USESO 2022

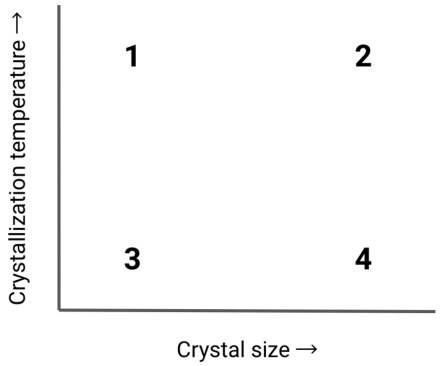
Open Exam

Section I

Instructions:

- Section I consists of 30 multiple choice questions. Each question is worth 2 points.
- Questions are **not** ordered by difficulty.

1. A petrologist infers that a rock cooled very quickly from a silica-rich melt. A rock represented by which labeled region(s) of the graph would be consistent with this inference?



   A. 1 only

   B. 2 only

   C. 3 only

   D. 4 only

   E. Either 3 or 4

2. Earth's early atmosphere, often referred to as its primary atmosphere, was largely produced by the outgassing of magma. How did the formation of oceans most significantly change the composition of this atmosphere?

   A. Increase in nitrogen

   B. Increase in oxygen

   C. Decrease in carbon dioxide

   D. Decrease in argon

3. Flow between ocean basins, or interbasin transport, can have significant effects on the global ocean circulation. On average, interbasin transport brings freshwater *into* the Atlantic basin. If the magnitudes of freshwater flux from precipitation, evaporation, and runoff into the Atlantic are denoted P, E, and R respectively, which of the following must be true?

   A. $P - R = E$

   B. $P + R = E$

   C. $P - E + R > 0$

   D. $P - E + R < 0$

   E. $P + E - R < 0$

4. Although surface conditions on Venus are very different from those on Earth, aeolian features have also been observed on Venus's surface. However, some recent research indicates that aeolian features may be less common on Venus due to a lack of sediment. Which of the following *incorrectly* explains why this discrepancy may exist?

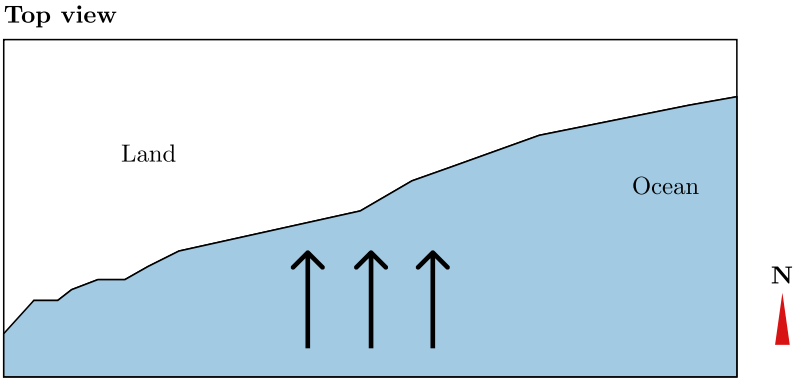
   A. Venus's thick atmosphere prevents meteorites from forming surface sediment.

   B. Venus's dense atmosphere slows winds, preventing sediment transport.

   C. Venus has no liquid water or ice on its surface to erode rock.

   D. Venus has no plate tectonics to promote erosion.

5. The following image shows a map of a coastal region in the Northern Hemisphere with wind blowing over the ocean towards land. Which of the following best describes what will happen to water at the surface and at depth, respectively?



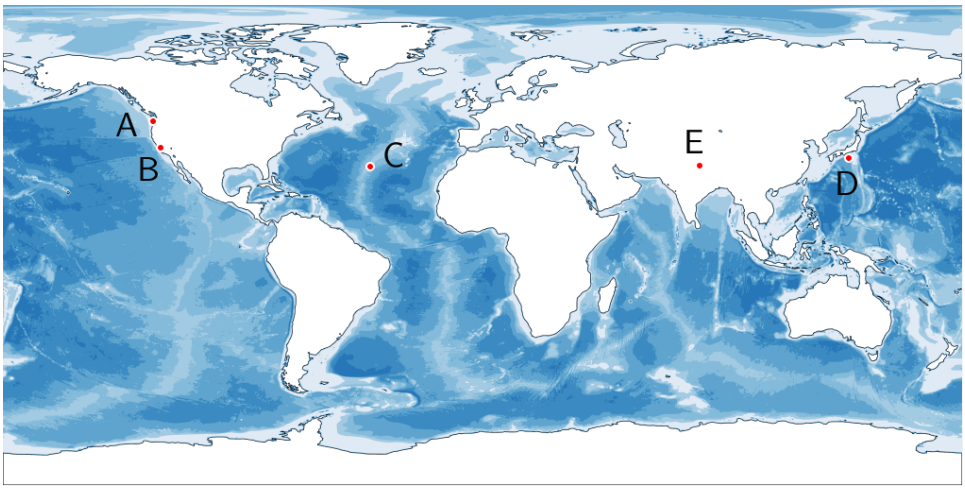
A. Moves parallel to the coast; upwelling

B. Moves parallel to the coast; downwelling

C. Moves away from the coast; upwelling

D. Moves away from the coast; downwelling

6. Earthquakes with a hypocenter depth greater than 300 km are known as deep-focus earthquakes. Which of the locations on the bathymetric map below has the greatest concentration of deep-focus earthquakes?



A. A

B. B

C. C

D. D

E. E

7. A ridge on an upper-air map would dissipate most quickly if directly underlain on the surface by a:

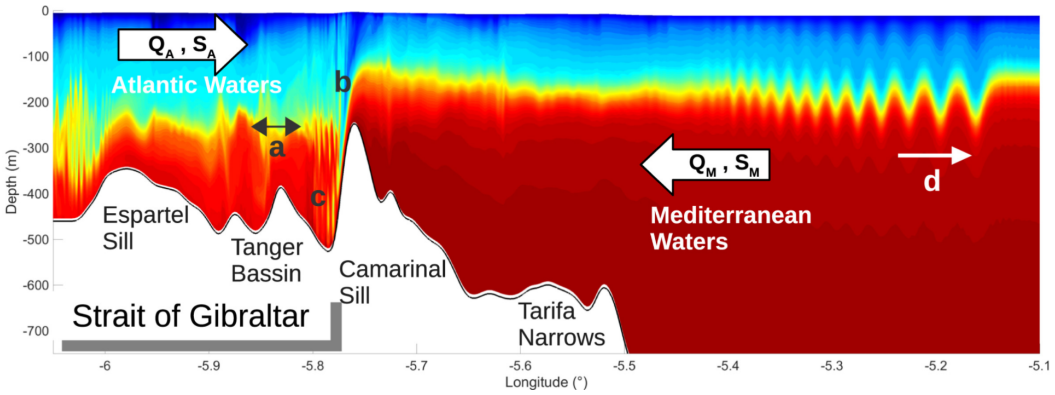
   A. High-pressure region

   B. Low-pressure region

   C. Ridge

   D. Trough

8. Shown is a modeled density profile of the region around the mouth of the Mediterranean Sea (left - Atlantic; right - Mediterranean). On the Mediterranean side of the Strait of Gibraltar, internal waves are periodically generated and observable from satellites.



Select all of the following that are true.

I) The Camarinal Sill likely generates most of the eastward propagating internal waves.

II) Internal waves are more prominent on the Mediterranean side due to a strong halocline.

III) Westward-propagating internal waves become more observable in the Atlantic when a strong thermocline is present.

   A. I only

   B. II only

   C. I and II

   D. I and III

   E. I, II, and III

9. Katabatic winds are strong downslope flows that dominate the Antarctic surface wind field for much of the year. Which of the following statements are true?

I) Coastal katabatic winds are typically strongest during austral (southern) winter

II) Katabatic winds are approximately in geostrophic balance

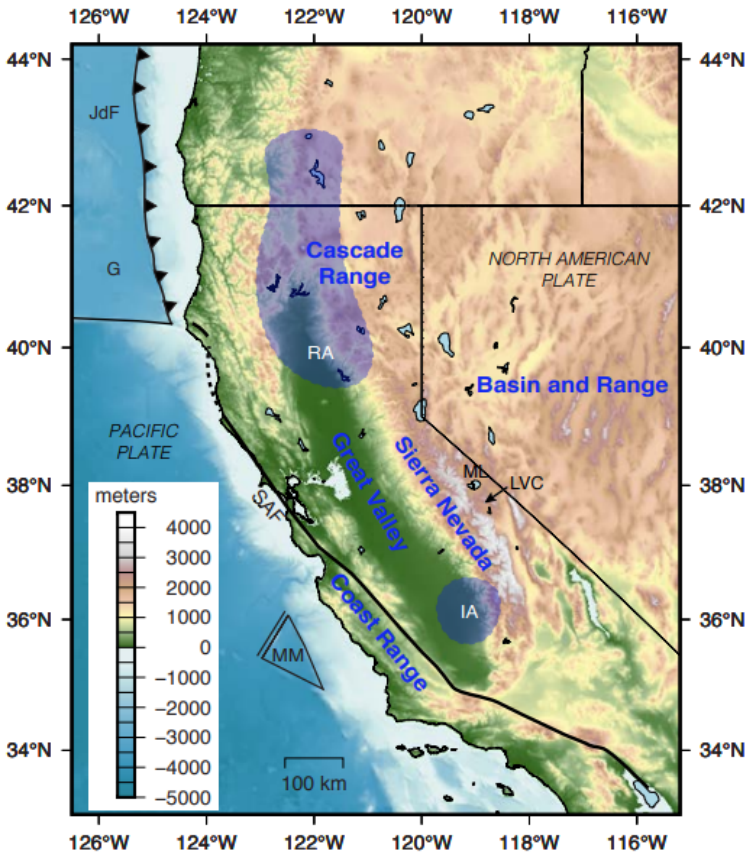
   A. I only

   B. II only

   C. I and II

   D. None

10. The Isabella anomaly (IA) is an upper-mantle, high-speed P wave anomaly within California's southern Great Valley and the foothills of the Sierra Nevada. It is hypothesized to be either the sinking mafic root of the southern Sierra Nevada batholith or a fossil slab that is a continuation of the Monterey microplate translated beneath the Great Valley. Which of the following options are true *and* would support the second theory?



I) The Isabella anomaly consists of relatively soft, hot material.

II) The crust between the eastern portion of the mountains is thin.

A. I only

B. II only

C. I and II

D. None

11. Historical sunspot observations are one of the oldest and most continuous records in the earth and space sciences. Sunspot minima, during which few sunspots are counted, are associated with what climatic effect?

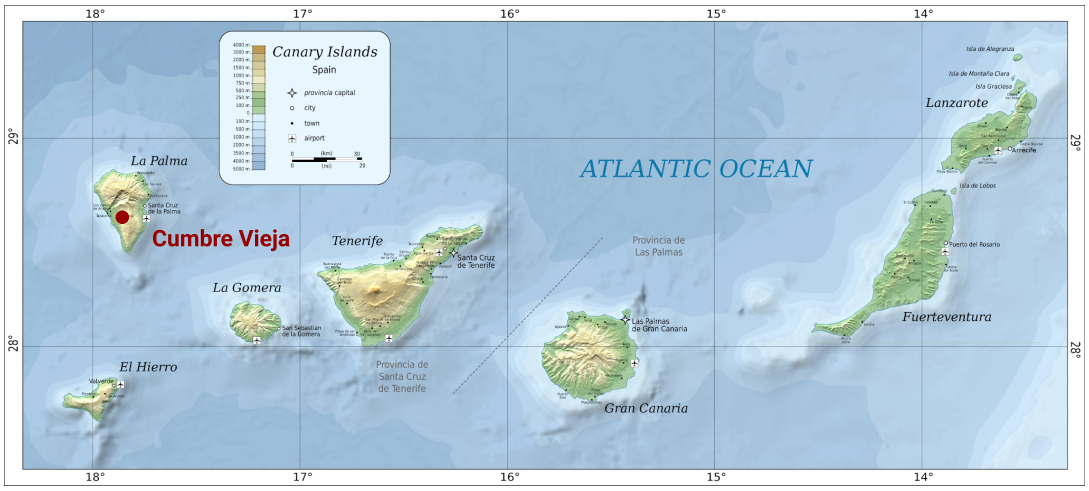
A. Warmer temperatures only in the northern hemisphere

B. Cooler temperatures only in the northern hemisphere

C. Warmer temperatures in both hemispheres

D. Cooler temperatures in both hemispheres

12. The accompanying map is of the Canary Islands off the coast of Africa with the Cumbre Vieja volcano labeled. This volcano erupted over several months in 2021, forcing thousands to evacuate.



Identify all of the following statements that are likely true of Cumbre Vieja:

I) The Canary Islands are located on a plate boundary.

II) Only the western islands in the chain are volcanically active.

III) The 2021 eruption involved andesitic magma.

A. I only

B. II only

C. III only

D. I and III

E. None

13. The complexity of silicate structures (e.g., complex network silicates to simple isolated tetrahedra) can influence the bulk properties of rock made from those silicate minerals. Which of the following trends is associated with increasing silicate complexity?

I) Increasing melting point

II) Increasing viscosity of magma

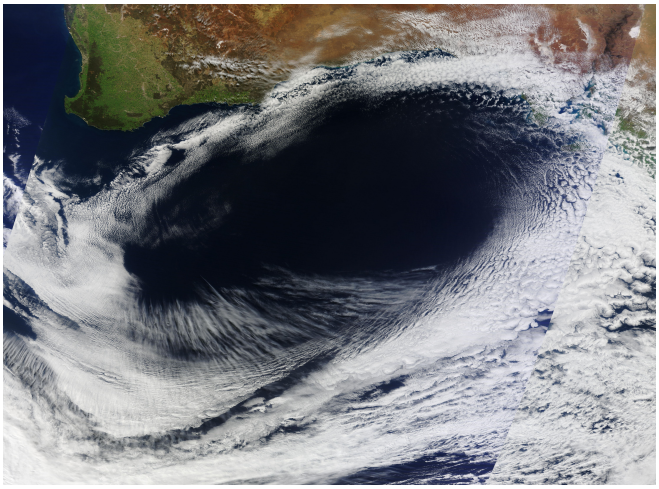
A. I only

B. II only

C. I and II

D. None

14. The following image shows an unusual weather system off the southern coast of Australia.



Identify all of the following statements that are likely true of this weather system:

I) The system rotates counterclockwise at the surface.

II) A 500 mbar isobaric map would show this region as high pressure.

III) The lack of clouds in the center is due to adiabatic cooling.

A. I only

B. II only

C. III only

D. I and II

E. I and III

Refer to the following for questions 15–16: Marine ice sheet instability refers to a positive feedback loop that amplifies ice mass loss. It involves ice flow over the grounding line, which marks the interface between the ice sheet, bedrock, and ocean.

15. Which of the following best describes how a landward shift in the grounding line would change ice flux (the volumetric rate of ice flow) over it?

A. Increased ice flux, since the ice sheet generally thickens landward.

B. Decreased ice flux, since the ice sheet generally thickens landward.

C. Increased ice flux, since the ice sheet generally thins landward.

D. Decreased ice flux, since the ice sheet generally thins landward.

16. Does a landward shift of the grounding line favor or work against this positive feedback loop?

A. Favors

B. Works against

C. Neither for or against

17. Kirkwood gaps in the asteroid belt are cleared by orbital resonances with Jupiter. Given that Jupiter is on average 5.20 AU from the sun, at which of the following distances would we be most likely to find a Kirkwood gap?

    A. 1.73 AU

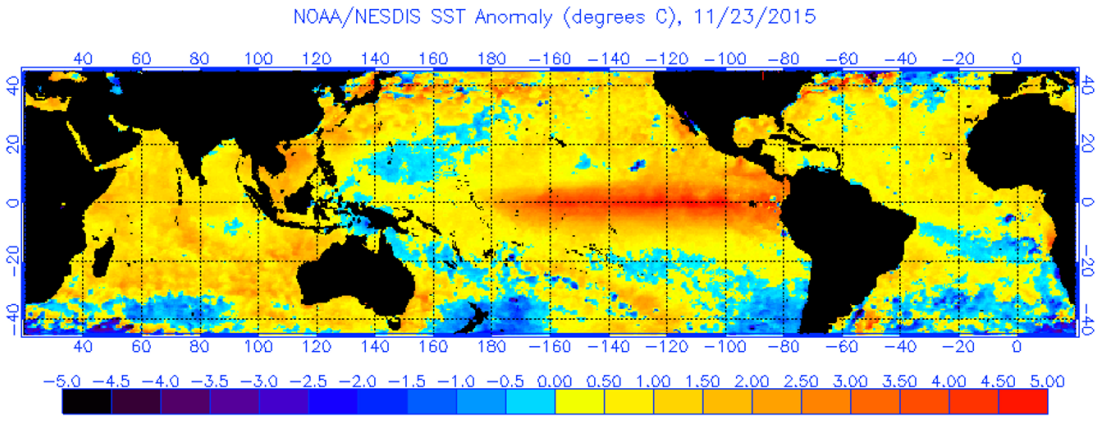
    B. 2.50 AU

    C. 2.60 AU

    D. 2.88 AU

    E. 3.46 AU

18. Consider the sea surface temperature anomaly map given.



    During this time, a high surface air pressure anomaly is expected to be found in the _____ Pacific, and easterly trade winds are _____.

    A. Western; weaker

    B. Western; stronger

    C. Eastern; weaker

    D. Eastern; stronger

19. A sandstone enthusiast has an extensive collection of sandstones from all over the world, and decides to plot feldspar content against the range of grain size for each rock. One would expect to find:

    A. A positive correlation

    B. A negative correlation

    C. No significant correlation; negligible change in one variable

    D. No significant correlation; points scattered randomly

20. Alice Springs (latitude 24°S, longitude 134°E) is located in central Australia. Based on its location, which of the following can be reasonably inferred about the climate in Alice Springs?

    I) Daily temperature ranges are greater in Alice Springs than in coastal locations of Australia.

    II) June is typically wetter than December due to seasonal shifts in global winds.

    III) The prevailing wind direction is southwest.

A. I only

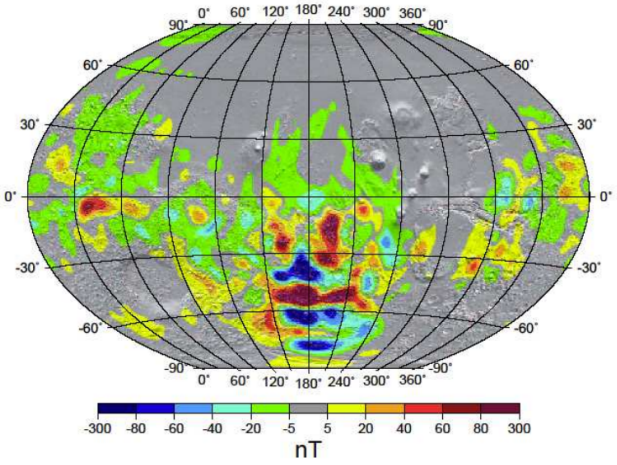
B. III only

C. I and II

D. I and III

E. II and III

21. Though Mars does not currently generate a magnetic field, parts of its crust are magnetized. The map shows the remanent magnetization present on Mars's surface.



Which of the following does the map suggest?

I) The lack of magnetization in impact basins is attributed to large impacts and thermal events erasing preexisting remanent magnetization.

II) The northern lowlands are thought to have experienced sedimentary or volcanic resurfacing.

A. I only

B. II only

C. I and II

D. None

22. Which of the following statements about lake temperature are true?

I) A temperate lake is typically most stratified during summer months.

II) In winter, a dimictic lake is approximately isothermal and isopycnal.

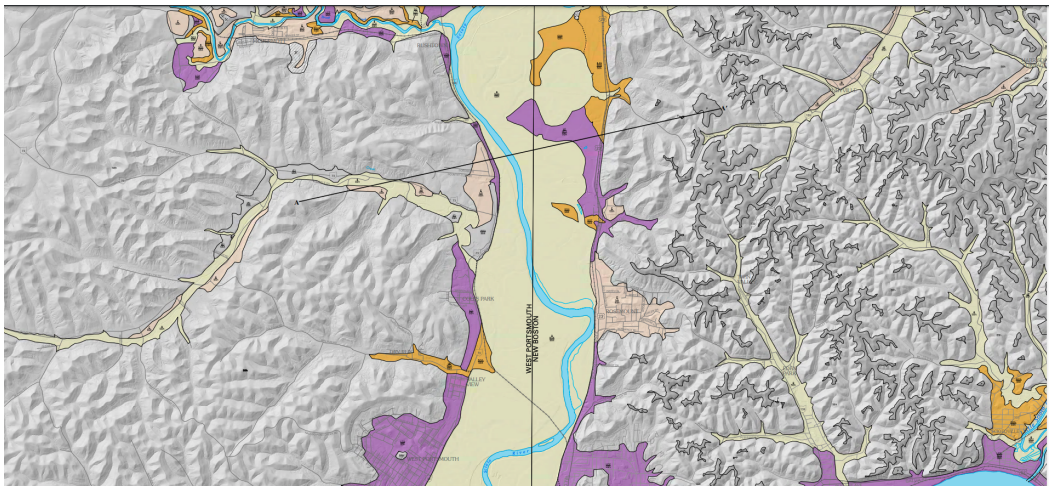
A. I only

B. II only

C. I and II

D. None

23. Based on the geologic map shown, if large-scale glaciation occurred, which of the following would most likely happen?



A. Increased deposition, hydrological cycle would slow down due to more water being in glaciers.

B. Nickpoint created, forming a waterfall due to a layer of hard, durable rock.

C. Lakes form and the river would have more meanders in order to adjust to the change in base level.

D. River starts downcutting, which could lead to the meanders becoming incised.

24. Although the fractions of silicon isotopes in diatoms is based on temperature, silica isotopic ratios are not as useful as oxygen isotopic ratios for paleoclimate proxies. Which of the following may explain this difference? (The atomic weight of Si is 28.086 and its major isotopes are ^{28}Si, ^{29}Si, ^{30}Si.)

I) Isotopes other than ^{28}Si are too rare to be useful.

II) There are varied sources of Si, which decreases the constraints Si isotopes can provide as a paleoclimate proxy, while the atmosphere provides a well-mixed, dominant source of oxygen in oxygen isotope proxies.

III) Biogenic silica is mainly precipitated from diatom tests while oxygen isotope data may also use the tests of calcareous forams.

A. I, II, and III

B. I and II

C. II and III

D. I and III

E. II only

25. Jill digs a core and finds this order of rocks, from bottom to top: sandstone, shale, limestone, shale, sandstone. Why might this be the case?

A. The sequence was formed between two interglacial periods separated by a glacial period.

B. The sequence was formed between two glacial periods separated by an interglacial period.

C. The sequence was formed during the transition from a glacial to an interglacial period.

D. The sequence was formed during the transition from an interglacial to a glacial period.

26. Which of these statements are true regarding winds and tropical cyclones (TCs)?

I) Most TCs originate near the equator due to low pressure created by converging surface trade winds.

II) Weak winds aloft and at the surface favor TC formation with all other favorable conditions present.

III) Minimum central pressure more reliably predicts maximum TC wind speed than the pressure gradient within the eyewall.

A. I only

B. II only

C. III only

D. I and II

E. II and III

27. Jerry found a meteorite that he identifies to be an iron meteorite due to its high density and metallic luster once cut open. Which of the following would NOT be expected of this iron meteorite?

I) It contains many vesicles and vugs.

II) There are shallow indentations on unweathered surfaces indicative of ablation.

III) The meteorite is nonmagnetic due to a thick fusion crust.

A. I only

B. III only

C. I, II, and III

D. I and II

E. I and III

28. A planet's equilibrium temperature is the temperature that it would have if it were a blackbody radiating away all incident energy absorbed from its parent star. Earth's equilibrium temperature is about 255 K (about -18 °C), but average global surface air temperature (GSAT) is about 290 K (about 12 °C). What primarily accounts for this discrepancy?

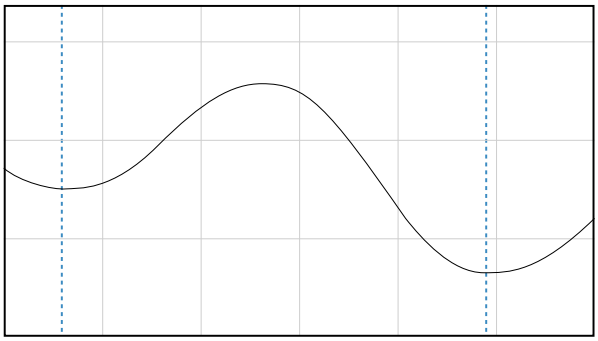
A. Equilibrium temperature fails to account for the Earth's albedo.

B. Greenhouse gases re-radiate outgoing radiation back to the surface.

C. The average global ground temperature, unlike average GSAT, is much closer to the equilibrium temperature.

D. Earth also receives energy from other stars outside of the solar system.

29. A harbor experiences a mixed semidiurnal tide, shown below. Two low tides are marked with dashed lines.



If the first low tide occurs on Tuesday at 1:50 PM, at what time does the second low tide occur?

A. Wednesday at 1:50 AM

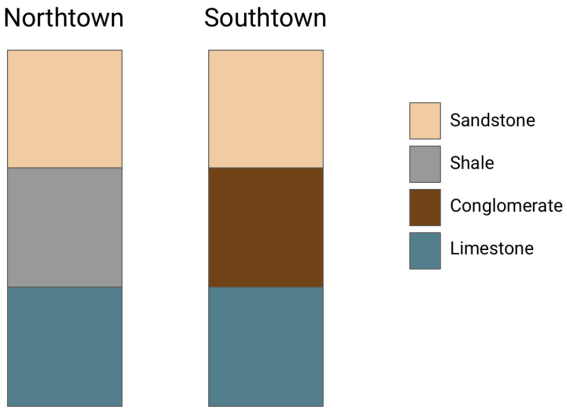
B. Wednesday at 2:15 AM

C. Wednesday at 1:50 PM

D. Wednesday at 2:15 PM

E. Wednesday at 2:40 PM

30. Shown below are stratigraphic columns for the coastal towns Northtown and Southtown. Assume they are the same distance from the coast.



Which of these can be inferred from the columns above?

I) In both columns, groundwater in sandstone is less saline than groundwater in limestone.

II) The column at Northtown contains a confined aquifer.

III) The column at Southtown contains a confined aquifer.

A. II

B. III

C. I and II

D. I and III

E. II and III