



*Exploring the World of Science*

Inaugural University of Michigan  
Science Olympiad Invitational Tournament

# Dynamic Planet

Test length: 50 Minutes

Team number: \_\_\_\_\_

School name: \_\_\_\_\_

Student names: \_\_\_\_\_

University of Michigan Invitational  
February 17, 2018

### **Dynamic Planet**

Each team may bring **four** 8.5" x 11" sheets of paper that may contain information on **both sides** in any form and from any source. Each team may bring two **non-programmable, non-graphing** calculators dedicated to computation to use during the event.

High score wins. Points will be awarded for the quality and accuracy of answers, the quality of supporting reasoning, and the use of proper scientific methods of responses. Selected questions may be used as tiebreakers.

Write your team name and number at the top of each page. If you tear apart the test, please staple the pages back together in order.

Part One Multiple Choice:        / 25

Part Two Short Answer:        / 118

Final Score:                        / 143

Placement:

### Part One: Multiple Choice

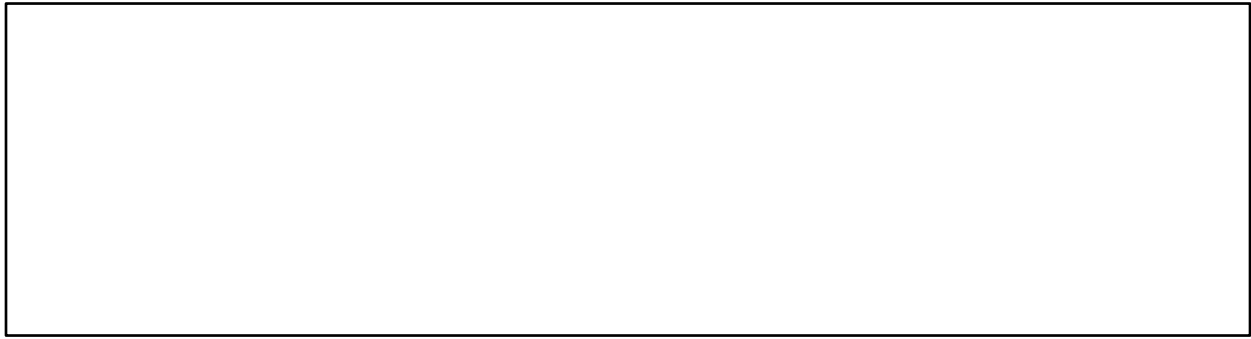
- Which of the following is **not** a characteristic of a continental-continental convergent boundary?
  - Mountain building
  - Strong earthquakes
  - Arc volcanism
  - None of the above
- When seismic waves from earthquakes reach the boundary between the mantle and liquid outer core:
  - all of the body waves get refracted
  - all of the body waves get reflected, but none are refracted
  - all P-waves stop because they are unable to move through the outer core
  - all S-waves vanish because they cannot move through a liquid
- Magmas that feed island-arc volcanoes:
  - are a result of decompression melting within Earth's mantle
  - occur over very wide zones thousands of kilometers in width
  - are located near continental-oceanic boundaries due to magma generation in the Benioff Zone
  - rise along transform faults associated with nearby divergent boundaries
- All of the following are features associated with Pangaea except:
  - Panthalassa Ocean
  - Iapetus Ocean
  - Tethys Sea
  - Gondwanaland
- Which of the following did not occur during the Phanerozoic Era?
  - Increase in cyanobacteria causes the great oxygenation event
  - Overall warming of the climate
  - Life merges from the sea
  - Flowering plants, called angiosperms, became more common
- If a rock deforms under the influence of a stress, but then returns to its original shape when the stress is removed, then the deformation behavior is described as:
  - brittle
  - plastic
  - elastic
  - ductile
- Which of the following statements is false?
  - Compression waves travel through solids as well as liquids
  - The speed of seismic waves generally decreases with depth in a layer
  - Seismic waves always slow down when reaching a liquid or partially liquid layer
  - When seismic waves pass from one material to another, the path of the waves is refracted
- The Modified Mercalli scale is used to measure:
  - the moment magnitude of an earthquake
  - the intensity of an earthquake
  - the amount of energy released during an earthquake
  - the height of the surface waves during an earthquake

9. The fact that the magnetic pole seems to have moved throughout geologic time is best explained by:
  - a. The movement of the continents
  - b. The movement of the magnetic pole
  - c. The movement of the axis of rotation
  - d. Both A and B
10. Magmas that feed island-arc volcanoes
  - a. Could not be derived from the Benioff Zone according to geochemical studies
  - b. Occur over very wide zones thousands of kilometers in width
  - c. Are located where they are as a result of magma generation in the Benioff Zone
  - d. Rise along transform faults
11. Which of the following pieces of evidence did Alfred Wegener **not** use to support his theory of plate tectonics?
  - a. Magnetic patterns on the seafloor
  - b. Matching coastlines
  - c. Matching geologic units
  - d. Glacial striations indicating direction of movement
12. When a ship passes over seafloor that has a 'reverse' magnetic polarization, how does this affect the magnetic field reading?
  - a. The magnetic field is directed south
  - b. The magnetic field is directed north
  - c. The strength of the magnetic field is slightly stronger than usual
  - d. The strength of the magnetic field is slightly weaker than usual
13. What is the character of magnetic anomalies on the seafloor?
  - a. Occur in stripes parallel to mid-ocean ridges and offset along transform faults
  - b. Occur in stripes perpendicular to mid-ocean ridges and parallel to transform faults
  - c. Occur in stripes parallel to continental margins and to transform faults
  - d. Occur in stripes perpendicular to continental margins and parallel to transform faults
14. In mountain systems that form at continental margins;
  - a. Earth's crust is thicker than average
  - b. Most deformation is a result of tensional stresses
  - c. Stretching and thinning of continental crust occurs
  - d. Little or no volcanic activity occurs
15. Which of these statements about paleomagnetism regarding spreading ridges is **false**?
  - a. Rocks along spreading ridges all show normal polarity regardless of age
  - b. The paleomagnetic pattern on one side of a ridge is a mirror image of that on the other side of the ridge
  - c. There is evidence that Earth's magnetic poles reverse approximately every half-million years
  - d. All of Earth's spreading ridges show evidence of paleomagnetic reversals in the adjacent oceanic rocks.
16. On average, the geothermal gradient inside the Earth is about:
  - a. 1000°C per kilometer
  - b. 100°C per kilometer
  - c. 50°C per kilometer
  - d. 25°C per kilometer

17. The type of volcanic hazard involving a huge cloud of tephra rushing down the volcano's slopes is a:
- Lahar
  - Lava bomb
  - Pyroclastic flow
  - Gas cloud
18. Which of the following sequence of events accurately describes the build-up to the eruption of Mount St. Helens about 28 years ago, on May 18th, 1980?
- Steam and ash release – bulge on mountain – earthquake – landslide – lateral blast
  - Bulge on mountain – steam and ash release – earthquake – landslide – lateral blast
  - Bulge on mountain – earthquake – steam and ash release – landslide – lateral blast
  - Steam and ash release – bulge on mountain – landslide – lateral blast – earthquake
19. Which principle of stratigraphy states that any horizontal sedimentary bed is younger than the bed below it but older than the bed above it?
- Principle of uniformitarianism
  - Principle of cross-cutting relationships
  - Principle of original horizontality
  - Principle of stratigraphic superposition
20. The correct arrangement of the different types of geologic time divisions, from longest to shortest, is:
- epochs, periods, eras, eons
  - periods, eons, epochs, eras
  - eons, eras, periods, epochs
  - eons, epochs, eras, periods
21. The Earth has a magnetic field because:
- magnetic minerals are common at temperatures above the Curie point
  - it has a magnetic iron-nickel core
  - the outer core creates an electric current which induces a magnetic field
  - its forms a magnetic resonance with mercury
22. The correct order of the 4 layers of rock types that make up oceanic crust, from top to bottom is:
- pillow basalts – sediments – gabbro – sheeted dike complex
  - pillow basalts – sheeted dike complex – gabbro – sediments
  - sediments – pillow basalts – sheeted dike complex – gabbro
  - sediments – pillow basalts – gabbro – sheeted dike complex
23. The Appalachians formed after the breakup and subsequent reassembling of the ancient supercontinent:
- Gondwana
  - Pangaea
  - Rodinia
  - Nubia
24. Which of the following statements is **true**?
- an earthquake has only one magnitude but the intensity can vary
  - an earthquake has only one intensity but the magnitude can vary
  - an earthquake's magnitude decreases with increasing distance from the epicenter
  - the intensity of an earthquake is the least at the epicenter



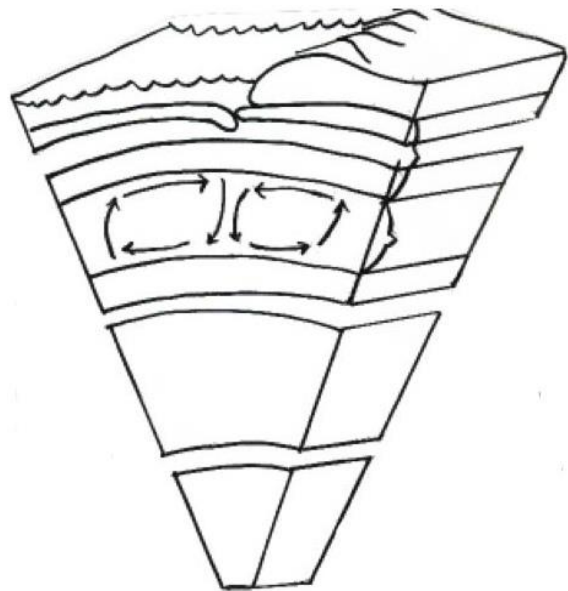
2. Draw cross sections of the three boundaries (convergent, divergent, and transform).



a. What type of stress operates within each boundary? (directional stress) On each of your cross sections draw the direction these forces are acting in.

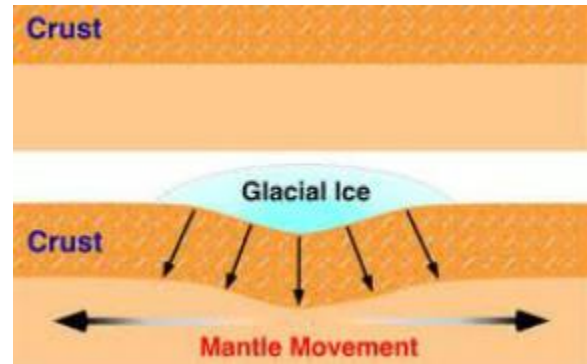
3. Refer to the following cross section of Earth's interior. Label each layer.

a. Which layer is molten? What evidence was used to prove this?.



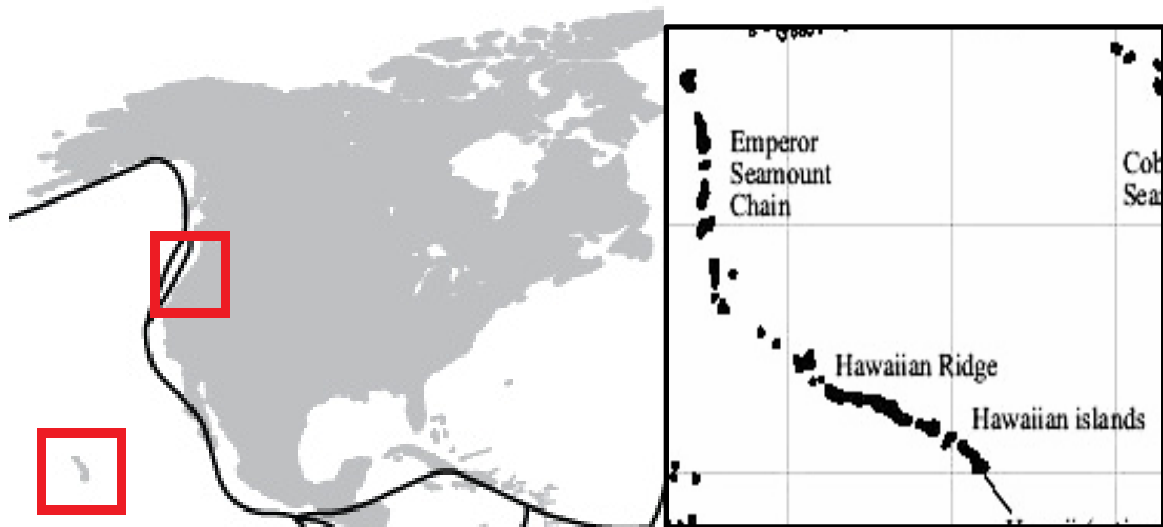
b. When Earth was first formed, the layers that exist today were not present. Explain the process that created Earth's layers. In which geologic eon did this occur?

4. Suppose this glacier melts/retreats. As a result of the glacier's removal, what would you expect to happen? Explain why this process occurs.



5. Consider the Rocky Mountains and the Appalachian Mountains. Which of the two ranges is older? Justify your answer.

6. Consider the two volcanoes on the map: Mt. St. Helens and the Hawaiian Chain.



- a. On the map above, draw arrows to illustrate the direction of plate movement at each location.
- b. What type of volcano would you expect at each location, and what type of volcanism is the volcano associated with?
  - i. Mt. St. Helens:
  - ii. Hawaii:

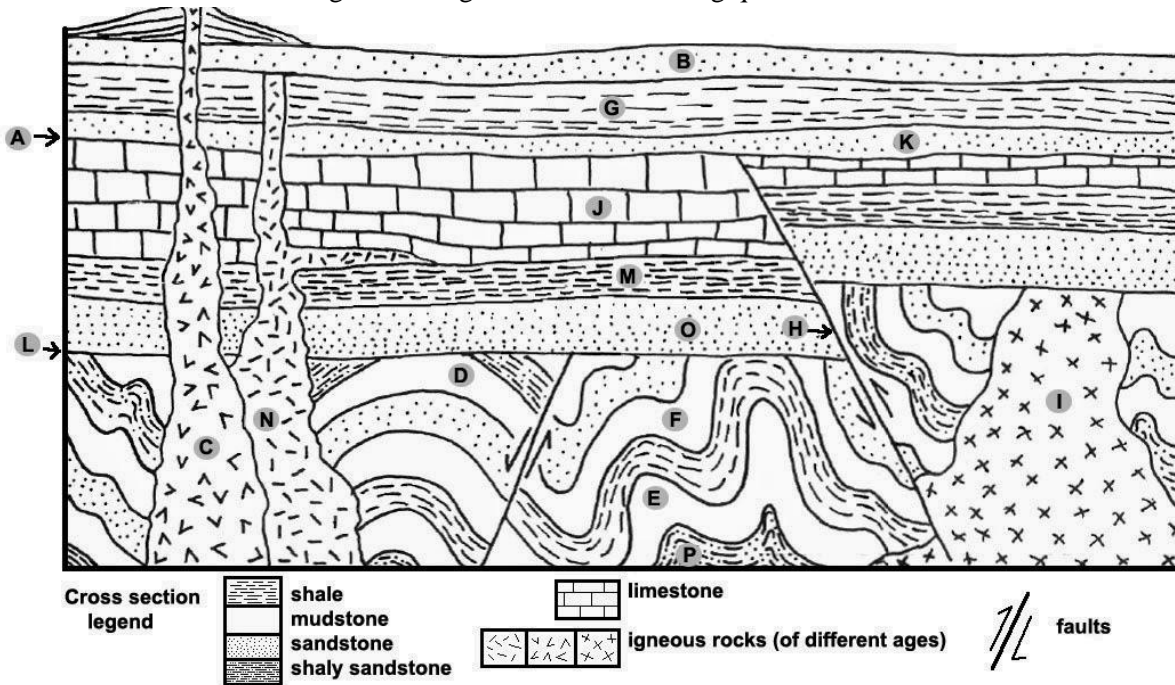


c. Consider Mt. St. Helens and Hawaii. Compare/contrast the magma properties.

	Mt. St. Helens	Hawaiian Chain
Composition		
Viscosity		
Cooling temperature		
Eruptive style		
Geologic setting		

d. If there is no plate boundary at Hawaii, explain how a volcano can still form.

7. Refer to the following block diagram for the following question.



a. Using the laws of original horizontality, superposition, and cross-cutting relationships interpret the order of the formation of the features in this cross section (oldest to youngest)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.
- 13.
- 14.
- 15.
- 16.

8. Considering the following: An ice sheet is imposed on a continental block, causing the continent to sink. Assuming the two are in isostatic equilibrium, it is possible for one to calculate the thickness of the ice sheet given the value of total isostatic rebound. The buoyancy pressure on the continental block equals the pressure that is imposed by the ice sheet. For the following problems, assume that the density of the ice sheet is always  $1000 \text{ kg/m}^3$  and that the density of the asthenosphere is  $3300 \text{ kg/m}^3$
- Calculate the displacement of the asthenosphere when the ice sheet has a thickness of 3.3 kilometers.
  - Calculate the thickness of the ice sheet when the displacement of the asthenosphere is equal to 0.85 kilometers.
9. Considering the following questions about plate convergence.
- At an oceanic-continental convergent boundary, the oceanic plate typically sinks. Explain why subduction of the oceanic plate is favored.
  - Is it possible that a geologic process, other than subduction, can occur at this type of convergent boundary?
  - If so, what is this process's effect on the convergent boundary?
10. Consider the different types of tectonic basins, and answer the following questions.
- Where are rift basins typically located?
  - What can be inferred from studying rift basins?
  - What geologic basins are associated with back arc basins?

d. Describe the formation of foreland basins.

e. Where are forearc basin regions typically located?

11. The Wilson Cycle describes the overall cycle of the rifting, drifting, and colliding of tectonic plates. In the spaces provided, number each event in order of their occurrence.

\_\_\_\_\_ An ocean basin is formed between the two continents.

\_\_\_\_\_ Most of the ocean basin has subducted.

\_\_\_\_\_ A stable continental craton exists. A hotspot rises up under the craton, causing it to split.

\_\_\_\_\_ In the subduction zone, magma is generated and rises to the surface, forming volcanoes that later build into a mountain range

\_\_\_\_\_ A subduction zone forms somewhere within the ocean basin.

\_\_\_\_\_ The mountains begin to erode, and the foreland continent returns to Earth's surface.

\_\_\_\_\_ A new divergent plate boundary is created.

\_\_\_\_\_ The two continents collide.

\_\_\_\_\_ As the ocean basin widens, the divergent continental margins begin to cool and sink below sea level

12. Answer the following questions concerning Earth's orogenic belts.

a. Define orogeny.

b. Give at least five examples of the processes that occur during orogeny.

c. Which orogenic belt is considered to be the most dramatic?

13. Match each scientist to his or her contribution to the field of geology.

- |                       |                       |                         |                   |
|-----------------------|-----------------------|-------------------------|-------------------|
| a. Abraham Ortelius   | b. Alfred Wegener     | c. Arthur Holmes        | d. Hugo Benioff   |
| e. Alexander du Troit | f. Sir Edward Bullard | g. Milutin Milankovitch | h. J. Tuzo Wilson |
| i. Ingo Lehmann       | j. James Hutton       | k. Nicolas Steno        | l. Charles Lyell  |
| m. William MacLure    | n. Harry Hess         |                         |                   |
- 

- \_\_\_\_\_ Studied mid-ocean ridges and concluded that seafloor spreading continually adds new material to the ocean floor
- \_\_\_\_\_ Credited with calculating eccentricity, precession, and obliquity
- \_\_\_\_\_ First noted the close fit of the shorelines of the Americas with those of Africa and Europe
- \_\_\_\_\_ Demonstrated that a better fit between the continents could be made if the continental shelf/slope boundary at a water depth of 1000 meters was used instead of the coastlines of the continents
- \_\_\_\_\_ Discovered the outer core by studying seismograms from earthquakes in New Zealand; observed that the seismic waves reflected off the boundary of the inner core
- \_\_\_\_\_ Proposed that plates might move over fixed “hotspots” in the mantle, forming volcanic island chains like Hawaii
- \_\_\_\_\_ Proposed the theory of uniformitarianism
- \_\_\_\_\_ Portrayed the breakup of Pangaea and the movement of the continents to their present positions in his book *The Origins of Continents and Oceans*
- \_\_\_\_\_ Considered the “Father of American Geology” for making the earliest geologic map of the United States
- \_\_\_\_\_ First suggested that thermal convection currents in the mantle are the force moving the continents
- \_\_\_\_\_ Author of *Principles of Geology*, which caused controversy during the science v. religion debate of the 1800s
- \_\_\_\_\_ Plotted the location of deep earthquakes around the Pacific Ocean, which revealed they were concentrated along well-defined lines (subduction zones)
- \_\_\_\_\_ Theorized that there were two great landmasses called Laurasia and Gondwana
- \_\_\_\_\_ Studied the formation of rock layers/strata and published his findings in his book *Prodromus*