

1. The white line separating the Grand Canyon Supergroup rocks from the Vishnu Basement Rocks is an example of a(n)

- a. Paraconformity
- b. Thrust fault
- c. Angular Unconformity
- d. Normal fault
- e. Nonconformity
- f. Reverse fault

2. The red line separating the Grand Canyon Supergroup Rocks from the Layered Paleozoic Rocks is an example of a(n)

- a. Paraconformity
- b. Thrust fault
- c. Angular Unconformity
- d. Normal fault
- e. Nonconformity
- f. Reverse fault

3. The black line cutting through the Vishnu Basement Rocks and Grand Canyon Supergroup Rocks is an example of a(n)

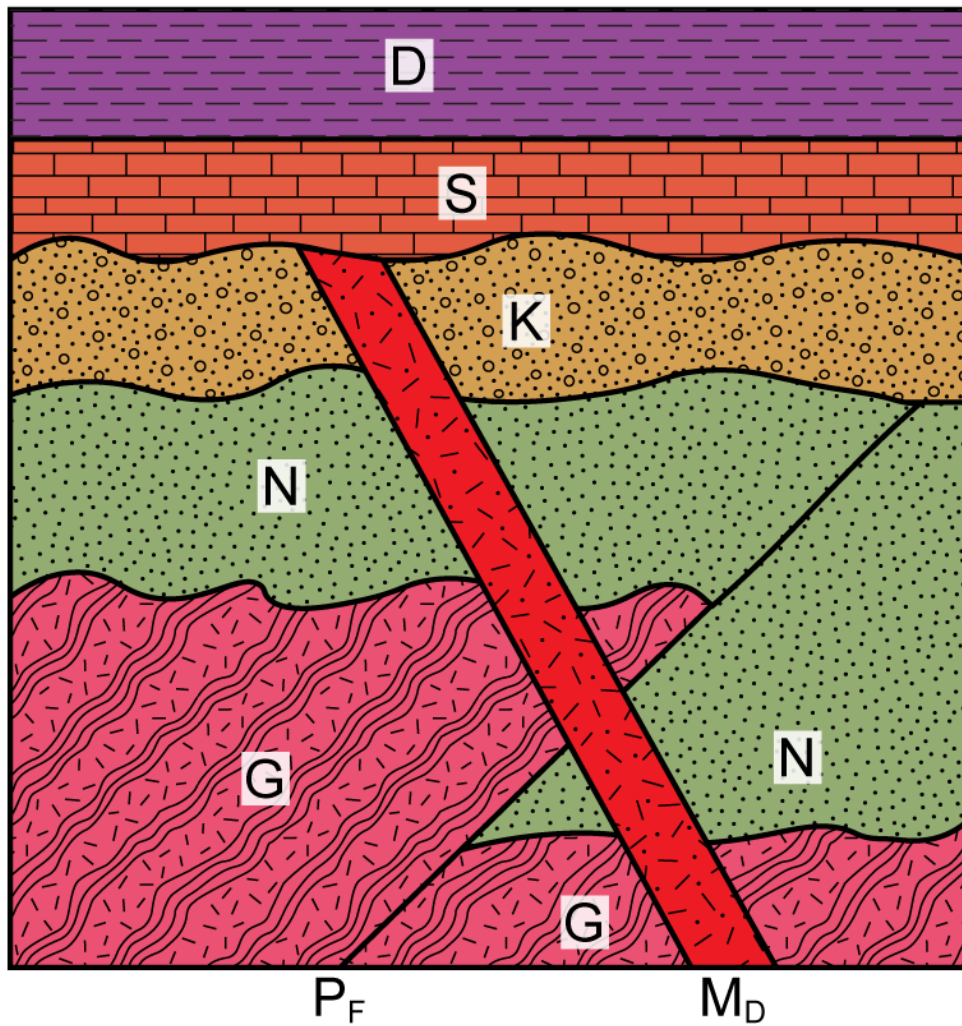
- g. Paraconformity
- h. Thrust fault
- i. Angular Unconformity
- j. Normal fault
- k. Nonconformity
- l. Reverse fault

4. Which type of stress is responsible for producing the feature from Question 3?

5. Which type of tectonic plate boundary is most commonly associated with this stress?

6. The Zoroaster Pluton is an intrusive igneous body, and as such its rocks most likely have what kind of texture?

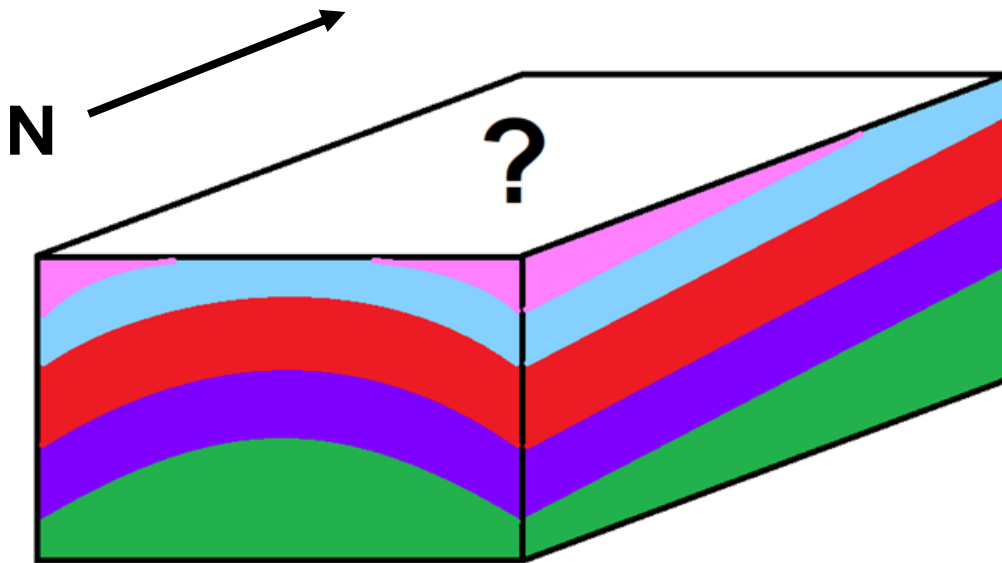
- a. Phaneritic
- b. Aphanitic
- c. Porphyritic



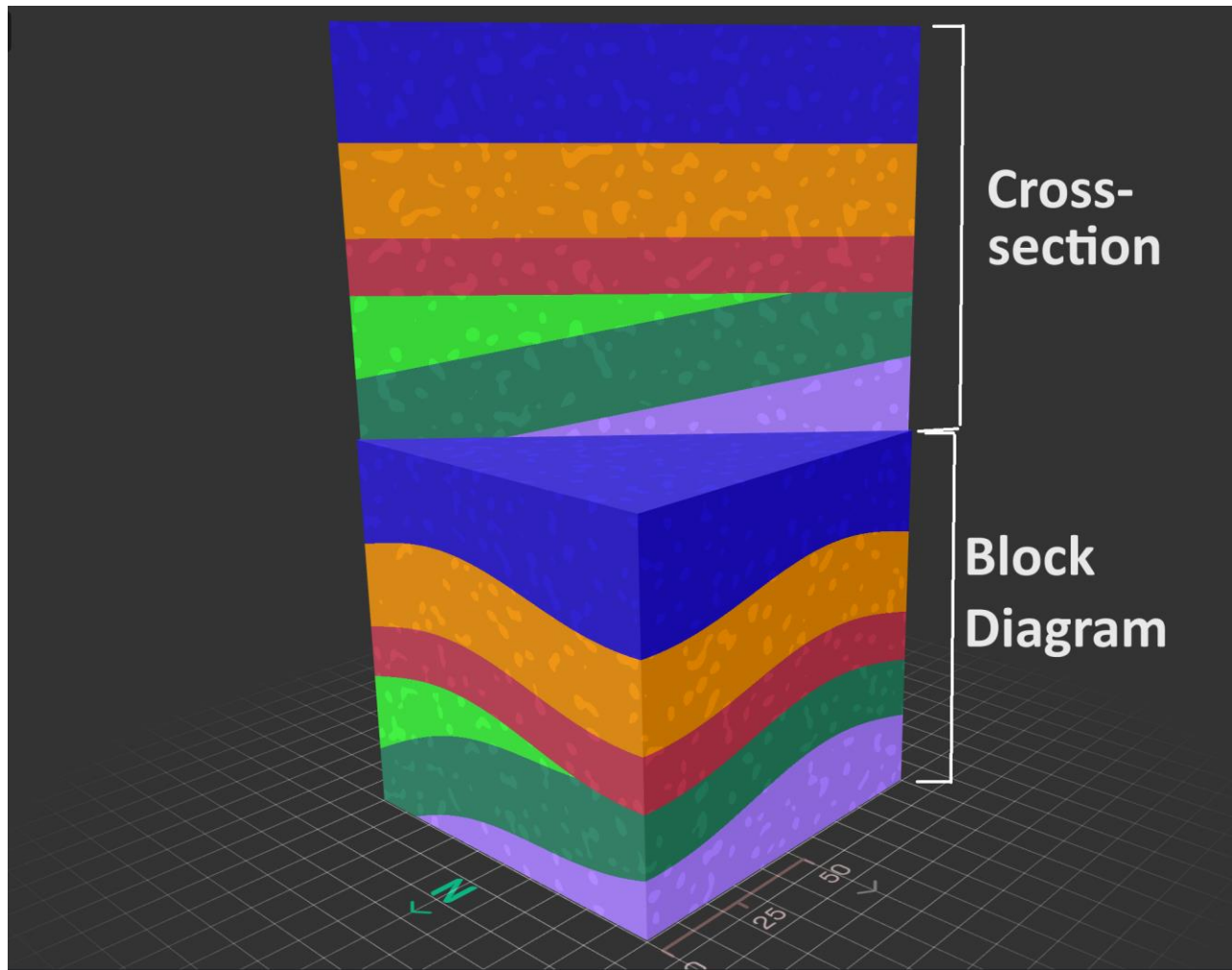
7. Order the seven labelled geologic structures in the diagram from *OLDEST* to *YOUNGEST*.

8. Which of the following stratigraphic principles are needed to arrive at the answer to the previous question? (Select all that apply)

- a. Principle of superposition
- b. Principle of inclusions
- c. Principle of cross-cutting relations
- d. Principle of faunal succession
- e. None of the above



9. Using the blank rectangle on the answer sheet and the provided crayons, sketch the top view of the block diagram above. Include a black dashed line for the fold axis.
10. Because the hinge line of this fold is tilted rather than horizontal, it's known as a _____ fold.
11. Is the fold shown in the block diagram a synform or an antiform?
12. What other information would be needed to identify this fold as a syncline or anticline?
13. How is it possible that without that information it could be either?
14. Draw a symbol that would commonly be used to represent this structure on a geologic map (orientation doesn't matter).



Notice the compass direction **NORTH** points to the *bottom left* of the image.

15. Order the following events from *earliest* to *most recent* by placing the associated roman numerals in the blanks on the answer sheet.

- i. **ORANGE** layer deposited
- ii. **RED** layer deposited
- iii. All current layers ***folded***
- iv. **PURPLE** layer deposited
- v. **BLUE** layer deposited
- vi. All current layers ***tilted***
- vii. **LIGHT GREEN** layer deposited
- viii. **DARK GREEN** layer deposited

16. What type of unconformity is present in the block diagram?
- Angular unconformity
 - Nonconformity
 - Disconformity
 - Paraconformity
17. In which direction is the fold axis plane oriented?
- North-South
 - East-West
 - Northwest-Southeast
 - Northeast-Southwest
18. Explain how the answer to the previous question can be determined.
19. For the tilted layers, what is a direction that the strike of these layers *cannot* point in?
- North-South
 - East-West
 - Northwest-Southeast
 - Northeast-Southwest
20. Explain how the answer to the previous question can be determined.
21. Given the cross section, what is the minimum possible angle of the true dip of the tilted layers?
- 4°
 - 8°
 - 12°
 - 16°
 - 20°
 - 24°

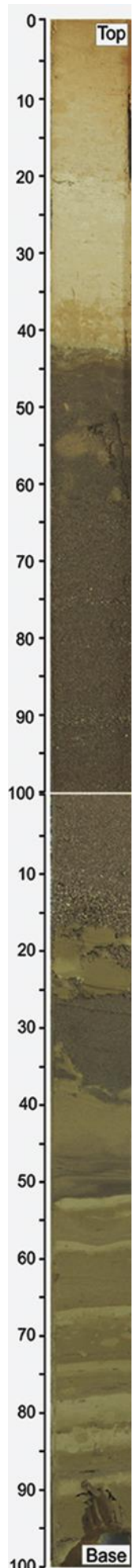
22. Sedimentary structures are useful to geologists because they
- Provide details about the environments in which the sediments were deposited
 - Provide a non-radiological method for absolute dating of rock units
 - Provide an indication of the degree to which a sedimentary rock has been metamorphized
 - Provide a means of identifying minerals in sedimentary rock clasts

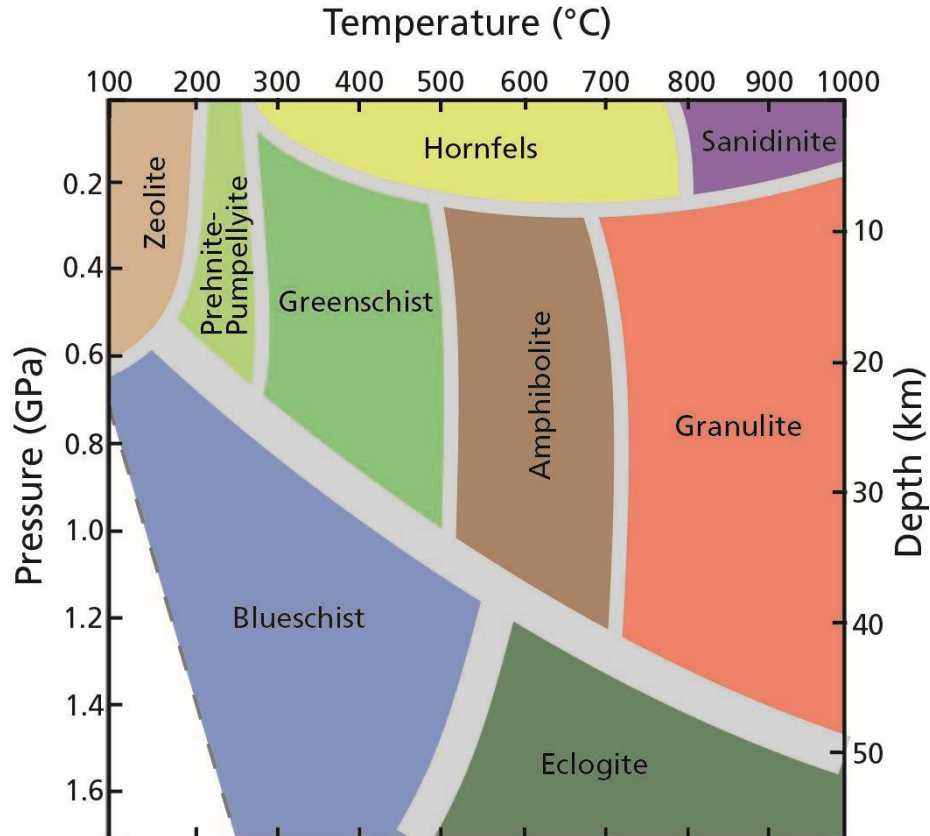
23. What type of sedimentary structure is visible in the core sample pictured?
- Cross-bedding
 - Mud cracks
 - Graded bedding
 - Recrystallization

24. Is this a primary or secondary sedimentary structure?

25. In what environment was this rock core most likely taken from?
- The debris apron of a cinder cone volcano
 - Deep-water lacustrine deposits
 - Uplifted bedrock near a convergent boundary
 - Submarine fans just beyond a continental shelf
 - Near the fracture zone of a mid-ocean ridge

26. Place the steps of collecting a rock core sample listed below in order
- “Fishing line” attaches to pulling arm on inner tube
 - Core is removed from inner tube and boxed
 - Clamp locks inner tube in place, drilling continues
 - Inner tube is inserted in stationary drill stem
 - “Fishing line” is dropped down into drill stem
 - Compressor spring prevents core from falling out of inner tube

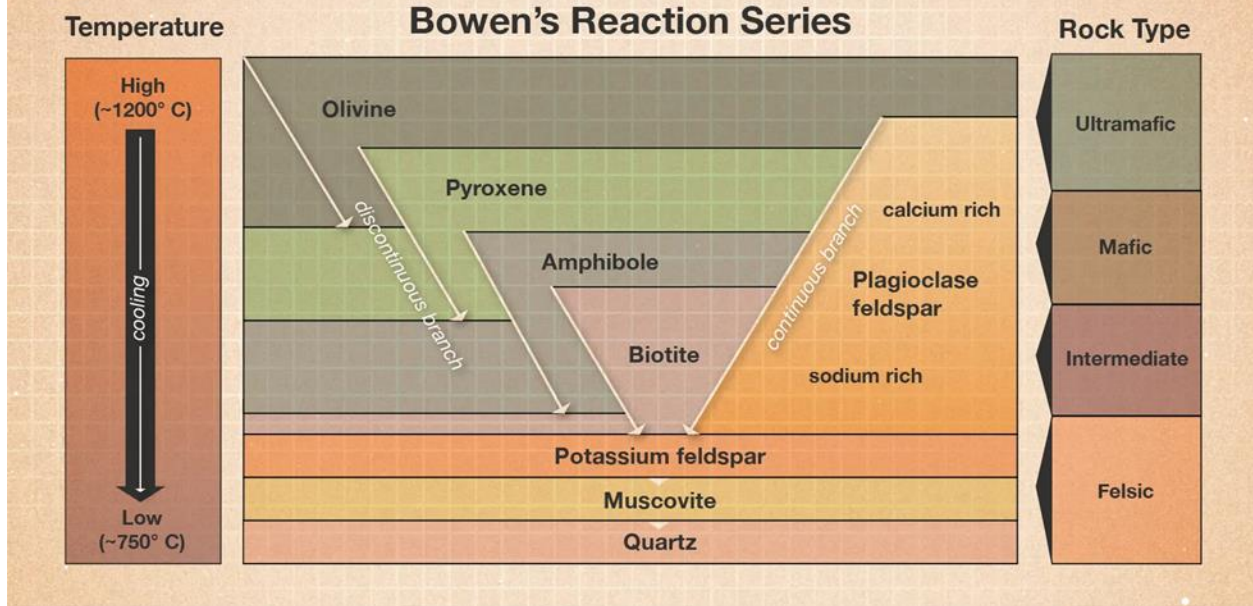




27. Contact metamorphism occurs when rocks are subject to high temperatures at relatively low pressure.

Which is true of the opposite situation, when rocks are subject to high pressures at relatively low temperature?

- It commonly occurs at convergent plate boundaries
- It is limited by the range of observed geothermal gradients
- It is responsible for the vast majority of amphibolites and greenschists on Earth
- It is known as regional metamorphism



28. Mafic rocks such as basalt would contain the highest concentrations of which of the following minerals?

- a. Muscovite
- b. Na-rich plagioclase feldspar
- c. Biotite
- d. Pyroxene

29. Which of the following minerals would be the most likely to be found together in the same igneous rock?

- a. Olivine and quartz
- b. Ca-rich plagioclase feldspar and potassium feldspar
- c. Biotite and Na-rich plagioclase feldspar
- d. Pyroxene and muscovite

30. Felsic rocks are more common in _____ crust and are typically _____ dense than mafic rocks.

- a. Continental; less
- b. Continental; more
- c. Oceanic; less
- d. Oceanic; more

31. Igneous rocks that have crystals too small to be seen with the unaided eye, such as rhyolite, are known as _____ igneous rocks.

- a. Felsic
- b. Aphanitic
- c. Porphyritic
- d. Phaneritic

32. What is the size of the area represented in this map, in degrees longitude and latitude?

- a. 0.075 degrees longitude – 0.100 degrees latitude
- b. 0.100 degrees longitude – 0.075 degrees latitude
- c. 0.167 degrees longitude – 0.125 degrees latitude
- d. 0.125 degrees longitude – 0.167 degrees latitude

33. What is the average approximate magnetic declination in the area shown in this map?

34. What is the interval for the topographic contours?

35. Lake Superior's water level is approximately _____ above sea level.

- a. 580 feet
- b. 600 feet
- c. 620 feet
- d. 640 feet

36. On Manitou Island, towards which direction do the beds dip?

- a. North
- b. West
- c. East
- d. South

37. On Manitou Island, the beds dip at angles of approximately

- a. 10-20 degrees
- b. 20-30 degrees
- c. 40-50 degrees
- d. 75-85 degrees

38. The bedrock of Manitou Island belongs to which rock formation?

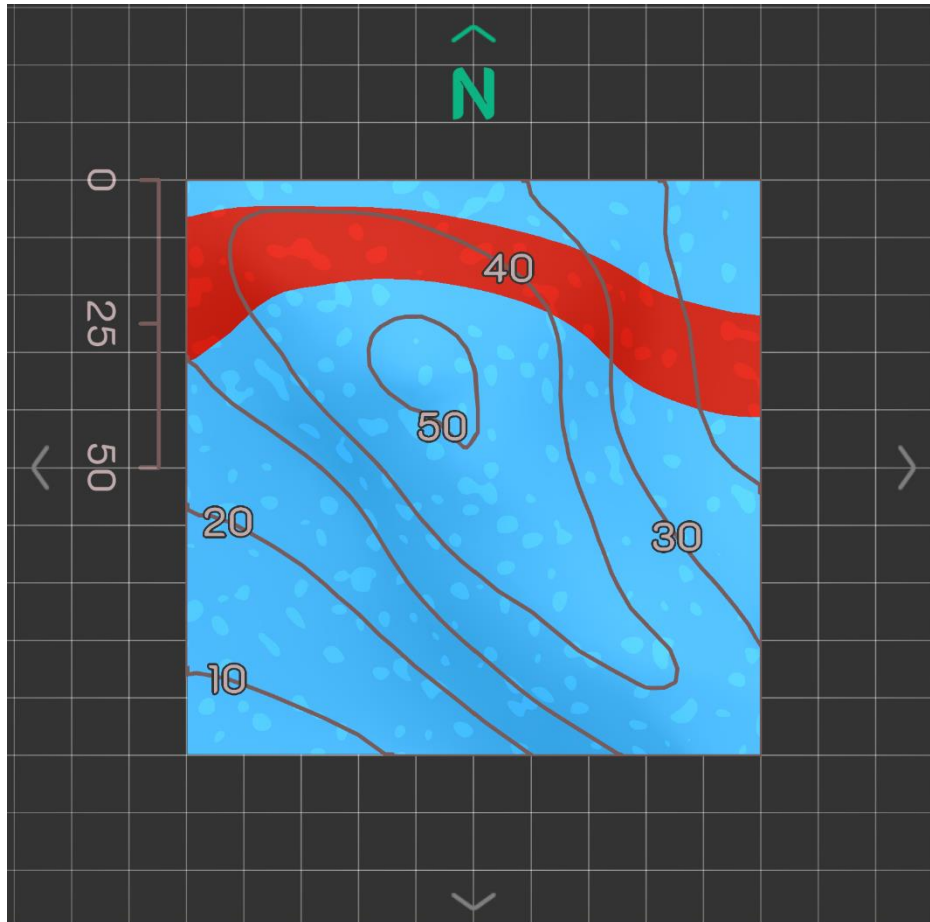
- a. Copper Harbor Conglomerate
- b. Portage Lake Lava Series

39. Why are areas near the shorelines shaded in darker colors?

40. North of Keweenaw Point, there are two rock units labeled "phc" and "pu". What type of rocks are these?

- a. Igneous- basalt
- b. Igneous- rhyolite
- c. Sedimentary- conglomerate
- d. Sedimentary- sandstone

41. Of the information asked about in this station, which is the most likely to have changed since the map's 1955 publication? Why?

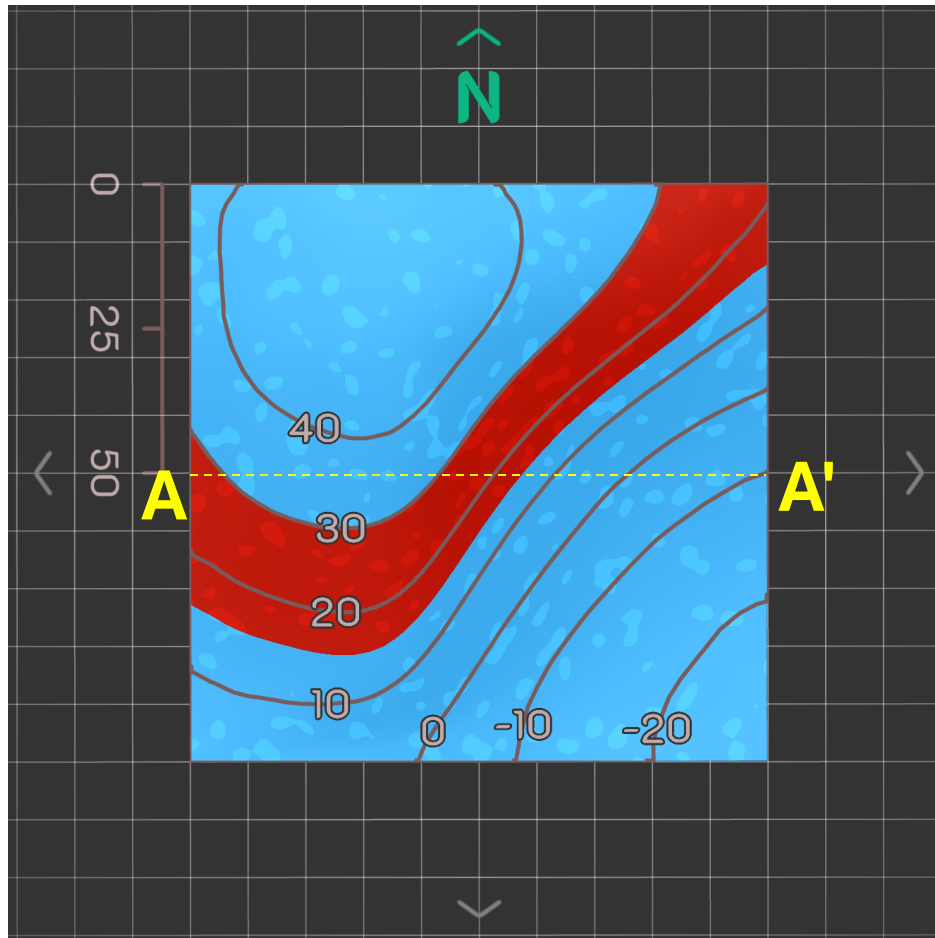


42. What is the strike azimuth of the bedding plane indicated in red?

- a. The bed is horizontal
- b. 000
- c. 045
- d. 090
- e. 135

43. Towards which direction does the red bedding plane dip?

- a. The bed is horizontal
- b. East
- c. West
- d. North
- e. South
- f. Northwest
- g. Southeast
- h. Northeast
- i. Southwest



44. What is the strike azimuth of the bedding plane indicated in red?

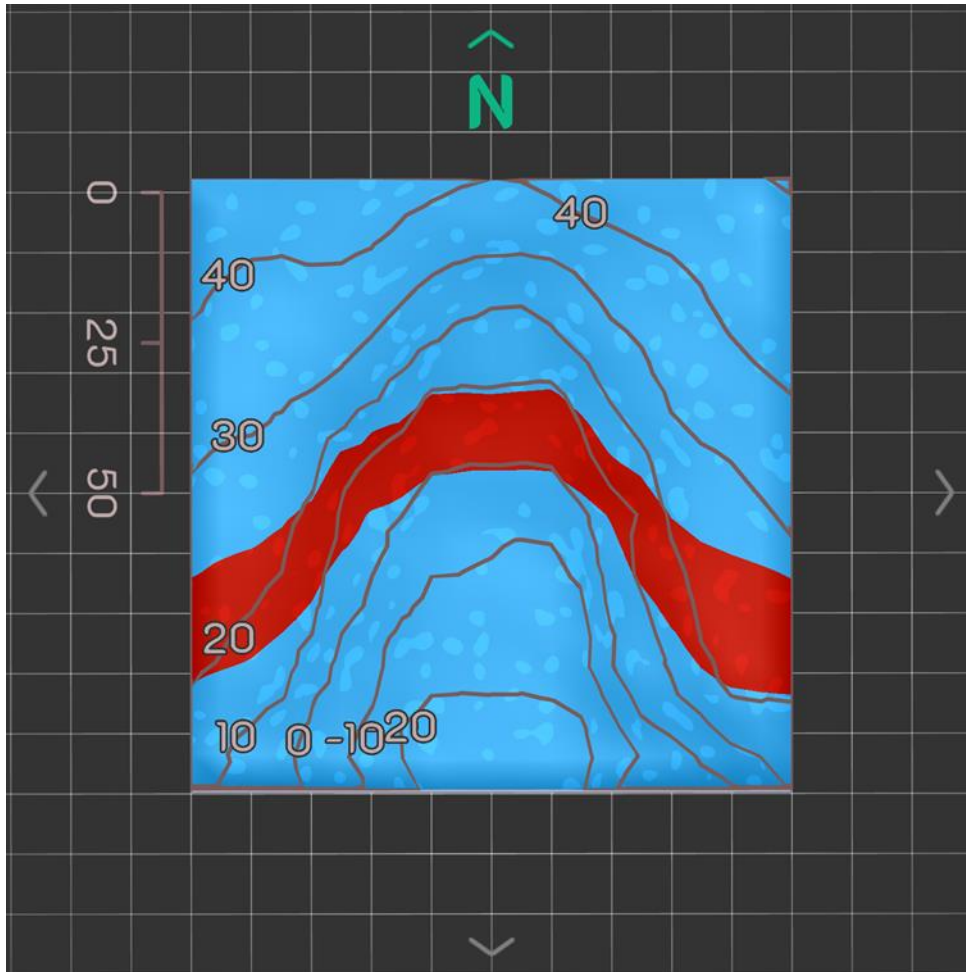
- The bed is horizontal
- 000
- 045
- 090
- 135

45. Towards which direction does the red bedding plane dip?

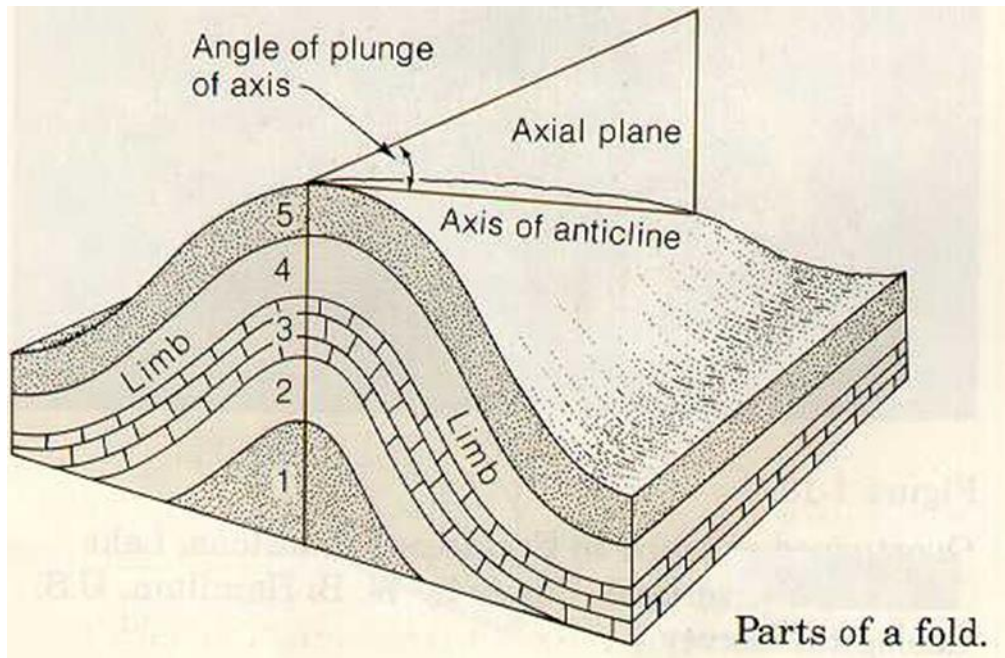
- The bed is horizontal
- East
- West
- North
- South
- Northwest
- Southeast
- Northeast
- Southwest

46. Approximately how thick (in “units”) is the red bedding plane?

47. Draw a cross-section of the diagram from A to A'. Include the topographic profile and the structural orientation of the rock units (you may substitute any two colors for blue and red).



48. Which of the following is true about the dip of the red bedding plane?
- It is 0° -- the bed is horizontal
 - It is 90° -- the bed is vertical
 - It dips South at an angle less than the slope of the valley
 - It dips South at an angle approximately equal to the slope of the valley
 - It dips South at an angle greater than the slope of the valley
 - It dips North



The layers of rock are as follows:

- 1: Sandstone
- 2: Shale
- 3: Limestone
- 4: Shale
- 5: Sandstone

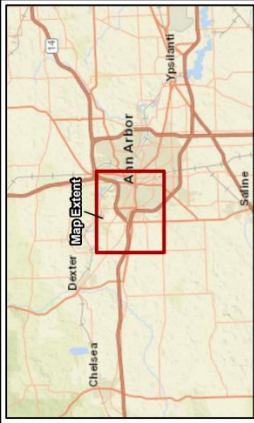
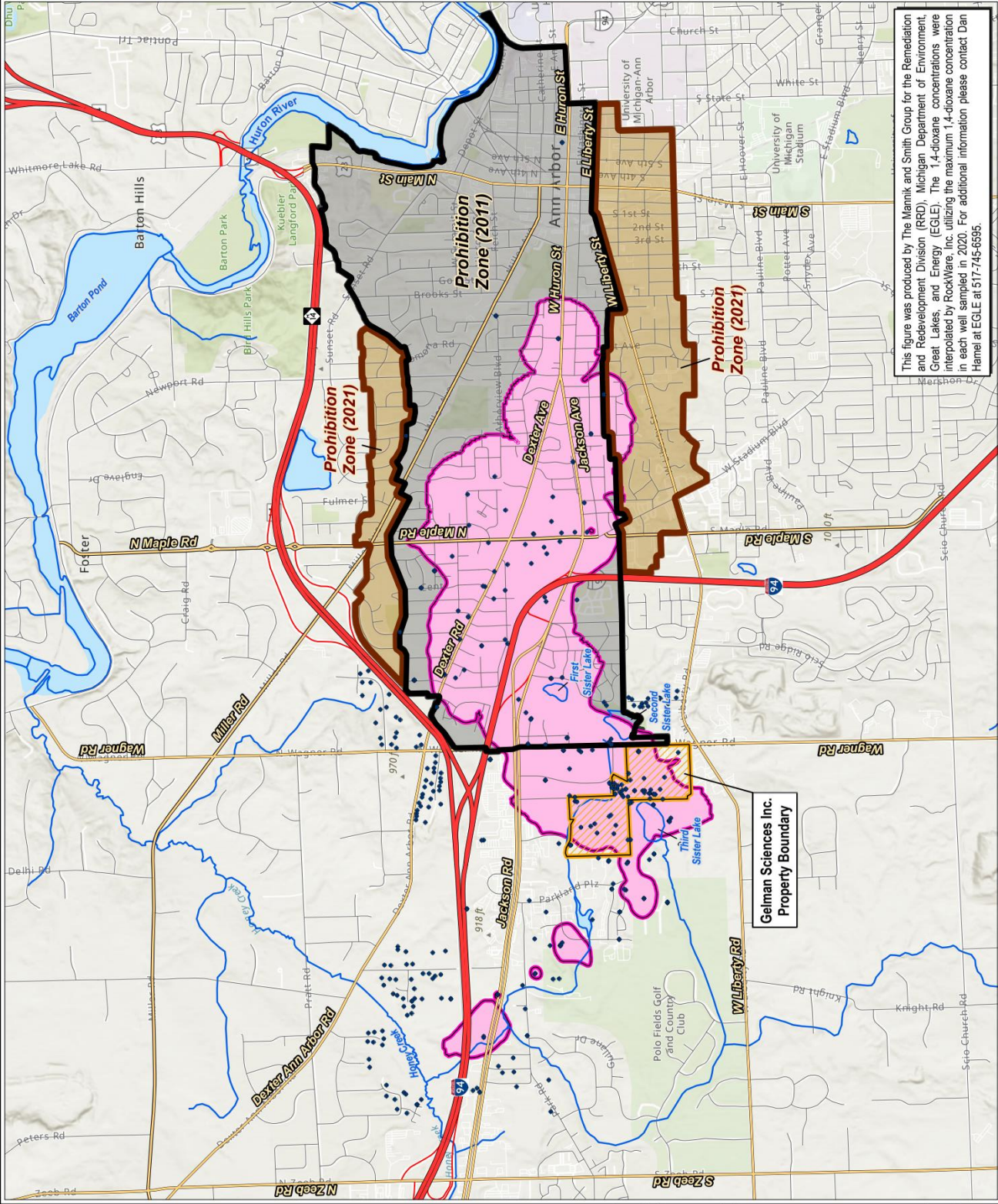
49. Which of the five layers would be the most likely reservoir of oil and natural gas?

50. Which of the five layers would also be a possible reservoir of oil and natural gas?

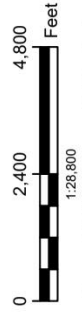
51. Which two properties of rocks are primarily responsible for whether that layer can be a hydrocarbon reservoir or not?

52. If the structure pictured was a synform instead of an antiform, how would the likelihood of finding hydrocarbon reserves change, if at all?

53. Other than folds, what is another type of structure where one might find hydrocarbon reserves?



- Extent of 1,4-dioxane greater than 7.2 ppb
- Sampled Well (2020)
- Approximate Gelman Sciences Inc. Property Boundary
- Prohibition Zone Boundary (2011)
- Prohibition Zone Boundary (2021)
- Surface Water Feature



Basemap Source: ESRI World Topographic Map Service



1,4-DIOXANE GROUNDWATER CONTAMINATION (2020)

Gelman Sciences Inc. Site
 Washtenaw County, Scio Township, Michigan
 DATE: 07/13/21
 DRAWN BY: KRB
 DESIGNED BY: KRB
 PROJECT NO.: EGLE006

54. When was this map prepared?

55. The scale of the map is 1:_____.

56. The source of the 1,4-dioxane pollution was an unlined lagoon used for dumping on the Gelman Sciences property. In general, what is the main direction the plume is moving?

57. When the map was created, 7.2 ppb was the maximum allowable residential groundwater concentration of 1,4-dioxane. Approximately how large of an area (in square miles) had a groundwater concentration at or exceeding this threshold?

Additional Links:

- [Map - USGS Store - Manitou Island Quadrangle](#)
- [Dioxane Plume Map - Original](#)
- [Q15 Block Model](#)
- [Q48 Block Model](#)