Station A:

At this station is a map of volcanic calderas in Idaho, Montana, Oregon and Wyoming.

Here is a table showing the age of volcanism in each of the calderas and their distances from the Yellowstone hot spot.

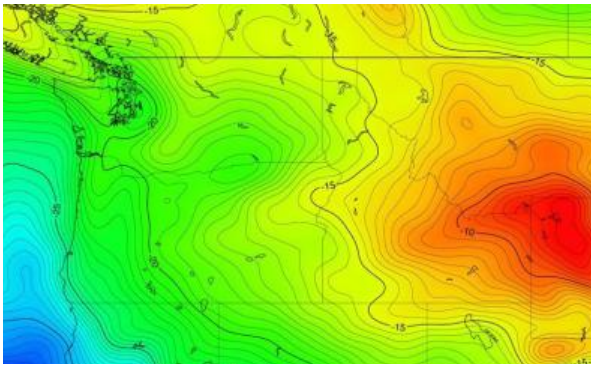
Caldera	Distance from NE of Yellowstone caldera (km)	Age (million yrs)	Rate of movement (cm/year)
Yellowstone Caldera	----------	0	----------
Heise Caldera	148	5	Ans 1
Picabo Caldera	322	10.3	3.1
Bruneau-Jarbridge Caldera	545	11.75	Ans 2
Owyhee Humboldt Caldera	670	13	5.2

1 - 2 Calculate the rate of movement away from the Yellowstone hot spot for each caldera in centimeters per year. Round your answers to the nearest tenths place and record them in the table above.

3: In what direction is the North American plate moving over the Yellowstone hot spot?

4: According to your data, how has the rate(speed) of movement of the North American plate changed over the last 13 million years?

5: What tectonic activity is happening at the east of the North American plate that is causing the movement of the North American plate?



6. Why is the area under Yellowstone caldera showing a gravity anomaly? The crustal material under the caldera is:

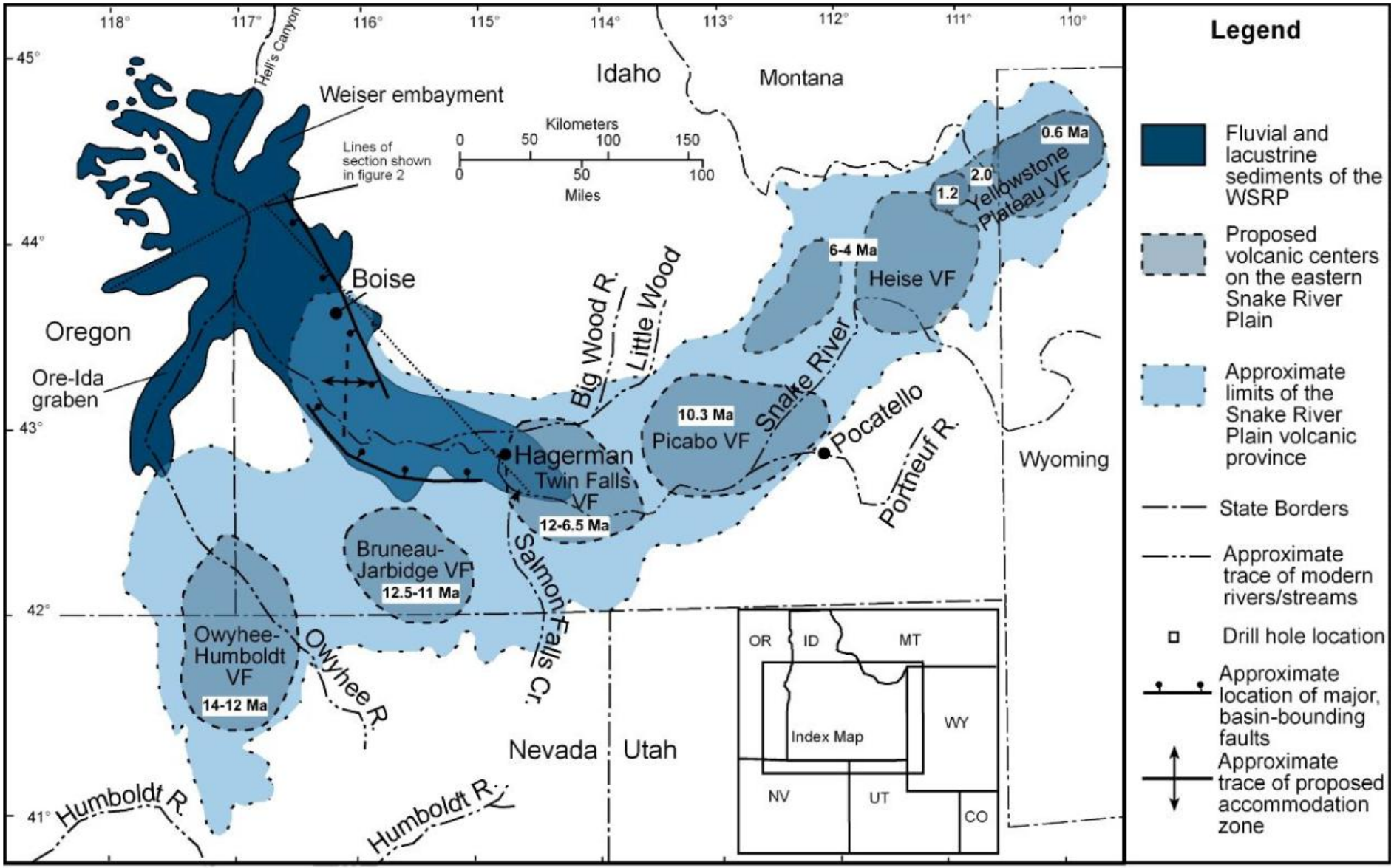
a. Less dense than the surrounding rock.

b. More dense than the surrounding rock.

c. Radiating significant heat into space.

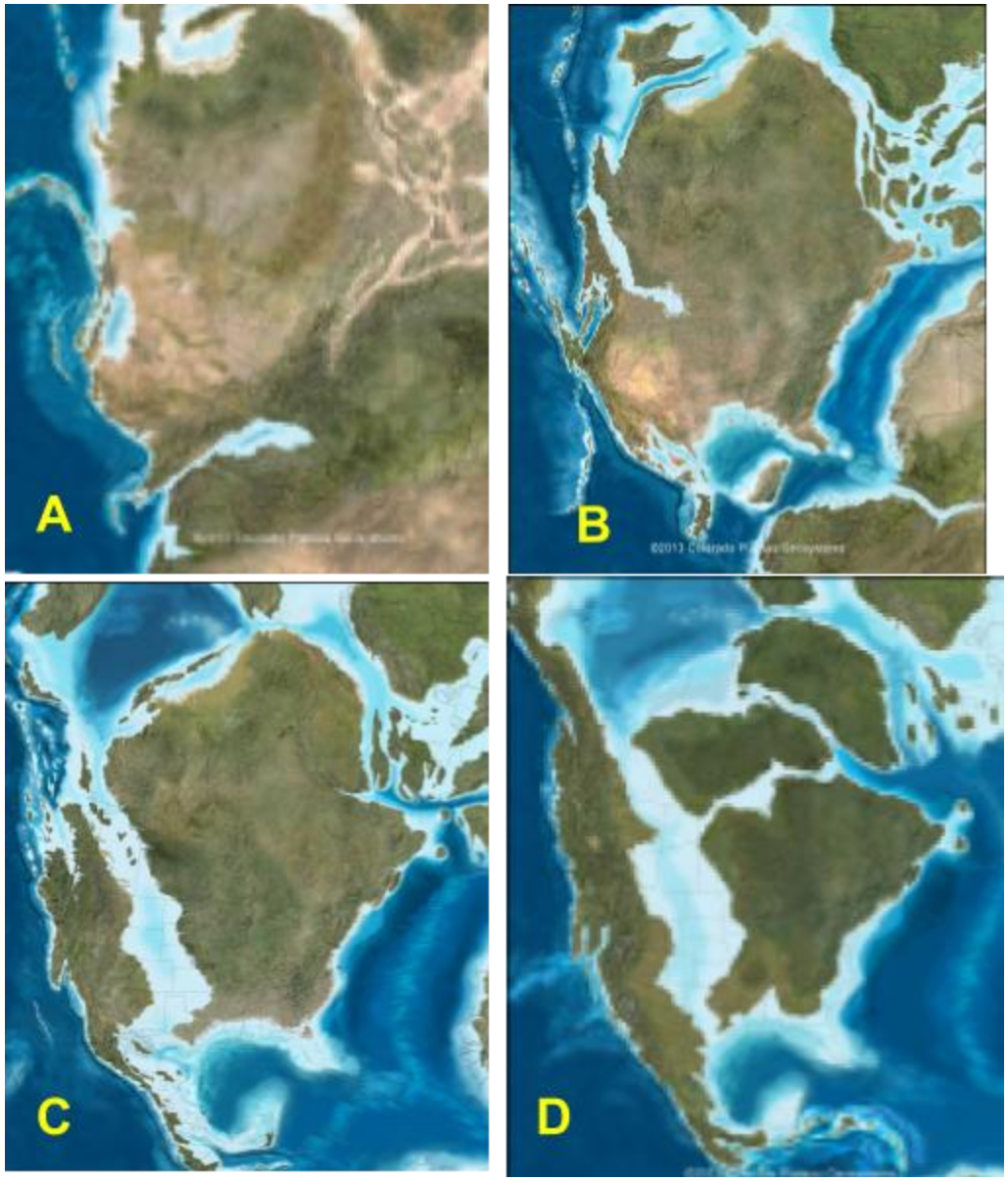
d. Younger than the material surrounding it.

7: Using the most recent rate of plate movement from your table above, calculate how far the North American plate would have moved since Montana became a state in 1889. Show your work.


Legend
Fluvial and lacustrine sediments of the WSRP
Proposed volcanic centers on the eastern Snake River Plain
Approximate limits of the Snake River Plain volcanic province
State Borders
Approximate trace of modern rivers/streams
Drill hole location
Approximate location of major, basin-bounding faults
Approximate trace of proposed accommodation zone
Idaho
Montana
Wyoming
Oregon
Nevada
Utah
Weiser embayment
Ore-Ida graben
Boise
Hagerman
Twin Falls VF
12-6.5 Ma
Picabo VF
10.3 Ma
Heise VF
6-4 Ma
Yellowstone Plateau VF
0.6 Ma
2.0
1.2
Bruneau-Jarbidge VF
12.5-11 Ma
Owyhee-Humboldt VF
14-12 Ma
Big Wood R.
Little Wood
Snake River
Pocatello
Portneuf R.
Salmon Falls Cr.
Owyhee R.
Humboldt R.
Hell's Canyon
Lines of section shown in figure 2
Kilometers
0 50 100 150
0 50 100
Miles
Index Map
OR
ID
MT
WY
NV
UT
CO
118°
117°
116°
115°
114°
113°
112°
111°
110°
45°
44°
43°
42°
41°

Station B:

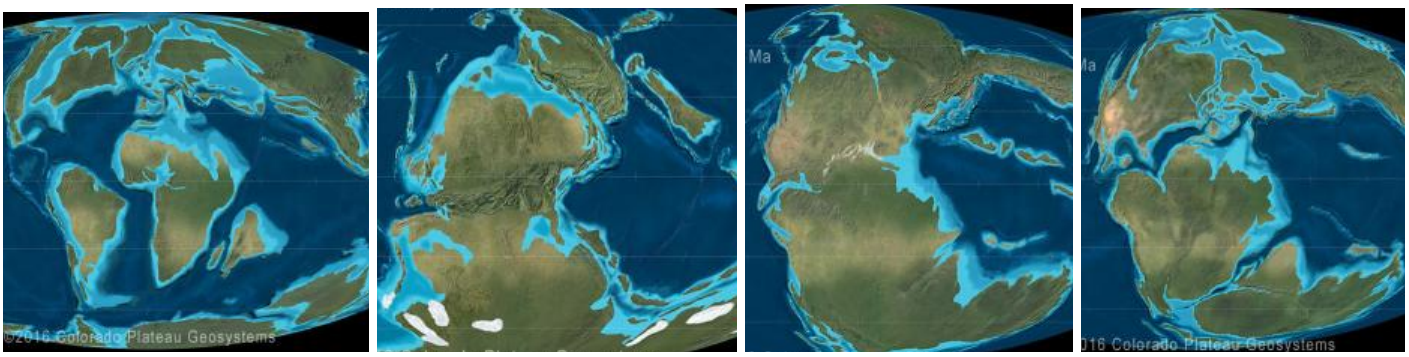
Below are four paleogeopraphic reconstructions of the North American plate



1. The time span in the images above is most likely to be
    A. Mid Cambrian to Early Paleozoic
    B. Mid Paleozoic to Late Mesozoic
    C. Early Triassic to Late Cretaceous
    D. Late Cretaceous to mid Cenozoic

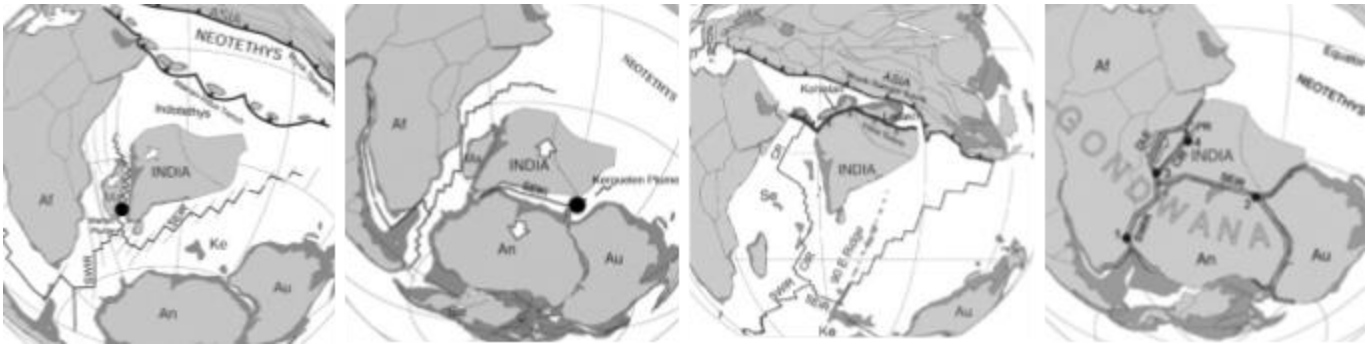
2. During the time period shown by the maps which of the following did not occur?
    A. Sea level rose as warm, less dense, new crustal material displaced ocean water.
    B. The Atlantic ocean formed and spread at the mid ocean ridge.
    C. An inland sea formed in the North America interior.
    D. A short-lived proto-ocean formed at a plate boundary from NW Canada to the Gulf of Mexico.

3. Order the following paleogeographic maps in order by age, oldest to youngest.



A B C D

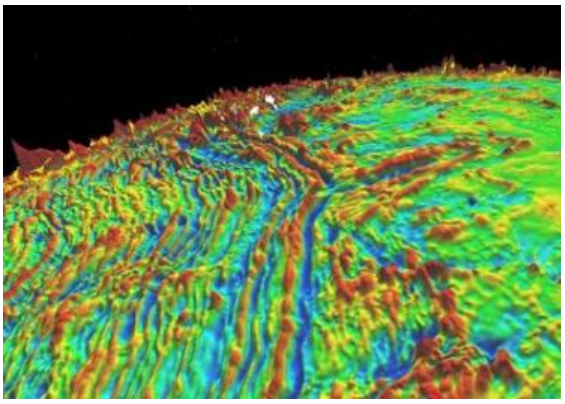
4. Order the following paleogeographic maps in order by age, oldest to youngest.



A B C D

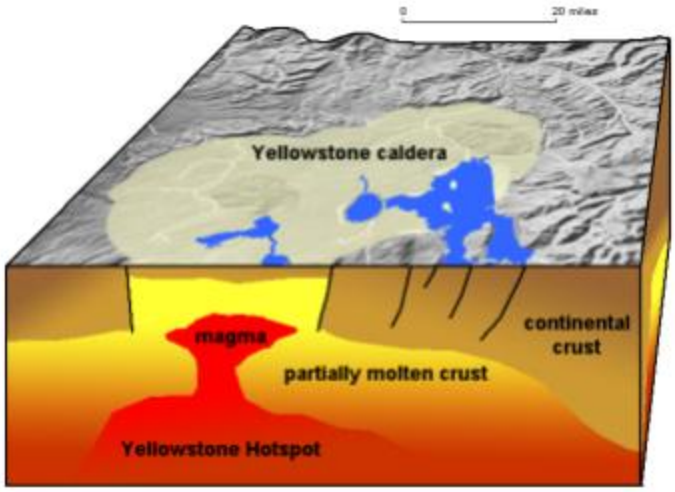
5. The convergent boundery shown in image C above continues to form what geographic feature? _____

6. The magnetic anomaly shown in the striped area to the left of the image below most likely represents...



a. Extensively folded iron-rich rocks of the Appalachian region of PA and NY.
b. Layered iron rich /iron poor sedimentary rocks tipped on their sides and exposed by erosion.
c. Crustal formation during ea-floor spreading over time in the Atlantic ocean.
d. None of the above.

Station C:



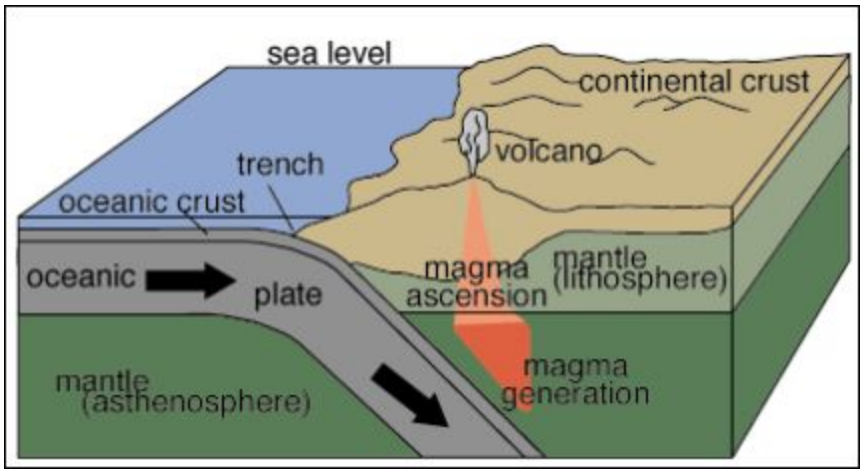
1. Extrusive materials from the Yellowstone hot spot in the last 20 million years.
   a. Are basaltic in composition.
   b. Are rhyolitic in composition.
   c. Vary from rhyolitic to intermediate to basaltic in composition.
   d. Are uniformly intermediate in composition.

2. Magma that generates volcanoes along mid-ocean ridges or at hotspots such as under Hawaii and Iceland tends to be.
   a. Mafic or ultramafic.
   b. Felsic magma.
   c. Intermediate.
   d. All of the above.

3. Which type of lava exists at the highest eruption temperature and has the the lowest viscosity?
   a. Rhyloite lava.
   b. Andesite lava.
   c. Basalt lava.
   d. Dacite lava.

4. Andesite lava is
   a. Intermediate in composition
   b. Mafic in composition
   c. Usually found at convergent plate margins
   d. Usually found at hot spots in oceanic settings.
   e. Both A and C
   f. Both B and D

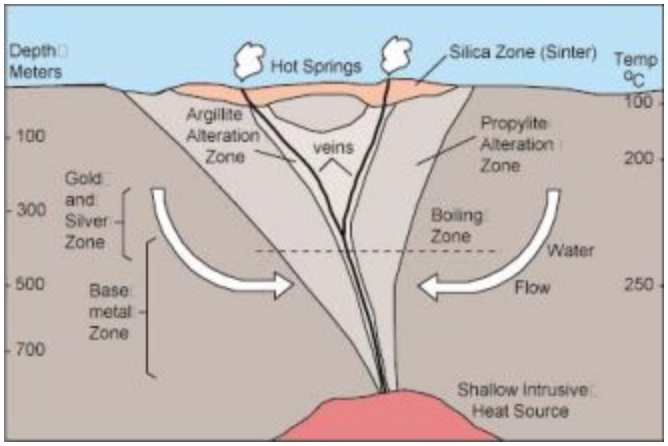
5. Magmas with intermediate composition are created in several processes including.
   a. Rise of mafic magmas through felsic crust and subsequent melting and mixing.
   b. Fractional crystallization of a mafic parent magma.
   c. Magma mixing between felsic rhyolitic and mafic basaltic magmas in a magma reservoir.
   d. Both A and C
   e. All of the above.



6. From the diagram above, we can assume that as an oceanic plate subducts under continental plate, which of the following occurs:
   a. Rising magmas will have an intermediate composition as basaltic lavas mix with more felsic continental rocks.
   b. Melting of oceanic sediments will contribute more felsic material to the resulting magmas.
   c. Rising magmas will be enriched in water content from the melting of subducting ocean crust and sediments.
   d. Both A and B.
   e. All of the above.

7. Mafic and ultramafic magma from the earth's upper mantle has relatively _____.
   a) High density, with high concentrations of Si, O, K, Al, and Na.
   b) High density, containing high concentrations of the Fe, Mg, and Ca.
   c) Low density, containing high concentrations of Si, O, K, Al, and Na.
   d) Low density, containing high concentrations of Fe, Mg, and Ca.

8. Crown Butte Mines, Inc. wants to mine gold, silver and copper at its New World deposit located near Yellowstone National Park. These elements were
   a. Deposited in rock above the magma body metal-rich waters heated by the magma.
   b. Deposited in lava flows formed by metal-rich magma from the upper mantle.
   c. Precipitated out of the hot springs/geysers in easily mineable surface lodes.
   d. All of the above in quantities economically advantageous for mining.



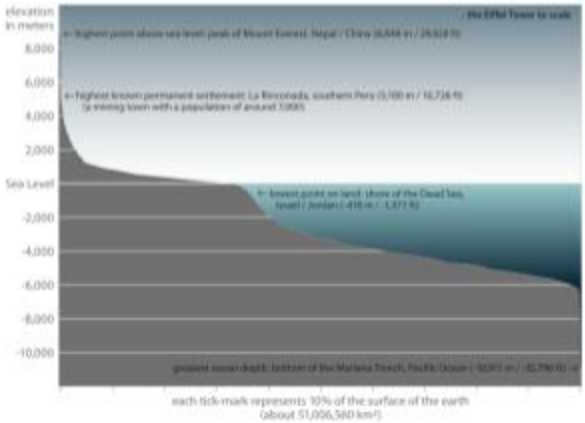
Station D:

Fill in the blank:

1. The image above from Kincraig Point in Scotland shows a step-raised beach caused by periodic upward movements with subsequent erosion, repeated over time, causing differences in the elevation of the beach/coastline relative to _____ (two words).

2. When substantial glaciers melt, downward-flexed parts of the lithosphere rebound upward and rise until they reach _____. This process continues today.

3. Other than accumulation of glacial ice, what are two other processes that can load the lithosphere and cause it to bend/flex downwards? a. _____ b. _____



4. Seen left, a _____, plots the elevation variations between mountains, lowlands, continental shelves, and deep ocean trenches.

5. The two factors which determine how high a continental mountain range "floats" when it is at isostatic equilibrium are _____ and _____.

6. Given the densities below, and assuming that isostatic equilibrium was reached, how thick was an ice sheet over Europe if it displaced the asthenosphere 1800m?

The density of the asthenosphere is 3300kg/m^3.
The density of ice is about 914 kg/m^3.

Show your work. (6 points)

Station E:

Match each scientist with their accomplishment in the history of plate tectonic theory:

1. First scientific map of the Atlantic Ocean floor.
2. How plates can move through sea-floor spreading.
3. Magnetic reversals show sea floor spreading from ridge
4. The boundary between crust and mantle is marked by changes in the velocity of earthquake waves.
5. Hot spots, cycle of ocean expansion/contraction
6. Radiometric dating and the age of the Earth
7. Hypothesized existance of Gondwana/Tethys Ocean

a. Harry Hess
b. Tuzo Wilson
c. Frederick Vine
d. Arthur Holmes
e. Marie Tharp
f. Eduard Suess
g. Andrija Mohorovicic

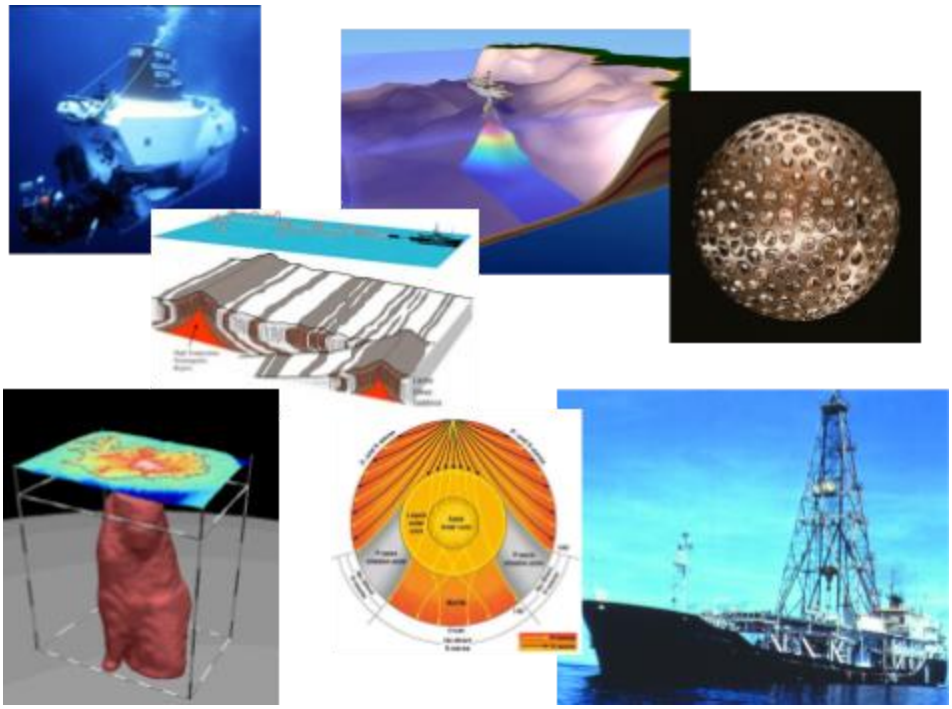
8. Which of these pieces of evidence did Wegener not use to support his theory of continental drift?

a. Similar plant and animal fossils found near the shores of different continents.
b. The underwater mountain chain/ridge running down the middle of the Atlantic.
c. Continuation of geologic features such as mountain belts across the Atlantic.
d. The facing sides of South America and Africa appear to fit together.

Match the technology or method with a discovery credited to its use.

9. Measuring rates of sea-floor spreading.
10. Deep Sea drilling evidence for sea-floor spreading
11. Earth is made of layers shown by shadow zones in P and S waves
12. Discovered first hydrothermal vents. on ocean floor.
13. Shape of Hawaiian hotspot plume.
14. Rocks on both sides of Mid-Atlantic mirror each other's polarity

a. Tomographic imaging
b. Glomar Challenger
c. Magnetometers
d. Alvin
e. Global seismic data
f. Laser-reflecting Lageos satellite and GPS



15. Which was NOT one of the leading elements of plate tectonic theory as it evolved between the 1950's and the 1970's?

a) We should be able to describe all geologic features by explaning how their formation has been driven by the relative motion of earth's tectonic plates.

b) Earthquakes and volcanic activity occur almost always in the interior of tectonic plates, rather than at plate edges.

c) Convection currents in the earth's molten mantle drive plate movements.

d) Plate movements include spreading within the oceanic crust, below the ocean waters, which causes continents exposed above ocean waters to drift apart.

Station F:

1. Rupture of rock along a fault line is an example of _____ ; _____ is stretching and/or flowing of rock under high heat and pressure.

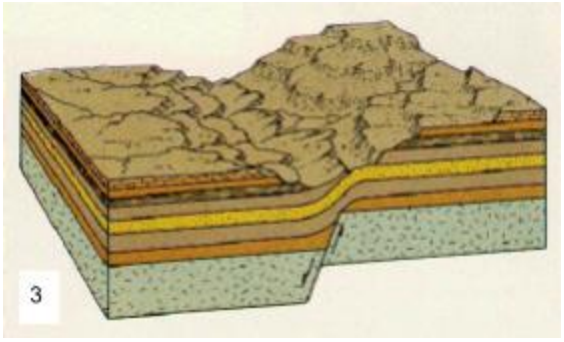
a) brittle deformation; ductile deformation.
b) plastic deformation; brittle deformation.
c) ductile deformation; brittle deformation.
d) ductile deformation; plastic deformation.

2. Which of the following is the weakest of the three tectonic processes below?

a) Slab pull. b) Slab suction b) Ridge push.

3. a. What are the three kinds of stress?

b. What is the fault shown in figure 2, below? What kind of stress produced it?



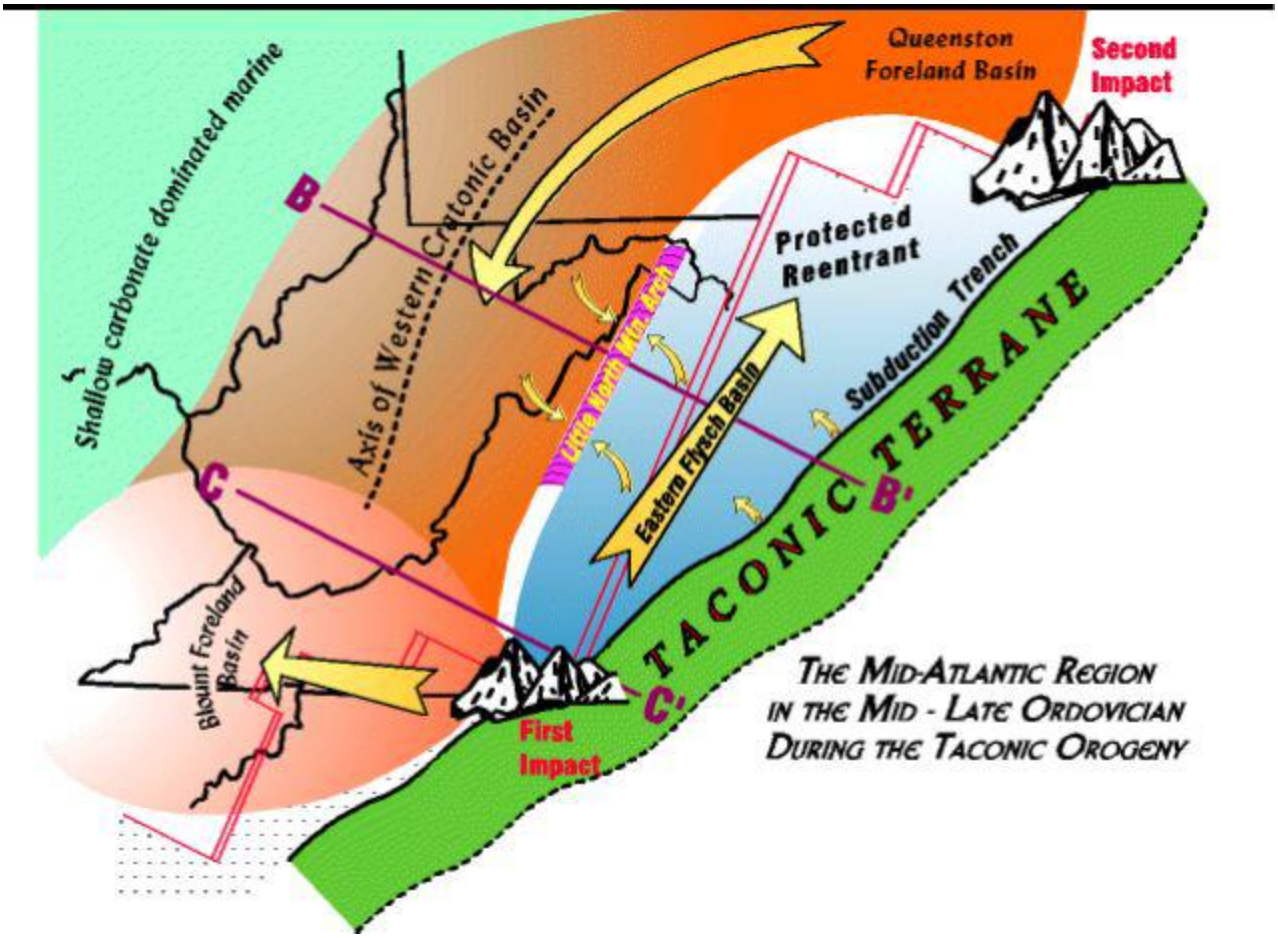
c. What kind of fold is shown in figure 3? What kind of fault?

d. What kind of fault is shown in Photo 4? What kind of stress produced it?

e. What type of fault, and what kind of stress, caused the bent tracks in Photo 5?

f. Did the forces that produced feature 6 result in crustal lengthening or shortening?

4. Analogy. Tension is to lengthen as stress is to _____.



Vocabulary

5. The geologic term for the joining together, along a major fault zone, of 2 distinct geologic crustal fragments is _____.

6. The geologic term _____ refers to a fragment of the earth's crust that breaks off from one tectonic plate and then becomes affixed to the crust overlying a second plate.

7. The process by which the taconic terrane will be added to North America is called _____.

Station G

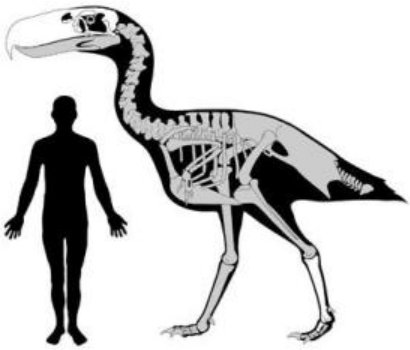
1. The joining of North and South America by the formation of the Isthmus of Panama (right) occurred

a. 225 mya
b. 65 mya
c. 3 mya
d. 0.25 mya

2. Which of the following are likely consequences of the joining of North and South America by the Isthmus of Panama? **Choose all that apply.**

a) Stopping equatorial currents moving from the Atlantic to the Pacific.
b) Increased precipitation in the Arctic and the build-up of ice sheets.
c) Migration of camels, porcupines, bears, sabre-toothed tigers, and giant ground sloths from one continent to the other.
d) Warmer climate in Northwestern Europe.
e) Increasing salinity of the Atlantic.

3. It is thought that the carnivorous Terror Bird, preying on an early horse, right, was the largest predator in South America from 62 mya until roughly 2 mya. **How might the formation of the Isthmus of Panama have lead to its extinction?**

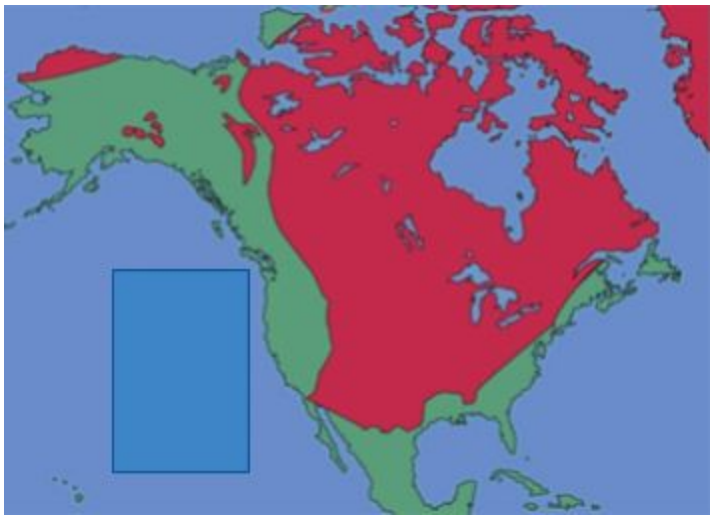


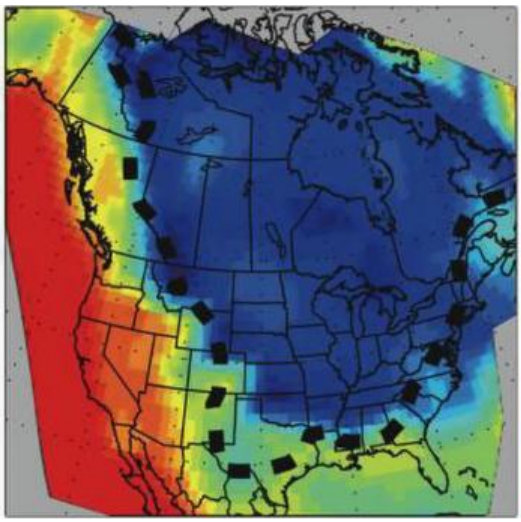
Disclaimer: Some suggest that fossil evidence from the many species of Terror Bird and its contemporaries shows that it might have been a carrion-eater or scavenger. This is also suggested of Tyrannosaurus Rex.

4. Which of the following was probably a result of the break-up Pangaea?

a) Geographic integration of habitats causing extinction of large land animals.
b) Increasing albedo caused the gradual cooling of the planet.
c) Increasingly wetter climate in the former interior regions of Pangaea
d) Weakening of ocean currents flowing between Laurasia and Gondwanaland.

5. Compared to the more geologically active and unstable exterior regions of a tectonic plate, the ___ in the interior (usually) of a plate is a much more stable part of the earth's crust. (Fill in the blank)





6. The red areas of the above left image and the blue areas of the above right image are largely the same. Those areas represent... **Choose all that apply.**

a) Remains of 6 microcrustal blocks that joined together more than 2 bya.
b) The North American Craton.
c) Glacial deposits from the Pleistocene era.
d) Areas underlain by crustal rocks largely older than 1 billion years.
e) Mostly highly metamorphic rocks overlain in places by younger rocks.
f) The thinnest portion of the North American crust.

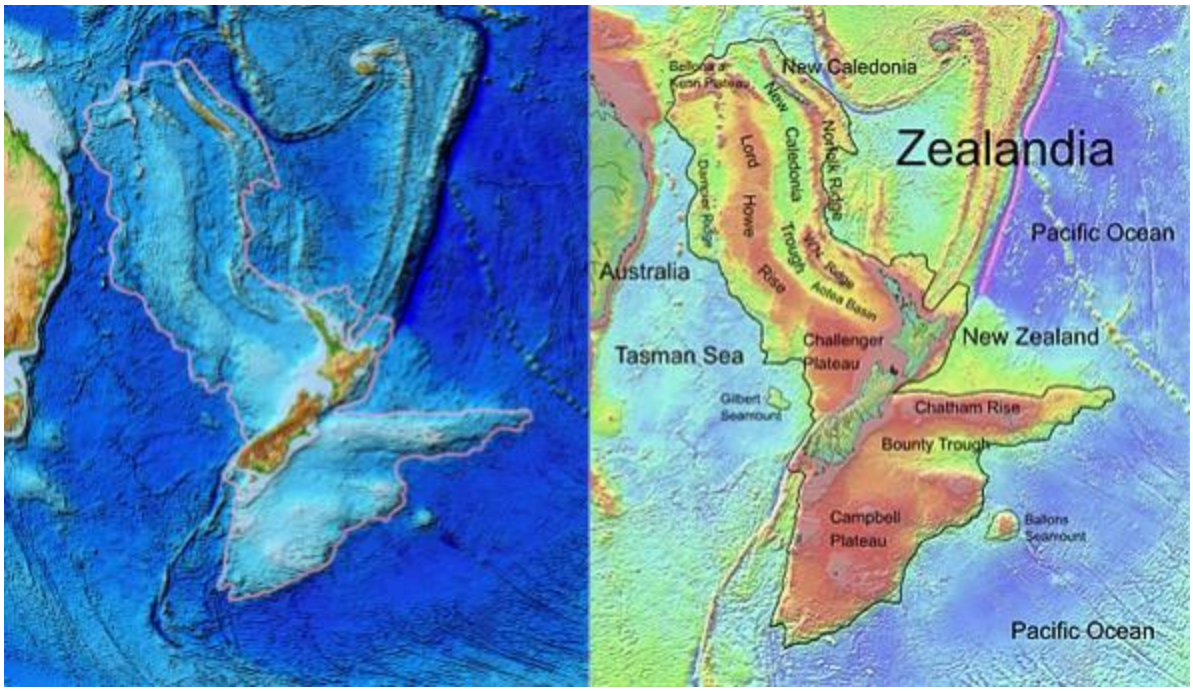
7. Which of the following are ore deposits that are associated primarily with divergent plate boundaries?

a. Sulfide deposits in oceanic hydrothermal vents.
b. Porphyry copper deposits.
c. Red-bed uranium deposits
d. Petroleum deposits

8. Which of the following are tectonic environments in which hydrocarbon (petroleum) reserves are likely to form? **Choose all that apply.**

a. Fore-arc basins
b. Subduction trench zones
c. Back-arc basins
d. Mid Ocean ridges

These images shows what some geographers are calling the 8th continent, Zealandia,



9. From the maps above, which of these statements is **not** true about Zealandia?

   a. The crust underlying Zealandia is likely denser and more mafic than the surrounding crust.
   b. The country of New Zealand is the portion of this continent above sea level.
   c. In the left map, the lighter the blue color, the higher the elevation.
   d. Zealandia constitutes a single block of crust rather than multiple smaller pieces