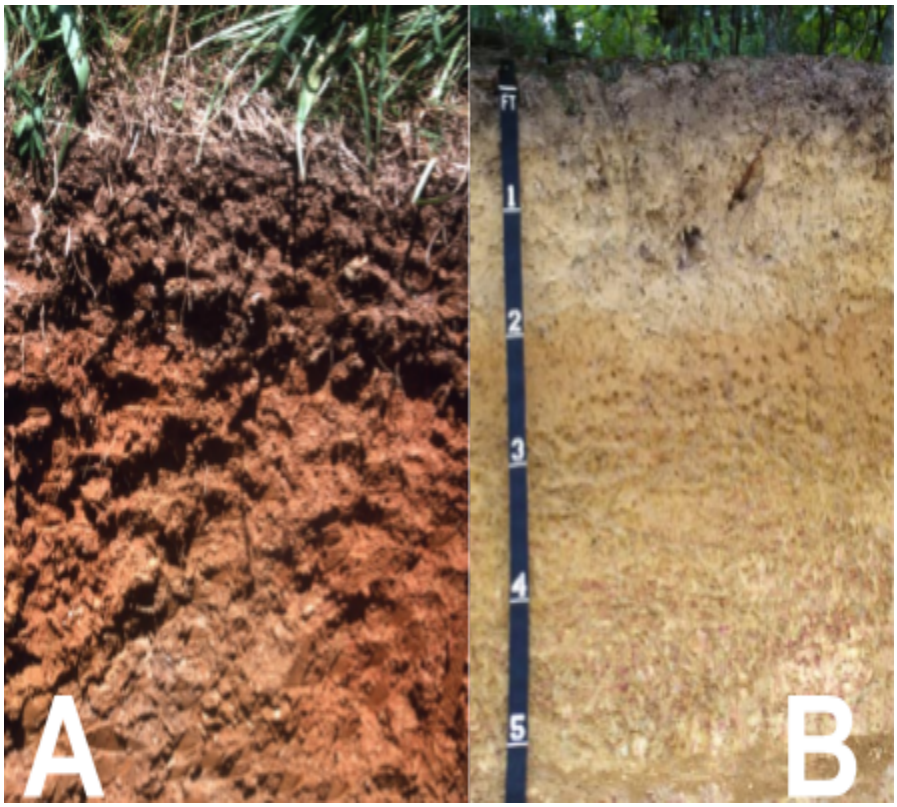
Geosphere Exam

Key: (*) = none, one, or more than one answer possible (e.g. Answer: A, D, and E)
In questions with many pictures/text, the part requiring an answer is denoted with an arrow (→) to help differentiate from background information.

1. Use the diagram below to answer the following question.



The image above shows two different soil profiles. Layer A is clayey and layer B is sandy.

→ Choose all of the following statements that are true concerning the two soils. (*)

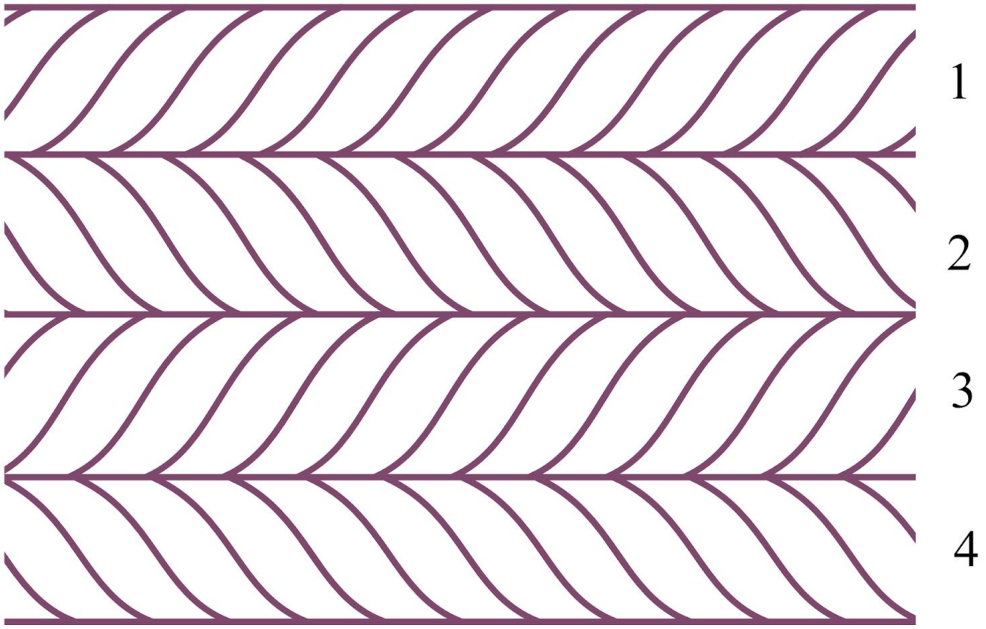
A) The O horizon in soil A takes up a smaller proportion of its picture compared to the O horizon in soil B.
B) Soil A would have a greater permeability than Soil B.
C) Soil A would have a greater porosity than Soil B.
D) The material of soil A would likely have a steeper angle of repose than the material of soil B.

2. Flowing fluids, whether it be air or water, leave characteristic sedimentary structures on their path.

   → Choose all of the following statements that are true about these sorts of structures. (*)

   A) Star dunes are formed by unimodal winds.
   B) Parabolic dunes are common in deserts with little vegetation.
   C) Lake beds typically contain symmetrical ripple marks.
   D) The graded bedding of turbidites is caused by a gradual change in the energy of the depositional environment.

3. Use the diagram below to answer the following question.



   → Select all of the following statements that are true of the above stratification. (*)

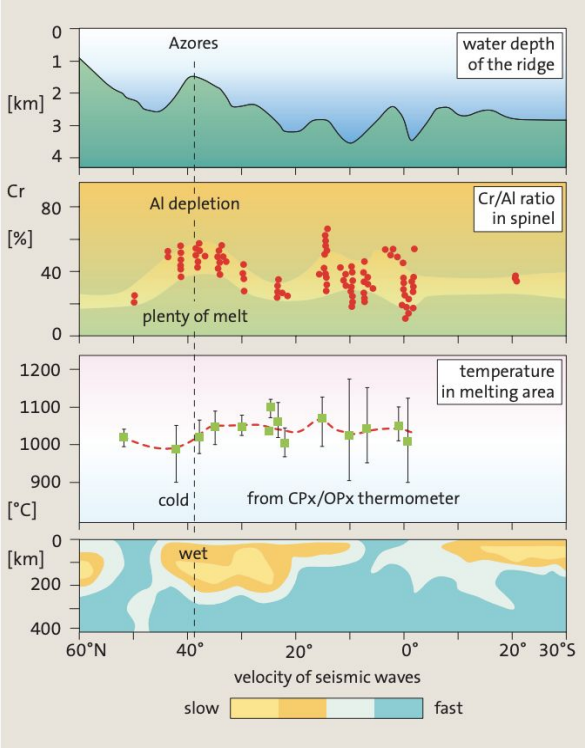
   A) 1 *and 3* represent rightwards-directed currents.
   B) *2 and 4* represent rightwards-directed currents.
   C) *Horizontal lines* represent erosional surfaces.
   D) *Diagonal lines* represent erosional surfaces.
   E) It likely indicates a past *fluvial* environment.
   F) It likely indicates a past *intertidal* environment.
   G) It likely indicates a past *deltaic* environment.
   H) It likely indicates a past *lacustrine* environment.

4. Benitoite is a rare, blue titanium silicate mineral that is the state gem of California. This mineral is found in veins and dikes in larger bodies of serpentinite in California and Japan.

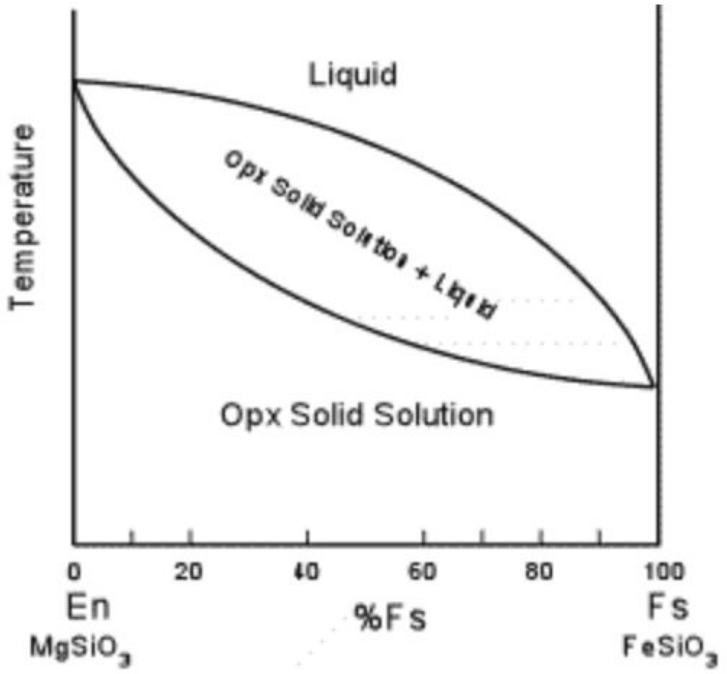
   → Given this information, with which of the following rocks would benitoite most likely be associated?

   A) Glaucophane schist (forms at relatively high pressure and low temperature)
   B) Eclogite (forms at very high pressures and relatively high temperatures)
   C) Migmatite (metamorphic rocks affected by partial melting)
   D) Hornfels (forms through contact metamorphism)

5. Geologists have studied the interesting case of hotspot volcanism found at the Azores Triple Junction, where the mantle below the region is actually cooler in temperature than other segments of the Mid-Atlantic Ridge. To study the geology of the region, lithospheric peridotite samples along the ridge were analyzed, producing the results shown in Figure 1 below. During partial melting of the mantle material, iron and aluminum preferentially exit the melt while magnesium and chromium remain in the peridotite. Thus, the chromium-aluminium ratio of spinel crystals is used to measure the extent of partial melting in the sample. Additionally, the peridotite temperature was tracked using the orthopyroxene geothermometer; the orthopyroxene solid solution phase diagram is shown in Figure 2 below.



Question 5, Figure 1. Data collected for the Mid-Atlantic Ridge from 60° N to 30° S.

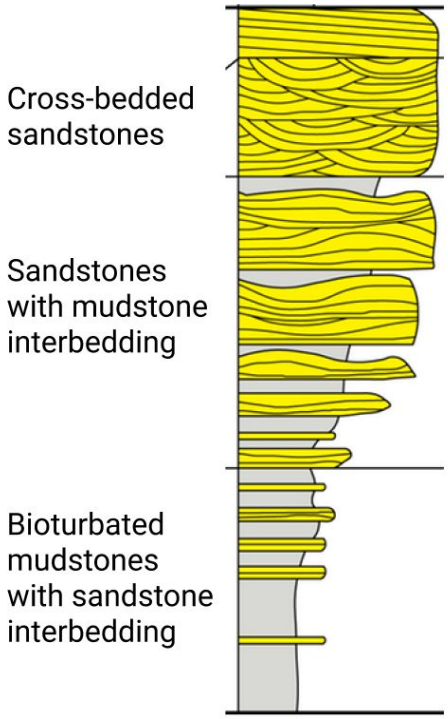


Question 5, Figure 2. The solid solution phase diagram for orthopyroxenes, ranging from enstatite ($MgSiO_3$) to ferrosilite ($FeSiO_3$).

→ Which of the following statements are likely TRUE? (*)

A) The silica content of the peridotite near the equator would be higher than the silica content of the peridotite near Azores.
B) The silica content of the peridotite near the equator would be lower than the silica content of the peridotite near Azores.
C) The silica content of the peridotite near the equator would be equal to the silica content of the peridotite near Azores.
D) Compared to other segments of the Mid-Atlantic Ridge, peridotites from the area of Azores would contain higher concentrations of enstatite.
E) Compared to other segments of the Mid-Atlantic Ridge, peridotites from the area of Azores would contain higher concentrations of ferrosilite.

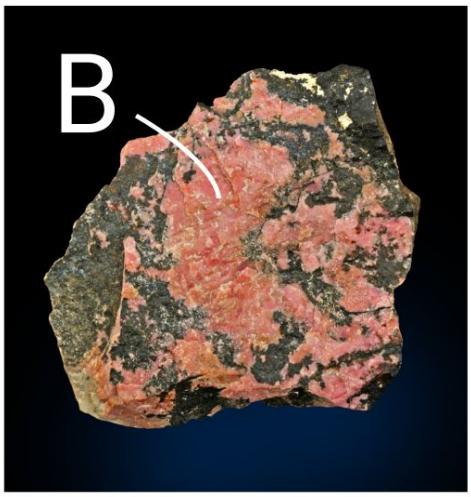
6. Use the diagram below to answer the following question.



→ Using the figure above, and assuming no overturning of strata, identify all of the following statements that are likely true. For the last four options, assume that other mentioned parameters do not change concurrently with the one in the answer choice. (*)

A) This parasequence was most likely deposited in a glacial lake
B) This parasequence represents a marine transgression
C) This parasequence represents a marine regression
D) This parasequence represents multiple cycles of transgression and regression
E) The deposition of this parasequence may be associated with an increase in seafloor spreading rate
F) The deposition of this parasequence may be associated with a decrease in seafloor spreading rate
G) The deposition of this parasequence may be associated with the formation of continental glaciers
H) The deposition of this parasequence may be associated with the melting of continental glaciers

7. Use the diagram below to answer the following question.



Shown in the figure [Source: Mindat.org] are two pink minerals, **A** and **B**, and a black mineral **C**. In the field, **A** was found roughly 1 km away from **B**, and **B** was found 30 meters from a 80 meter wide granitic intrusion. A quick test with cold dilute HCl leads to strong effervescence in **A** but no reaction in **B**. **B** is also found to be associated with a diverse assemblage of actinolite and spessartine, a garnet with chemical formula $Mn_3Al_2(SiO_4)_3$. After X-ray powder diffraction (XRD) analysis, it is determined that mineral **C** is pyrolusite, with a chemical formula of MnO_2.

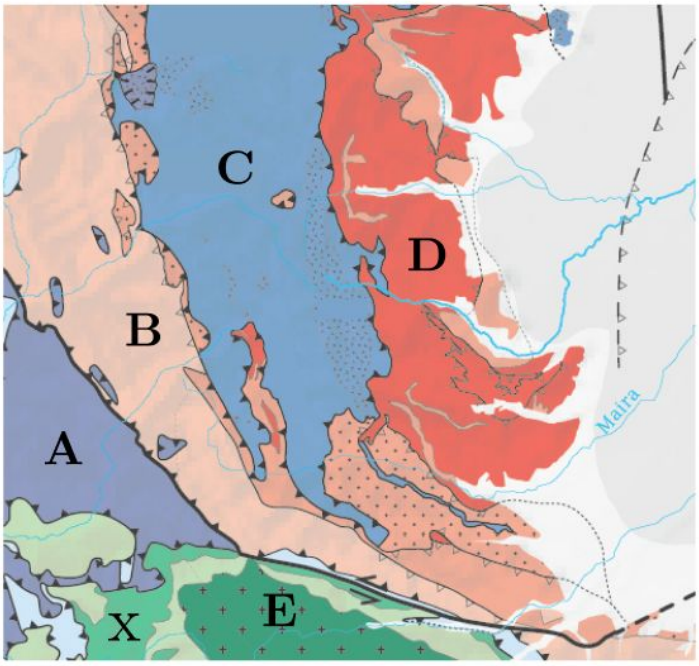
→ Identify all of the following statements that are likely **true** regarding minerals **A**, **B**, and **C**. (*)

A) Mineral **B** formed as a result of fractional crystallization of a granitic magma body rich in minerals **A** and **C**
B) Mineral **C** is an ultramafic xenolith from the upper mantle that was transported up in the granitic intrusion
C) Mineral **B** formed as a result of metasomatic processes that altered a parent rock with composition similar to **A**
D) Mineral **B** formed as a result of metasomatic processes that altered a parent rock with composition similar to **C**
E) The weathering of mineral **A** releases CO_2 and involves a negative feedback loop
F) The metamorphism of **B** to **A** releases CO_2
G) The formation of mineral **A** on a large scale is associated with an increase in ocean pH
H) The weathering of mineral **B** on a large scale causes a cooling of the global climate

8. This question has three parts.

   The Western Alps features a zone of intense deformation and offers a rare example of exhumed ultra-high pressure (UHP) metamorphic rock. Shown in Figure 1 is a geologic map of a small section of the Western Alps, with rock units labelled A through E. Letter x denotes a region of folding and faulting, of which a small surface map is shown in Figure 2. Figure 3 is a schematic of a possible mechanism proposed by Ernst *et al.* by which UHP rocks are exhumed to the surface.

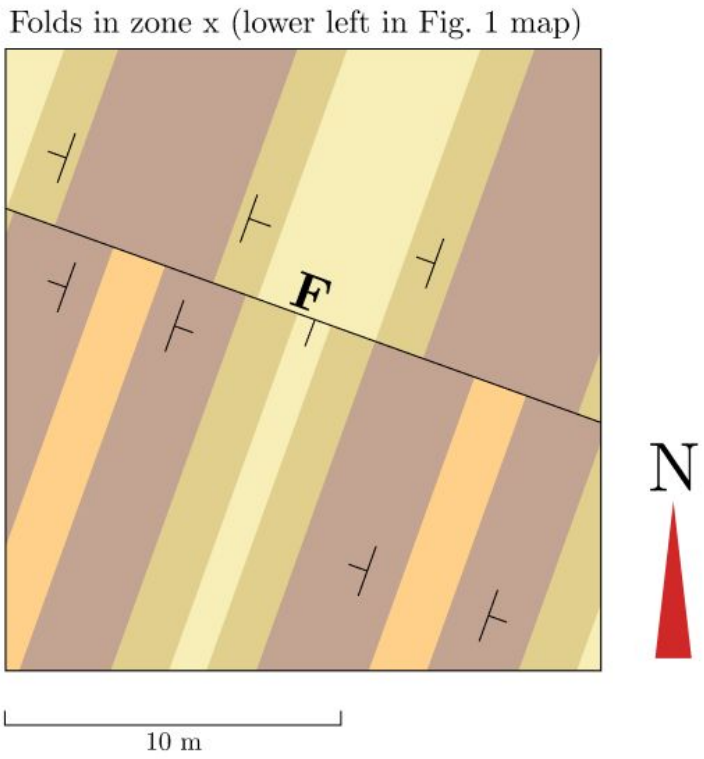
Lower Venasca UHP Nappe



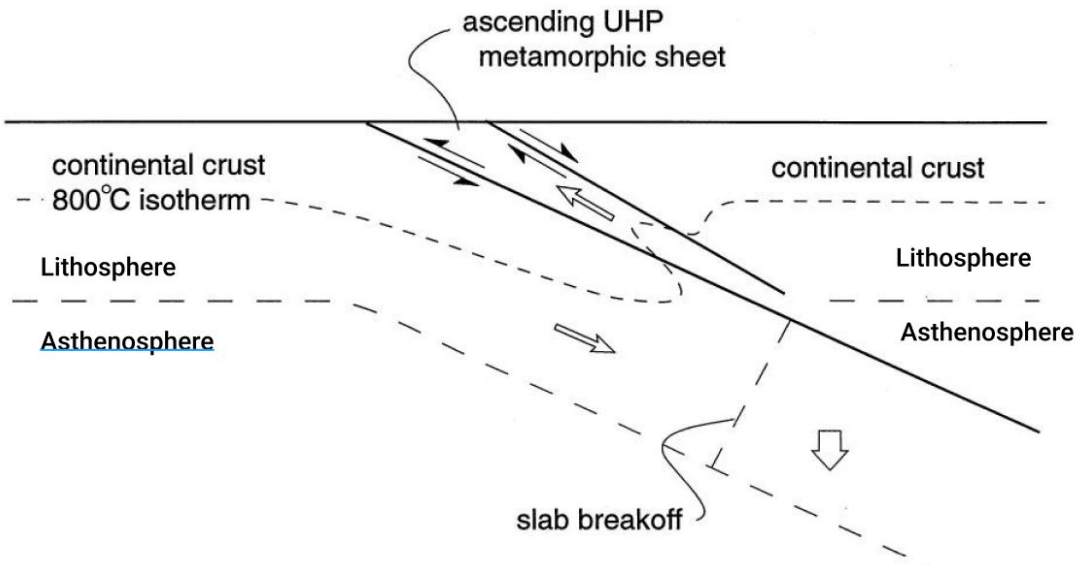
Mineral assemblages of units A-E:

A: chlorite, epidote, olivine
B: quartz, orthoclase, biotite, albite
C: garnet, chlorite, antigorite
D: coesite, garnet, omphacite (clinopyroxene)
E: biotite, garnet, quartz, magnetite

Question 8, Figure 1: Shows a geologic map as well as mineral assemblages of each of the units shown.



Question 8, Figure 2: Shows a horizontal cross section (looking down at a flat surface) of folds at location *x* in Figure 1. Notice fault F, which dips at 48 degrees (relative to the horizontal) towards the southwest.



Question 8, Figure 3 [courtesy to Ernst *et al.*]: Shows a possible mechanism by which UHP rocks are exhumed to the surface.

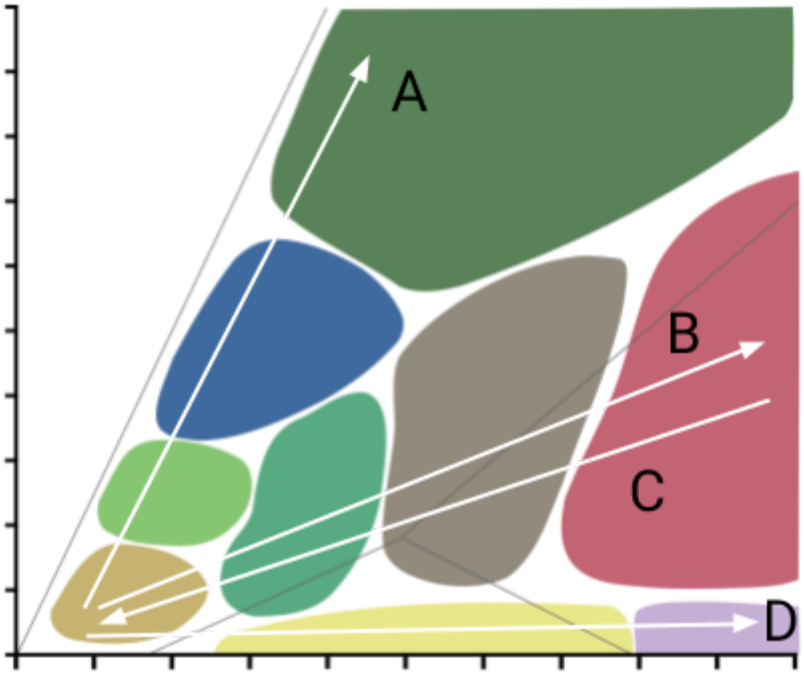
→ **Question 8, Part 1:** Using the mineral assemblages of units A-E given in Figure 1, determine which rock unit has undergone UHP conditions and preserved UHP minerals upon exhumation. Give your answer as a letter.

→ **Question 8, Part 2:** Using Figure 2, classify fault F as either normal, reverse, or thrust. Give your answer as N, R, or T and assume no overturning of strata.

→ **Question 8, Part 3:** Using Figure 3, identify all of following statements that are likely true: (*)

A) Continental slab breakoff (delamination) leads to subsidence of the mountains above
B) Continental slab breakoff is driven by the metamorphism of crust to produce denser rocks
C) The infiltration of water into the ascending UHP metamorphic sheet allows for better preservation of UHP minerals
D) At UHP, minerals have lower melting points, which leads to significant partial melting of UHP rocks
E) The ascension of the UHP metamorphic sheet occurs when the upwards buoyant force exceeds the force of slab pull

9. Use the diagram below to answer the following question.



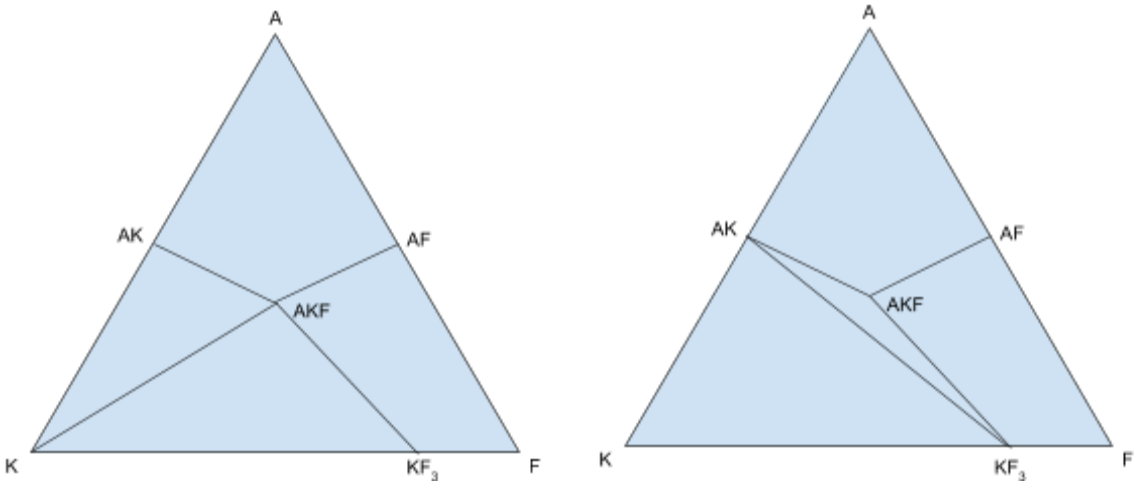
The figure above depicts *metamorphic facies*, where each "blob" represents stable mineral assemblages (i.e. groups of minerals) found under similar temperature and pressure conditions . The x-axis is temperature, and the y-axis is pressure.

Chloe the oceanographer has drawn some arrows that depict the progression of mineral assemblages under varying conditions, but has forgotten which arrow corresponds to minerals she observed in her time in the Peru-Chile trench. The Peru-Chile trench is the result of ocean-continental convergence between the Nazca and South American Plate.

→ Which arrow most accurately describes the most likely progression of mineral assemblages Chloe encountered as she descended along the Peru-Chile trench?

A) Arrow A
B) Arrow B
C) Arrow C
D) Arrow D

10. Use the diagram below to answer the following question.



Brian the metamorphic petrologist is studying the figure above, which depicts a phase diagram of a three component mixture for a given temperature and pressure. Lines represent minerals that may coexist in a rock under these conditions. The two triangles shown depict a compositional diagram "before" (left) and "after" (right) a chemical reaction occurs.

→ Which of the following is the most likely reaction that occurred?

A) $K + AK + 3AKF \rightarrow KF_3 + 4A + 4K$
B) $K + 3AKF \rightarrow 3AK + KF_3$
C) $A + K + F \rightarrow AKF$
D) $AKF \rightarrow A + K + F$
E) $AK + AKF + K + KF_3 \rightarrow 2AK + 2F + 2KF$
F) $3AK + KF_3 \rightarrow 3AKF + K$

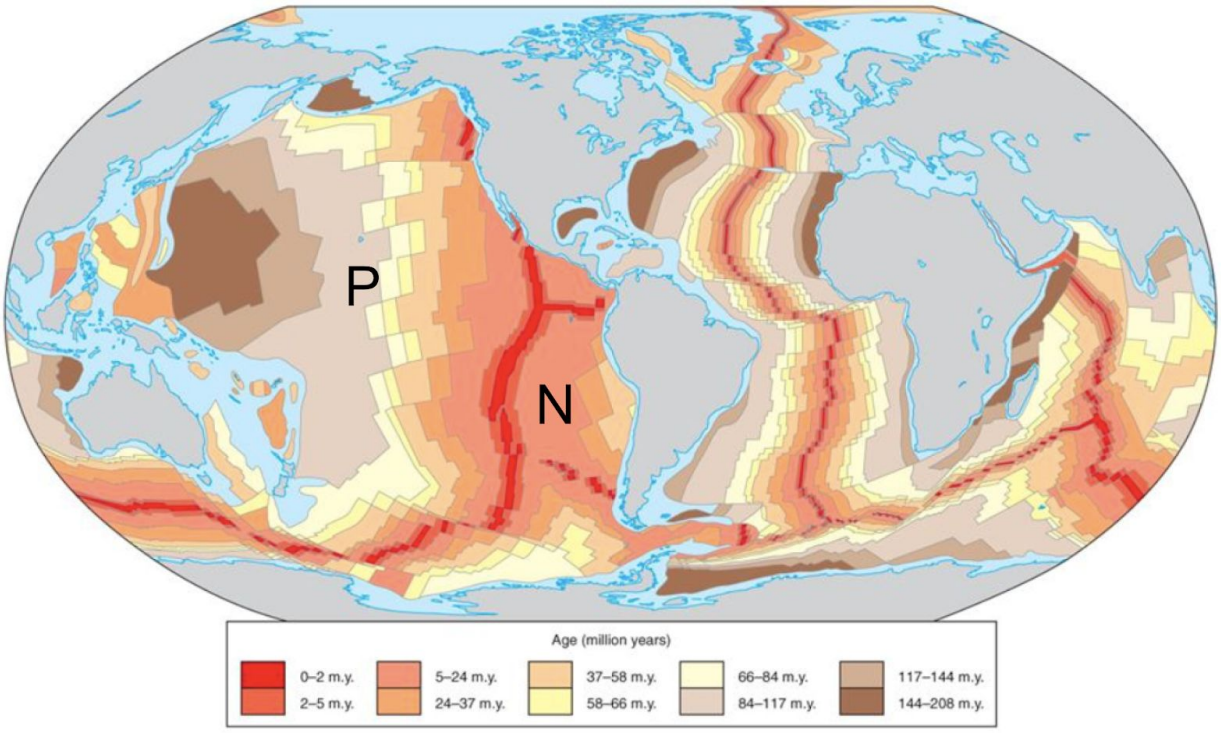
11. While doing field work in Italy, Walter Alvarez observed a clay layer at the K-T boundary. Above this layer, the microfossils of foraminifera changed. This is important because it showed...

A) That evolution occurs gradually with each generation slowly evolving
B) That the base of the food chain had suddenly disappeared.
C) That the clay layer represents an unconformity.
D) That ionizing radiation had killed off the foraminifera.

12. The key question Walter Alvarez had was how long did it take for the clay layer at the K-T boundary to be deposited? This led him to look for iridium in the clay layer because...

    A) Iridium is relatively rare on Earth, but is deposited by meteorites, so the amount of iridium could be used to extrapolate the duration of the clay event.
    B) Iridium-192 has a very long half life, so its abundance can be used to age rocks as it breaks down into other radioactive isotopes.
    C) Iridium is a daughter product of the radioactive breakdown of Potassium, thus it can be used to date the age of rocks.
    D) His dad was into doing research on iridium, so he thought it would be fun to work with his dad.

13. Use the diagram below to answer the following question.

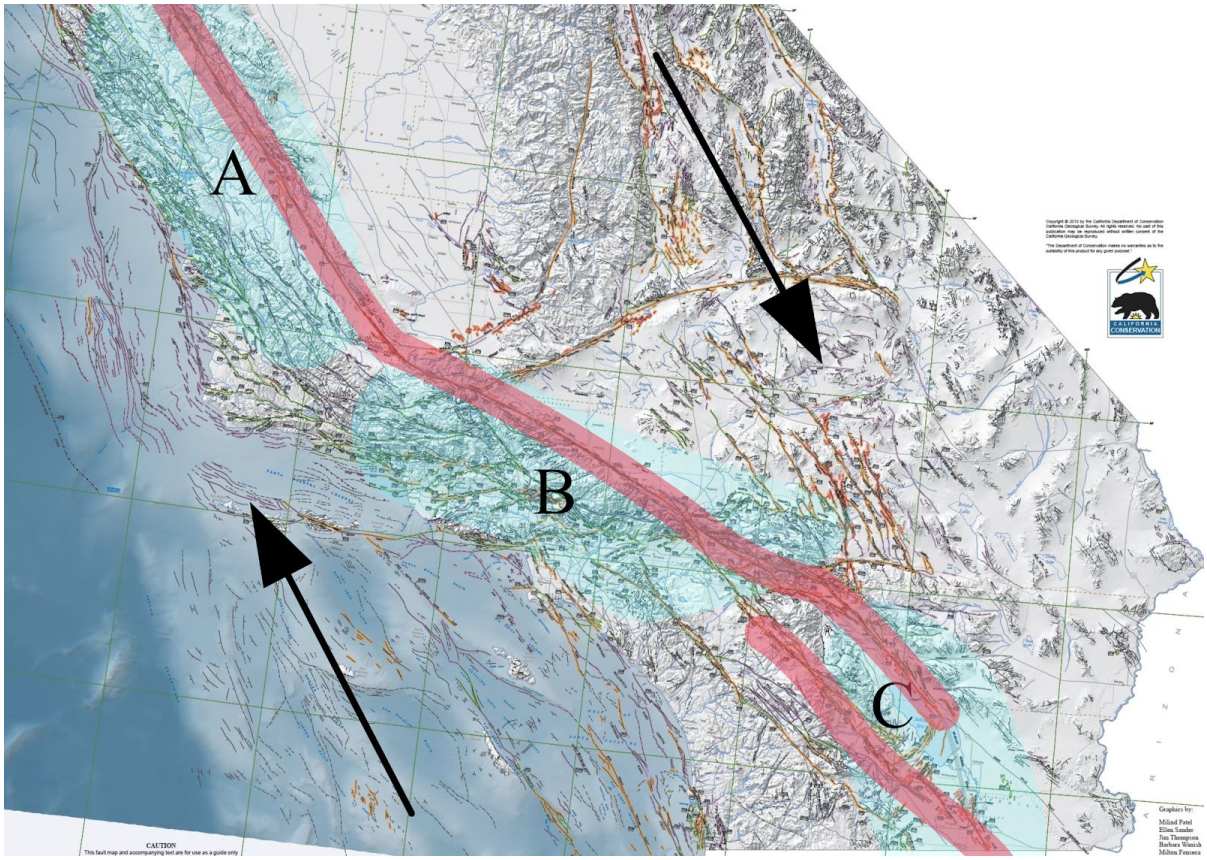


Shown in the image is a map of seafloor ages. Select all of the following that can be reasonably inferred or concluded about the East Pacific Rise (EPR), a mid-ocean ridge that lies between the Pacific plate (P) and the Nazca plate (N); and its relation to surrounding regions.

→ Select all of the following that are true. (*)

A) The average spreading rate is greater than that of other ridges.
B) A greater spreading rate would likely increase the subduction angle of the Nazca plate.
C) The EPR exhibits ridge asymmetry where, on average, the *Pacific plate* spreads faster than the *Nazca plate.*
D) The EPR exhibits ridge asymmetry where, on average, the *Nazca plate* spreads faster than the *Pacific plate.*
E) Asymmetry can be determined for lithosphere generated *0-25 million* years ago.
F) Asymmetry can be determined for lithosphere generated *0-50 million* years ago.
G) Asymmetry can be determined for lithosphere generated *0-75 million* years ago.
H) Asymmetry can be determined for lithosphere generated *0-100 million* years ago.
I) Given that the Pacific Ocean is currently closing, the spreading rate of the EPR is greater than the sum of the subduction rates of the Pacific plate and the Nazca plate.
J) Given that the Pacific Ocean is currently closing, the spreading rate of the EPR is less than the sum of the subduction rates of the Pacific plate and the Nazca plate.

14. Use the diagram below to answer the following question.

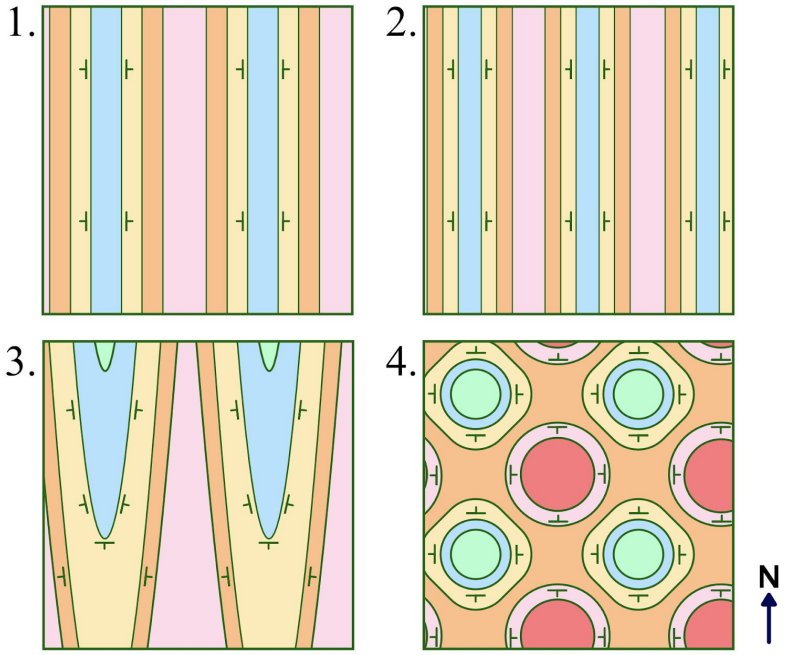


The map above shows the faulting activity of Southern California. The arrows denote the movement of the Pacific plate and the North American plate. The red highlights portions of the San Andreas Fault and San Jacinto Fault, both dextral strike-slip faults.

→ Select all of the following that are true. (*)

A) The formation of the *Coast Ranges at region A* is likely a consequence of strike-slip activity.
B) The formation of the *Transverse Ranges at region B* is likely a consequence of strike-slip activity.
C) *Region A* is currently experiencing crustal thickening.
D) *Region B* is currently experiencing crustal thickening.
E) *Region C* is currently experiencing crustal thickening.
F) C is dominated by *compressional* stress.
G) C is dominated by *tensional* stress.
H) C is dominated by *shear* stress.
I) C is *not under significant differential* stress.

15. Use the diagram below to answer the following question.



The figures above idealize folds as they would appear intersecting the ground (here given to be the horizontal plane). Figure 1 represents the precursor to further deformation in three independent scenarios whose respective results are shown in figures 2-4. Assume no folds are overturned.

→ Select all of the following statements that are true. (*)

A) The blue rock unit is older than the green rock unit.
B) The red rock unit is the youngest rock unit shown out of all figures.
C) The green, blue, and yellow rock units are likely more resistant to weathering than the pink unit.
D) The axial planes of the folds in 1 and 2 are vertical while in 3 they are not.
E) The amplitude of the folds in 2 are likely greater than those of 1 and 3.
F) The amplitude of the folds in 4 are likely greater than those of 1 and 3.
G) A N-S cross section of 3 yields bedding with an apparent dip to the north.
H) An E-W cross section of both 3 and 4 yields an approximately sinusoidal pattern.
I) Both 2 and 3 experienced primarily E-W compressional forces following the folding events of 1.
J) 4 experienced highly localized compressional forces following the folding events of 1.

16. Suppose arkose is found with quartz arenite near an inland mountain belt. It was determined that one of these units was present before past faulting and uplift that exposed granitic basement rock, and that the other was deposited afterwards. Select all of the following descriptions concerning these sandstones that are likely true. (*)

    A) The arkose has a greater porosity than the quartz arenite.
    B) The arkose probably contains more zircon than the quartz arenite.
    C) The arkose has a lower ratio of Ca-rich to Na-rich feldspar compared to its parent rock.
    D) The arkosic unit is bedded above the quartzose unit.

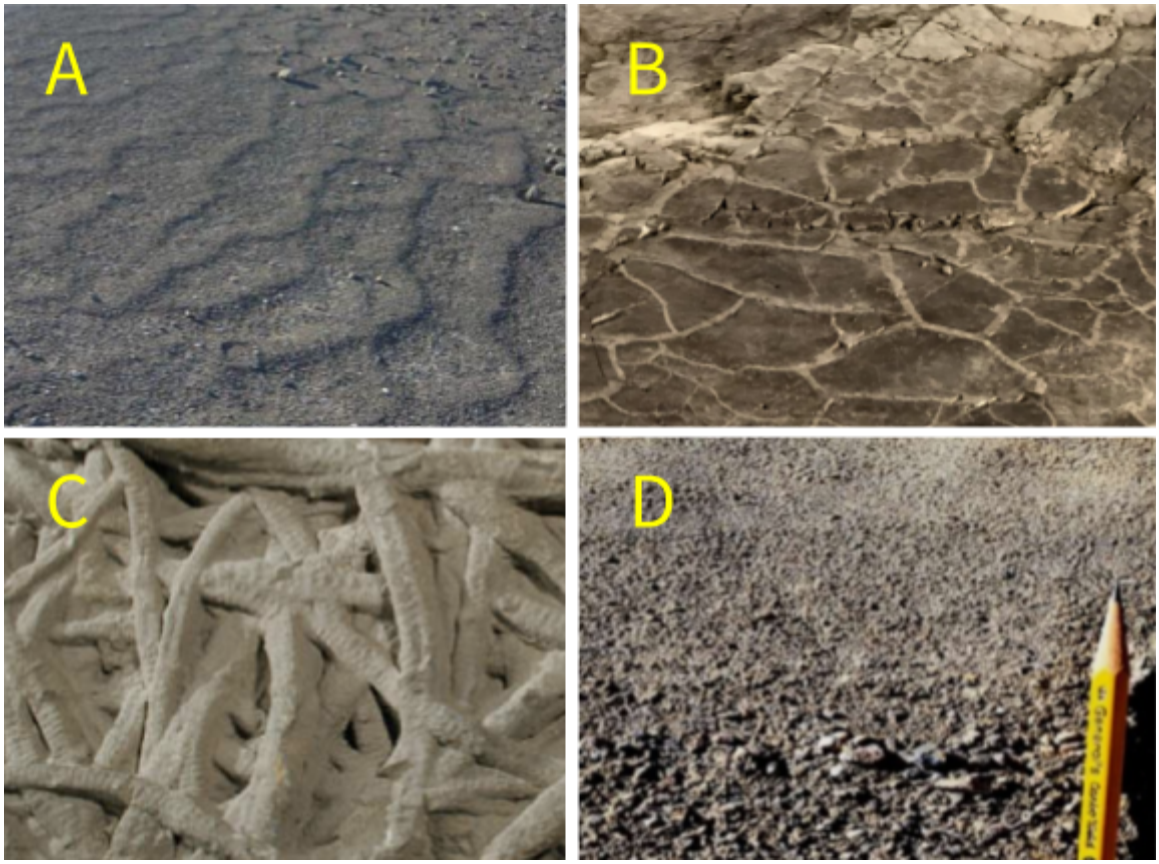
17. Sediments derived from both varieties of sandstone were later transported by a stream to the coast. Select all of the following about this new deposit that are true assuming it consists exclusively of these sediments. (*)

    A) It likely contains significant amounts of kaolinite.
    B) The new deposit has a higher proportion of matrix material compared to clasts.
    C) Once lithified, the new deposit is most similar to the quartz arenite.
    D) The resistance of the deposit to weathering is an intermediate of the two types of sandstone.

18. Which of the following statements relating to Bowen's Reaction Series is/are correct? (*)

    A) Going down the series, silicate structures tend to become less complicated with fewer bonds.
    B) Minerals that crystallize at lower temperatures in the series tend to resist weathering more than minerals that crystallize at higher temperatures.
    C) If an intermediate melt partially cools and experiences magmatic differentiation then it most likely becomes more felsic.
    D) Orthoclase and plagioclase feldspar make up the two ends of the continuous series in the Bowen's Reaction Series.
    E) In a porphyritic rock, the larger crystals are higher in the series than the fine-grained matrix.

19. Use the diagram below to answer the following question.

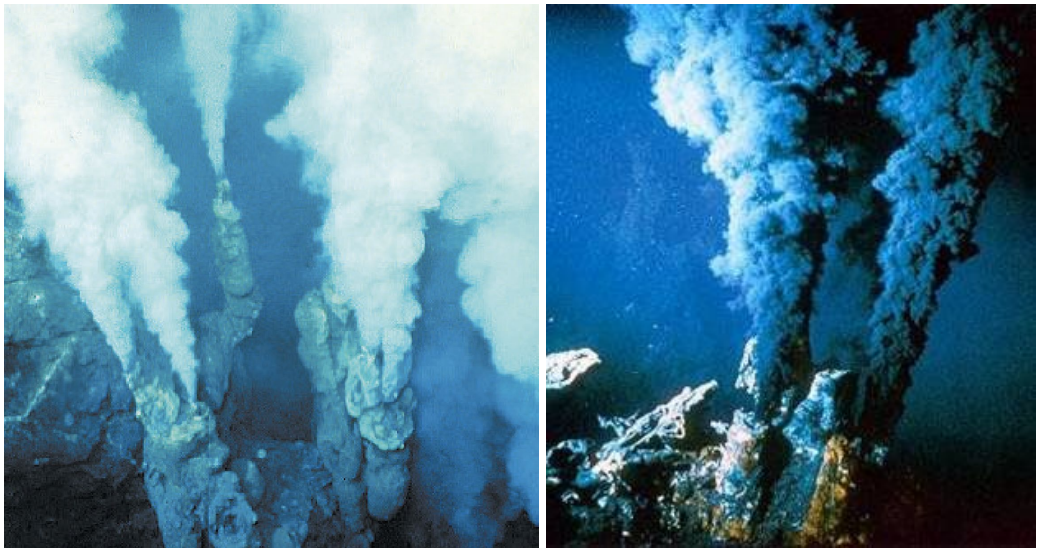


Sedimentary structures provide invaluable insight into the history of a region. Each of the four photographs above represents a sedimentary structure that can be observed in field investigations.

→ Which of the following statements is likely true regarding these sedimentary structures? (*)

A) Structure A was formed by unidirectional current movement over unlithified sediment.
B) Structure A was formed by back-and-forth current movement over unlithified sediment.
C) Structure B is an example of a direct interaction between the biosphere and the geosphere.
D) Structure C is an example of a direct interaction between the biosphere and the geosphere.
E) Structure D would be found in a lake.
F) Structure D would be found in a medial moraine.
G) Structure D would be found on the continental rise.

20. Use the image below to answer the question that follows.



The left and right images above show two types of hydrothermal vents, known as white smokers and black smokers respectively. These chimney-like towers result from the exchange between seawater and heated rock below the ocean floor. The circulated material eventually rises upward, emerging from fractures in the oceanic crust. Upon mixing with the colder seawater, the dissolved material precipitates to form turbulent clouds.

→ Which of the following statements is true regarding black and white smokers? (*)

A) The minerals pyrite (FeS_2), sphalerite (ZnS), and chalcopyrite ($CuFeS_2$) are commonly found in deposits associated with black smokers.
B) The minerals calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), and siderite ($FeCO_3$) are commonly found in deposits associated with black smokers.
C) Black smoker plumes are generally lower in temperature than white smoker plumes.
D) Black smoker plumes are generally higher in temperature than white smoker plumes.
E) For smokers coexisting in the same hydrothermal field, white smokers would be found farther from the plate boundary.
F) For smokers coexisting in the same hydrothermal field, black smokers would be found farther from the plate boundary.