2.00 pts) What is the gradient from point E to point B in m/m? Round to the nearest thousandth.

Expected Answer: Gradient = (Higher elevation - lower elevation) / (horizontal distance) = (22 - 10) / (21.54) = 0.557 m/m. (2 points, all or nothing)

45. (2.00 pts) Which line segment(s) is (are) parallel to the strike of the green unit?

Expected Answer: CD, FD, or CF (accept any, or accept all) (2 pts for answer)

46. (4.00 pts) What is the true dip of the green unit (Js)? Round your answer to one decimal place and describe your work.

Expected Answer: We know that CD is a strike line at an elevation of 20 meters (0.5 pt). Drawing a line perpendicular to CD and connecting to A, we get line AE, which intersects with CD at point F. This is our dip direction. By reading the contours, we see that A is at an elevation of 27.5 meters (0.5 pt). We can thus construct a right triangle with height 7.5 meters and base 12.68 meters. The true dip can then be expressed as $\arctan(7.5/12.68)$ (1 pt), which evaluates to 30.6 degrees (2 pts).

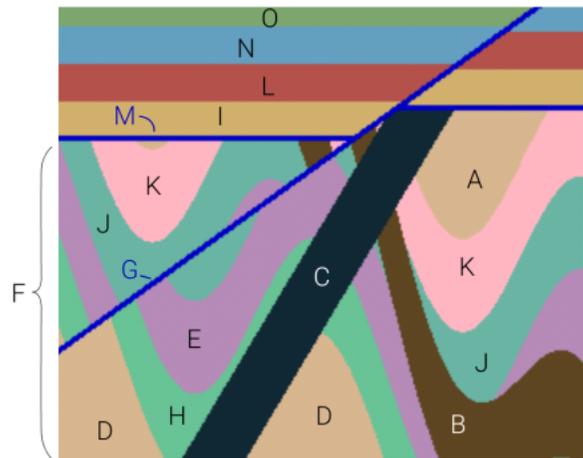
47. (4.00 pts) Calculate the true thickness of the green unit. Round your answer to one decimal place and describe your work.

Expected Answer: We know the horizontal distance along the dip direction is 41.68 meters. From the dip in part c, we can find the true thickness by constructing a right triangle with hypotenuse measuring the horizontal thickness, an opposite side measuring the true thickness, and a theta equal to true dip (1 pt). Thus, the true thickness is $HT\sin(\theta)$ (1 pt), which evaluates to 21.2 meters (2 pts).

48. (1.00 pts) Which of the units shown is the oldest? (Only provide the two/three-letter abbreviation)

Trs

Questions 50 - 54: Shown in the figure below is a cross-section of a hypothetical stratigraphic sequence.



49. (8.00 pts) Order the letters A-O in terms of deposition/occurrence, from earliest to latest. Letter F refers to the folding event below the unconformity M.

Expected Answer: D H E J K A B F C M I L N O G (0.5 pt for each consecutive correct letter)

50. (1.00 pts) What type of fault is G? (exactly one word)

Normal

51. (1.00 pts) What type of unconformity is M?

Expected Answer: Angular unconformity

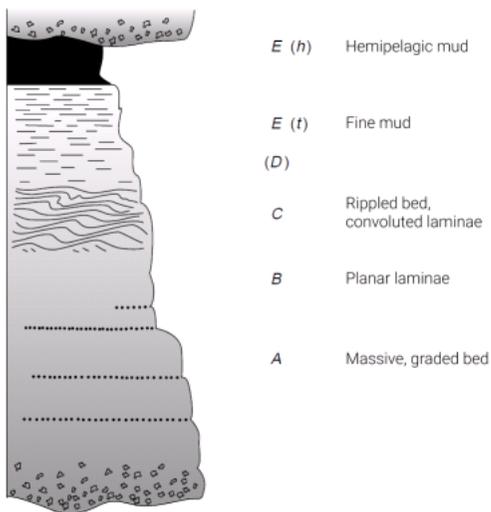
52. (1.00 pts) What type of feature is C? (exactly one word)

dike

53. (2.00 pts) What type of feature is B? Justify your answer.

Expected Answer: Dike (1 pt); we see that B cuts across A, K, F, and E, which means that B is likely a dike (1 pt).

Questions 55 - 57: Shown in the figure below is a stratigraphic sequence.



54. (4.00 pts) Describe a depositional environment that this sequence may reasonably develop in. Justify your answer.

Expected Answer: Various explanations are possible. The rippled bed with convoluted laminae suggests there is flow of a sediment rich fluid through another fluid (1 pt). The graded bedding suggests that the settling time is significant enough to separate out particles of different sizes, which suggests that this occurs in water (1 pt). The repeat of another set of gravel at the top suggests that these deposits are cyclic. The most accurate answer would thus be a marine turbidite (2 pts), but award points to other answers as long as they're reasonable.

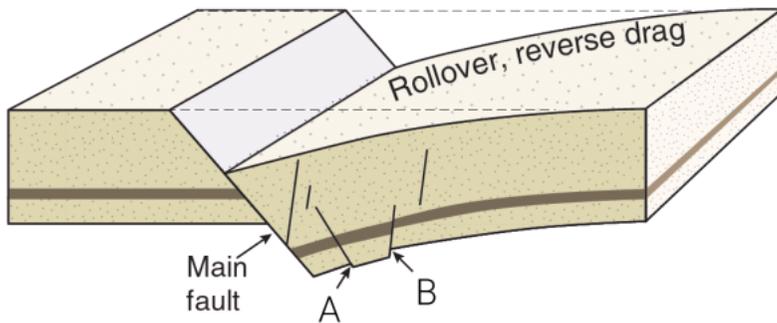
55. (1.00 pts) Is the depositional environment of this sequence classified as continental, marine, or transitional?

Expected Answer: Marine (1 pt) OR (0.5 pts) for transitional

56. (1.00 pts) What is the specific name of this progression of facies? (2 pts)

Expected Answer: Bouma sequence (2 pts) OR (1 pt) for turbidite.

Questions 58 - 61: Refer to the figure below for the following questions



57. (3.00 pts) What type of geologic structure is shown?

Expected Answer: Half-graben

58. (1.00 pts) What type of fault is A, classified based on the orientation relative to the main fault? (1 pt)

Expected Answer: Synthetic fault

59. (1.00 pts) What type of fault is B, classified based on the orientation relative to the main fault?

Expected Answer: Antithetic fault

60. (1.00 pts) Is it possible for this structure to be associated with listric faults? (only the word "yes" or "no")

yes

Questions 62 - 64: The Cascadia Subduction Zone (CSZ) is the major defining tectonic feature of the Pacific Northwest.

61. (1.00 pts) What plate is being subducted at the CSZ?

Expected Answer: Juan de Fuca plate

62. (3.00 pts) The Pacific Northwest contains many majestic volcanoes, which form due to magma generation at the CSZ. Briefly explain how magma is generated at the CSZ.

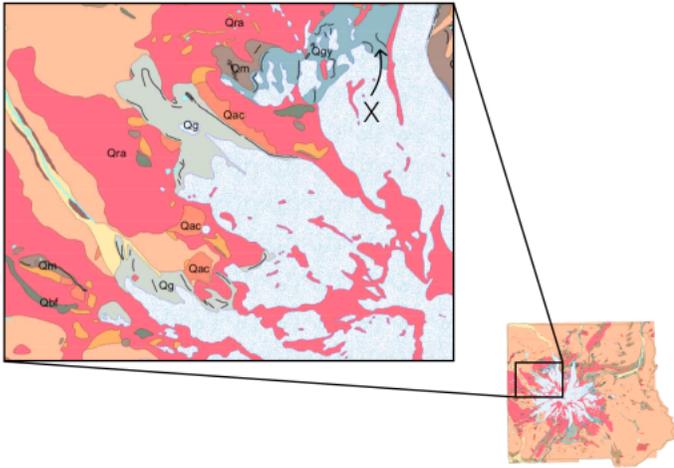
Expected Answer: Volatiles introduced from a subducting "wet" oceanic plate lowers the melting point (i.e. lowers the solidus) of the mantle. (1 pt) This causes partial melting, which generates buoyant magma that rises up through the continental crust. (1 pt) This mechanism of magma generation is known as flux melting. (1 pt)

63. (3.00 pts)

How does the composition of this magma change as it rises through the continental crust in the CSZ? Describe the mechanisms or processes that may lead to those changes.

Expected Answer: Assimilation of relatively felsic continental crust and fractional crystallization (1 pt each) cause the magma to become more felsic (1 pt) as it rises through the continental crust. The magma evolves along the calc-alkaline series. Magma mixing from foreign sources may also act to change overall magma composition (1 pt). [Award up to 3 pts, multiple ways to earn full points]

Questions 65 - 71: The figure below shows a geologic map of a volcano located in Washington state.



64. (2.00 pts) Propose a rock that the majority of Qra (the pink unit) can be made of.

Expected Answer: Accept any reasonable intermediate or felsic extrusive igneous rock (may include, but not limited to: rhyolite, andesite, dacite)

65. (1.00 pts) What is represented by the radiating white stripes?

Expected Answer: Glacial ice or snow

66. (2.00 pts) What type of volcano is this? Justify your answer.

Expected Answer: The presence of many glaciers suggests a steep profile (1 pt); further, its location as an arc volcano adjacent to a subduction zone (1 pt) suggests that this is a stratovolcano (1 pt). [Award up to 2 pts, multiple ways to earn full points]

67. (2.00 pts) What type of feature is labeled 'X'? Is it consolidated or unconsolidated?

Expected Answer: Moraine (1 pt), unconsolidated (1 pt). [More specific types of moraine can be accepted].

68. (1.00 pts) During which geologic period did this volcano last erupt? (exactly one word, you don't need to include the "Period" part)

Quaternary

69. (2.00 pts) The figure below shows a layered deposit near this volcano. Propose a reasonable process by which this layered structure may have formed.



Expected Answer: Eruptions deposit ash/tephra (1 pt), which eventually get compacted to become soil (1 pt). Accept reasonable alternatives.

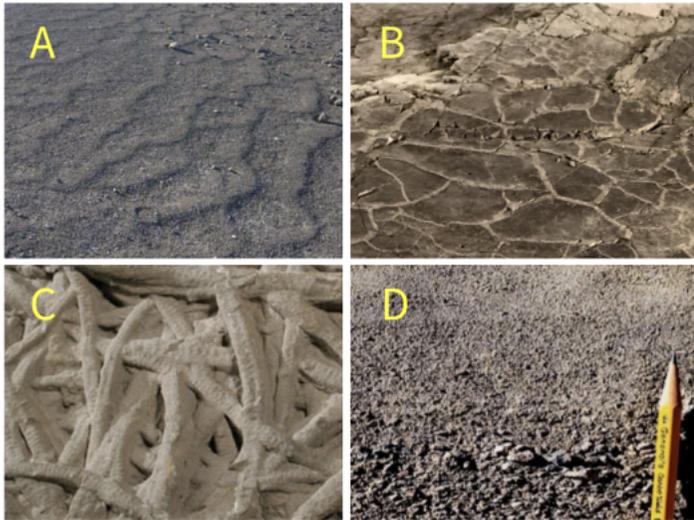
70. (1.00 pts) What is the name of this volcano?

Expected Answer: Mount Rainier (or Tahoma, or Tacoma)

71. (3.00 pts) Describe two situations that would result in the formation of accreted terranes.

Expected Answer: (1) Buoyant fragments of crust - microcontinent, seamounts, basalts plateaus - accrete by subduction zone. (2) Island arc accretes by subduction zone, and the sea between them closes. (3) Crustal fragment becomes accreted onto larger continent along a transform fault - prevalent along oblique faults. (4) Two continents fuse and rift again by continental collision and rifting. Accept any other process that makes sense.

Questions 73 to 79: Sedimentary structures provide invaluable insight into the history of a region. Each of the four photographs above represents a sedimentary structure that can be observed in field investigations. Answer the following questions about these structures.



72. (1.00 pts) Identify sedimentary structure A.

Expected Answer: Ripple marks

73. (1.00 pts) Identify sedimentary structure B.

Expected Answer: Desiccation cracks/mud cracks

74. (1.00 pts) Identify sedimentary structure C.

Expected Answer: Worm burrows/bioturbation

75. (1.00 pts) Identify sedimentary structure D. (*Hint: this is a cross section*)

Expected Answer: Graded bedding

76. (2.00 pts) List all of the above sedimentary structures (by the letter) that can be used as “way-up” indicators for younging direction.

Expected Answer: A, B, D (2 pts for all three, 1.5 pts for only A and B)

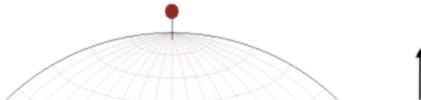
77. (1.00 pts) What does B indicate about its depositional environment?

Expected Answer: It was deposited in a relatively dry environment.

78. (3.00 pts) Propose a reasonable depositional environment for A. Justify your answer.

Expected Answer: Stream channel near its mouth; asymmetrical ripples indicate a clear direction of flow, small clasts indicate relatively low energy. (1 pt for any reasonable answer that has to do with unidirectional flow in a river, 2 pts for justification)

79. (3.00 pts) Using the stereonet below, describe the feature marked by the blue curve, along with its orientation with appropriate notation.



Expected Answer: A plane; 090, 38 S (1 pt each)

Yay! You completed the test!

If you have any questions or comments, feel free to send me an email at vivek.vajipey@gmail.com or message me on discord (Glaucophane#8844). You can contact Yuchen Li at yuchenli713@gmail.com (and follow his mineral Instagram account: [yl.min4](#)) and Chloe Cheng at chloe.cheng03@gmail.com.

Thanks for taking our test and have a nice day! :^>