

# IESO 2016

# WRITTEN TEST No 1

## Theme

### Earth System: Some cyclic events and interactions

Please follow the instructions while answering the questions. The different sets of questions, linked by sentences in boxes, are independent ; but the whole theme follows a general guide-line.

Analysing and using the documents are a primary requirement to understand the questions. Of course, you need to use what you know to analyse those documents!

Circle the questions will be as follows unless otherwise stated :

- *Questions with only one correct answer:* 1 point (= mark) for the correct answer; zero point for a wrong answer.
- *Questions with many correct answers:* 1 point (= mark) for each correct answer; (minus) – 0.5 for each wrong answer; no question will be marked less than 0 even if the number of wrong answers exceeds the number of correct answers. There is always at least one wrong answer. So, even if you choose ALL the given answers, 0 will be applied.
- Some questions may have a specific way of marking.

Geological processes permanently transfer material from one place to another, at the surface of the earth, or vertically from surface to depth in the geosphere... and *vice versa*. Some transformations may occur during those transfers, involving different spheres: hydrosphere, atmosphere, geosphere and biosphere. We shall now study SOME of those transfers starting at a local scale.



**Photo 1**

G = granite / S = sand on the beach, or between the boulders P : see photo page 3 - white arrow : joints



**Photo 2**

Photo 3 – Detail of the joints pointed by the white arrows in photo 1.



These photos were taken at the seaside, **45° latitude**, by the Atlantic Ocean. In both cases, the rocks are granites, although they look slightly different. The granites have been subjected to weathering and erosion which we are going to study. Use the documents and your knowledge to answer the questions.

Table 1 : Mineralogical composition of the granites and of the material that can be found between the rocks as seen in photo 2.

	<b>Granite (%)</b>	<b>Material found between the rocks (%)</b>
quartz	36	43
feldspar	25	19
muscovite	3	4
biotite	3	4
Clay (kaolinite)	-	11
Other minerals	32	17
water	1	2
<b>Total</b>	<b>100%</b>	<b>100%</b>

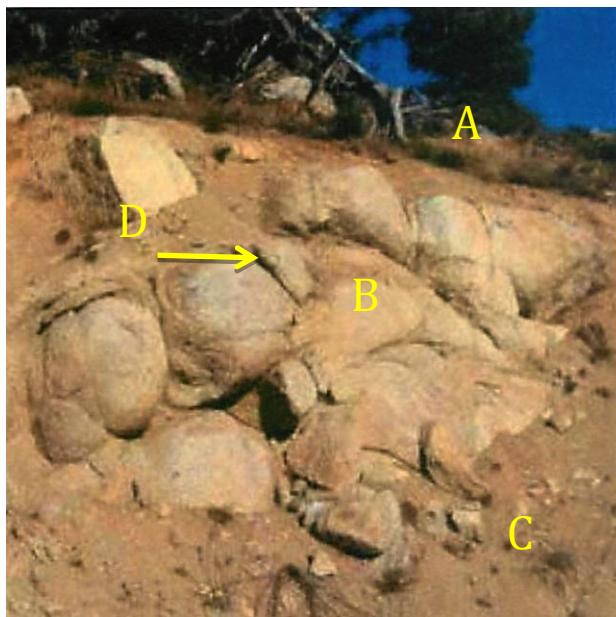
**1) Choose the correct statements using your knowledge and the documents (several possible answers):**

- a) Feldspar is more resistant to chemical weathering than quartz.
- b) Quartz is more resistant to chemical weathering than feldspar.
- c) The clay (kaolinite) may have come from the chemical weathering of the quartz contained in granites.
- d) The clay (kaolinite) may have come from the chemical weathering of the feldspar contained in granites.

The intensity of weathering is related with some conditions linked with climate or the rock's properties.

**2) Choose ALL correct statements (*several possible answers*).**

- a) The climate here is favorable for weathering because it is warm most of the year.
- b) The climate here is favorable for weathering because the place is probably quite rainy.
- c) The joints (white arrows) are a result of the volume change of granite due to the decrease of pressure and temperature as they were brought to the surface.
- d) The orientation of the joints (white arrows) is a clue that they are linked with tectonic faulting.
- e) These joints are an important contact surface between rock and water, which makes weathering easier.



This photograph is taken at place P shown on Photo 1.



A zoom in of zone D

**3) Which of the four zones in the photo above represents granite (*only one answer*)?**

- a) Zone A
- b) Zone B
- c) Zone C
- d) Zone D

**4) Which of the four zones in the photo above presents sand after erosion (*only one answer*)?**

- a) Zone A
- b) Zone B
- c) Zone C
- d) Zone D

**5) Which of the four zones in the photo above presents soil (*only one answer*)?**

- a) Zone A
- b) Zone B
- c) Zone C
- d) Zone D

**6) Using all the preceeding informations and your knowledge, choose ALL the correct answers (The locations of photo 1 and photo 2 are specified simply as 1 and 2.) (*several possible answers*).**

- a) The erosion of granite seen in 2 is more intense than seen in photo 1.
- b) The boulders in 2 were probably transported from the sea.
- c) The boulders in 2 probably rolled down due to gravity after weathering only.
- d) The boulders in 2 probably rolled down by gravity after weathering AND erosion by water.
- e) Weathering was probably more intense or longer in 2 than in 1.
- g) The vegetation seen on the top of granites tends to protect the rock from erosion by preventing water from run off.
- h) The vegetation seen on the top of granites could tend to increase the erosion because its roots tend to widen the fractures, which will help in weathering.

Try to imagine the great quantity of material that must have been produced by the weathering of the big granite on photographs 2 (and 1). The material on the beach (S) is richer in quartz and has less feldspar than the material described in Table 1.

**7) Where has all the material resulting from granite weathering gone? Choose ALL THE LIKELY EXPLANATIONS (*several possible answers*).**

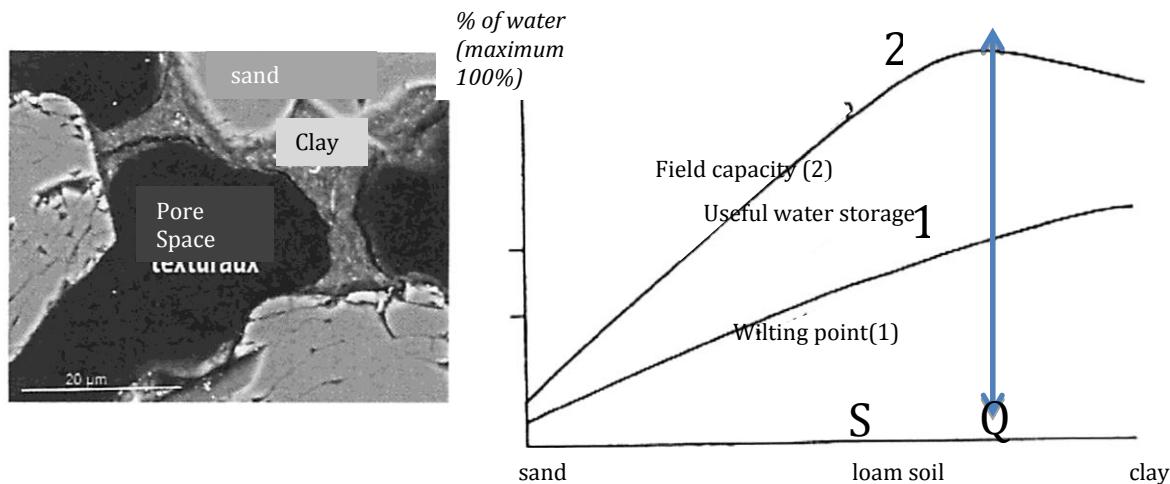
- a) All of the material stayed on the beach after the granite was weathered and eroded.
- b) Most of the material was taken away by the sea and may have been deposited elsewhere.
- c) Very little material is left because most of it is now dissolved in sea water.
- d) Some of the material may have been taken away for human activities.
- e) Most of the feldspar has been eroded by the sea; grains of quartz being heavier stayed on the beach.
- f) It is absolutely certain that all the material on the beach came from the granite nearby.
- g) Some of the material may have come from another granite, and may have been brought by the sea and deposited.

This outcrop itself has, of course, been subjected to interactions among geosphere/ atmosphere/ hydrosphere/ biosphere. Inside (5 cm below the surface ) the soil, inside a granite boulder, inside the sand layer, or in the weathering zones, which types of interactions have taken place and are important for the geological evolution of the site?

8) In the context of the geological evolution of the site, write Y (Yes) in the table below if there is an interaction with geosphere or N (No) if there is no interaction with geosphere. (1 point per line, only if THE WHOLE line is correct.)

	Atmosphere	Hydrosphere	Biosphere
Surface of outcrop	Y	Y	Y
Inside granite			
Inside zone of weathering			
Inside the sand layer			

In question 9, we will have a closer look at the soil and the interactions that take place there →



Graph: % of water on y axis; Constitution of the soil in terms of sand and clay contents on x axis. 100% sand on the left, 100 % clay on the right.

Photo: A microscopic view of a soil, with the constitution of S on the graph (pores texturaux: space between mineral grains in the structure of soil).

Graph: EAU = % of water; x = constitution of the soil in terms of sand (sable) and clay (Argile) contents. 100% sand on the left, 100 % clay on the right.

Curve 1 (wilting point): The % of water under which plants **cannot absorb** the water contained in the soil. (wilting = when a plant dries due to lack of water)

Curve 2 (field capacity): The % of water that is retained by soil after a heavy rain; the excess water is drained out of the soil and can not be stored.

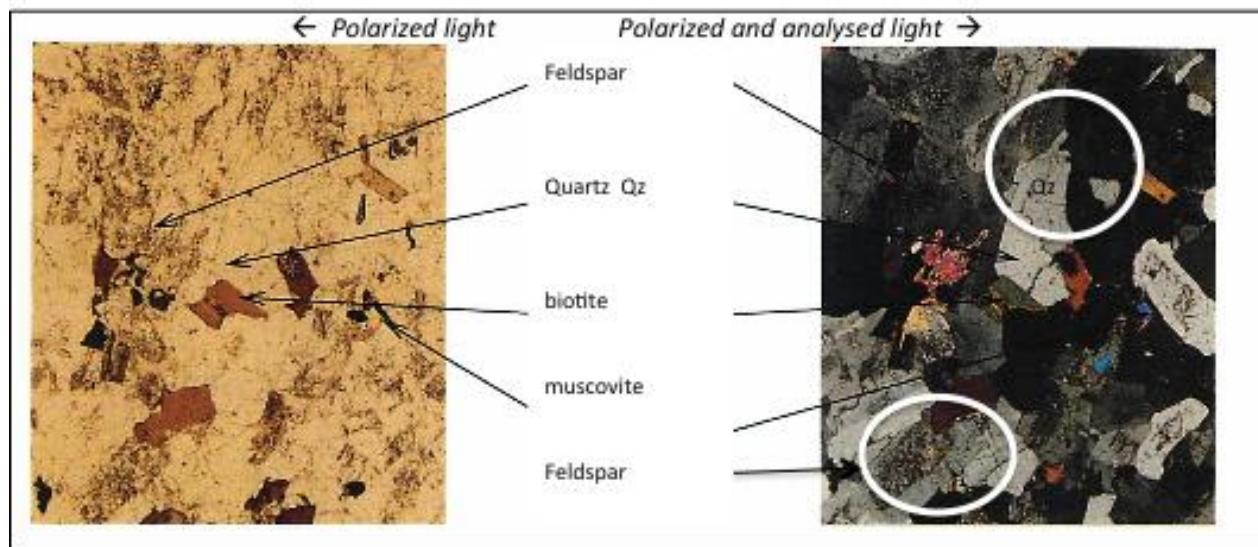
Useful water storage (Eau utile): The water stored underground, which can be used by plants.

Studying the relations among geosphere/hydrosphere/biosphere is a necessity for agronomists.

**9) Choose ALL THE CORRECT STATEMENTS by considering information from the documents and using your knowledge (several possible answers).**

- a) It seems reasonable to think that water stays in the pore spaces of soil and is retained mainly by strong interactions with sand particles.
- b) It seems reasonable to think that water stays in the pore spaces of soil and is mainly retained by strong interactions with clay particles.
- c) The highest proportion of clay (100%) offers the best condition for water availability for the vegetation.
- d) The highest proportion of sand (100%) offers the best condition of water availability for the vegetation.
- e) Water availability of a soil containing 100% clay can be improved by adding sand.
- f) A soil with sand and clay in the proportions shown by Q in the graph is the best for vegetation because it allows the maximum water quantity of about 30 % in the soil.
- g) The soil with sand and clay in the proportions shown by Q in the graph is the best for vegetation because it allows a water availability of about 15 % in the soil.
- h) Watering a field continuously as much as possible increases water availability and is a good choice.
- i) If the quantity of water in soil is above curve 1, watering a field is just a waste of water and does not benefit the vegetation.
- j) If the quantity of water in soil is above curve 2, watering a field is just a waste of water and does not benefit the vegetation.

*We will now study the process of weathering of the granite.*



**Photo 4: Thin section of a granite.** Names of the main minerals are indicated.

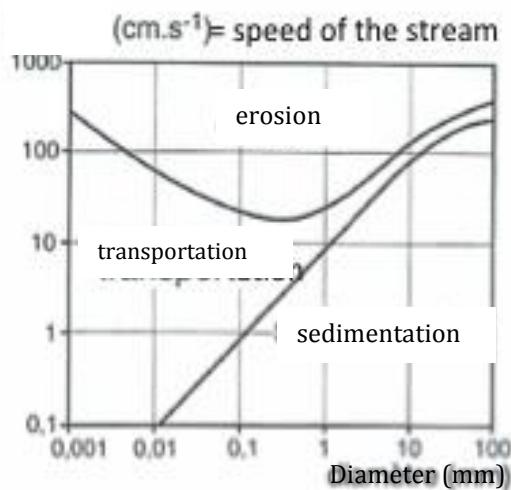
We shall now study the link between the conditions of crystallisation and the weathering of some of the minerals of granite. Quartz crystalises after Feldspar. The photo of the thin sections above provides clues to the order of alteration.

**10) Choose the CORRECT STATEMENT (just ONE answer):**

- a) Having crystallised at a higher temperature, quartz is more stable at the earth's surface, which explains why it is less easily weathered than feldspar.
- b) Having crystallised at a higher temperature, feldspar is more stable at the earth's surface, which explains why it is more easily weathered than quartz.
- c) Having crystallised at a higher temperature, quartz is less stable at the earth's surface, which explains why it is more easily weathered than feldspar.
- d) Having crystallised at a higher temperature, feldspar is less stable at the earth's surface, which explains why it is more easily weathered than quartz.

*After weathering comes erosion, transportation, deposition.....*

This experimental diagram gives the relationship among stream speed and the particle size or diameter and surface geological processes – Erosion, transportation and sedimentation/deposition. Size limit for clay particles is 0.02 mm.

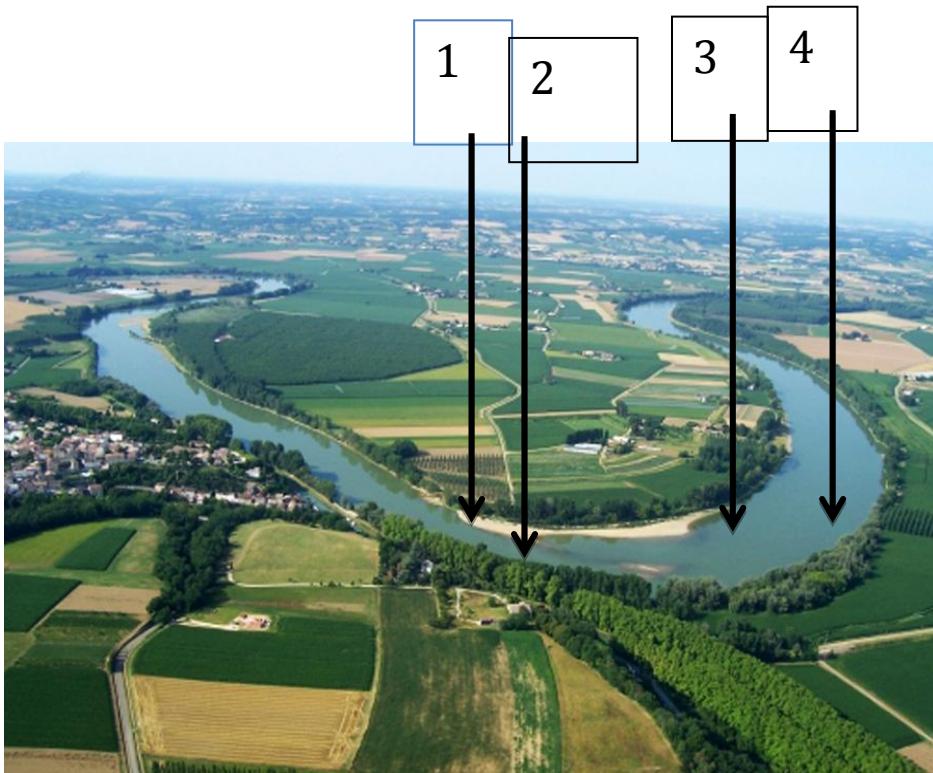


**11) Choose ALL THE CORRECT STATEMENTS (several possible answers):**

- a) A particle with a diameter of 1mm drops to the bottom of the river if the stream speed decreases to less than 1 cm per second.
- b) Considering that river carries particles of different sizes, the bigger ones are carried farther than the smaller ones as its speed decreases.
- c) A 0.1 mm particle has a wider range of speed for transportation than a 1 mm particle.
- d) As the diameter of a particle increases, it is more and more difficult to erode.

**12) Based on the diagram above, choose ALL THE CORRECT statements or possible explanations (several possible answers):**

- a) Clay particles with a diameter less than 0.01 mm would never be eroded.
- b) Clay particles with a diameter less than 0.01 mm would never get deposited.
- c) Clay particles with a diameter less than 0.01 mm are deposited when the stream speed is very low.
- d) Clay particles are so small that they form a stable solution in water.



The photograph above is of a meander of the River Lisos. Points 1 and 2 are on the river bank, and points 3 and 4 in the river.

**13) Choose the correct answer (just one answer):**

- a) The speed of the river is higher at point 3 than at point 4.
- b) The speed of the river is higher at point 4 than at point 3.
- c) The speed of the river is the same at point 3 and at point 4.

**14) Choose the correct answer (just one answer):**

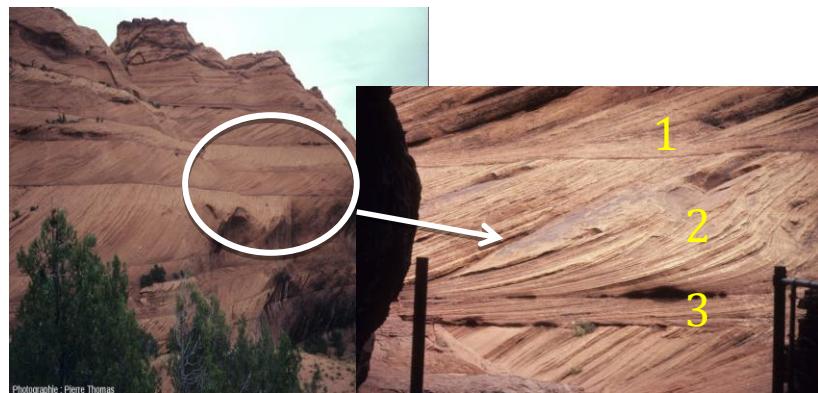
- a) The main geological process at point 1 is erosion.
- b) The main geological process at point 1 is transportation.
- c) The main geological process at point 1 is deposition.

**15) Choose the correct answer (just one answer):**

- a) The main geological process at point 2 is erosion.
- b) The main geological process at point 2 is transportation.
- c) The main geological process at point 2 is deposition.

*Learning from the present can help in understanding the past.... →*

The geologist who took pictures below of an outcrop claims that these layers come from wind transported sediments.



Outcrop

A zoom-in of the circled area

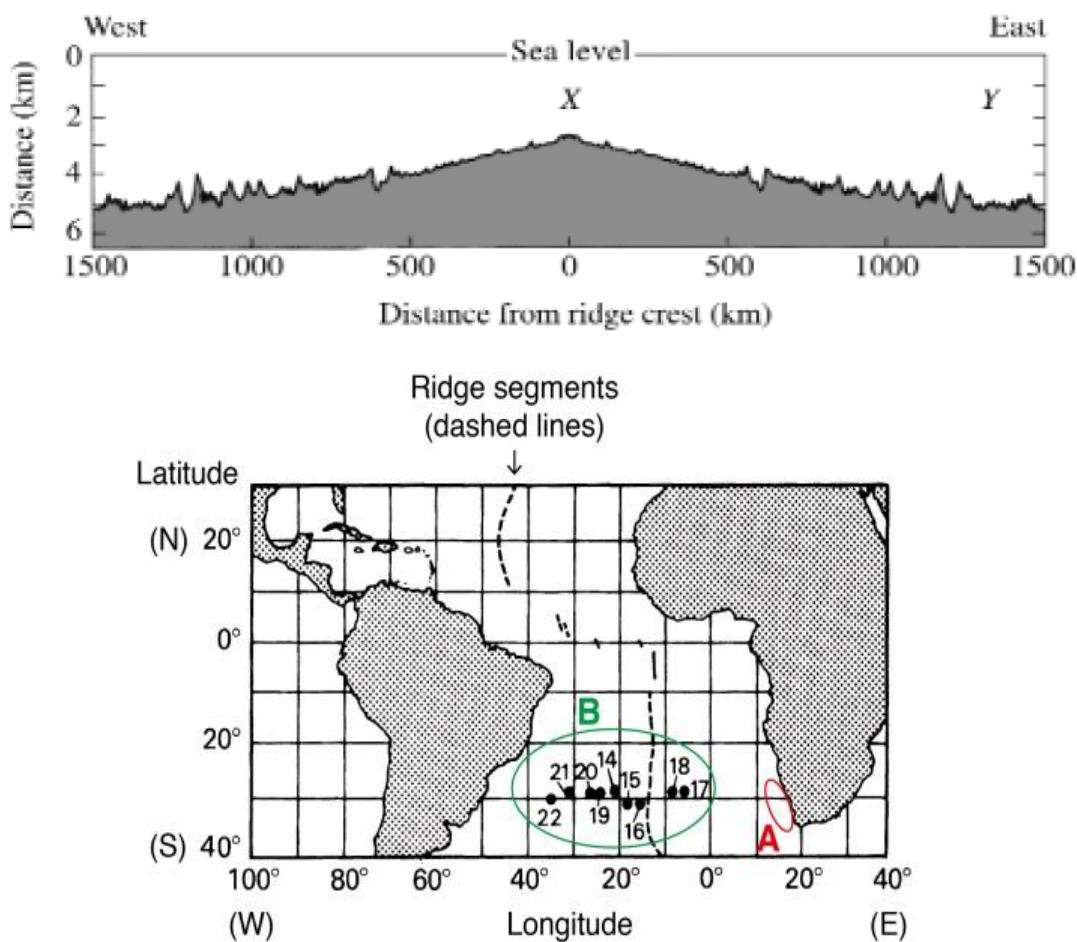
Scale: I-----I 20 cm (approximately)

**16) Assuming that the sediments are wind-deposited, which of the statements below are correct? (several possible answers)**

- a) The size of the grains is uniform.
- b) Each deposit could be the back side (downwind side) of a little dune; the wind would have blown from right to left.
- c) Each deposit could be the back side (downwind side) of a little dune; the wind would have blown from left to right.
- d) Wind deposits are never horizontal.
- e) The most reliable hypothesis to explain the horizontal lines in 1 and 3 marked areas is that they present the top of the fossil micro-dunes.
- f) The most reliable hypothesis to explain the horizontal lines (layers 1 and 3) is that from time to time, a strong wind would erode and level the dunes.
- g) The unconformity observed at 1 can only be related with tectonic events.

*Let us now leave the continents or the continental shelves to study transformation or exchange processes on a more global scale.*

The diagram below presents the relation between the depth of the oceanic crust and its distance from the oceanic ridge. In the map below, point 17 (Y) is deeper than point 16 (X).  
**Read questions 17 and 18 carefully to be sure you understand the difference between them.**



**17) Choose ALL THE EXPLANATIONS which can be considered logical (several possible answers):**

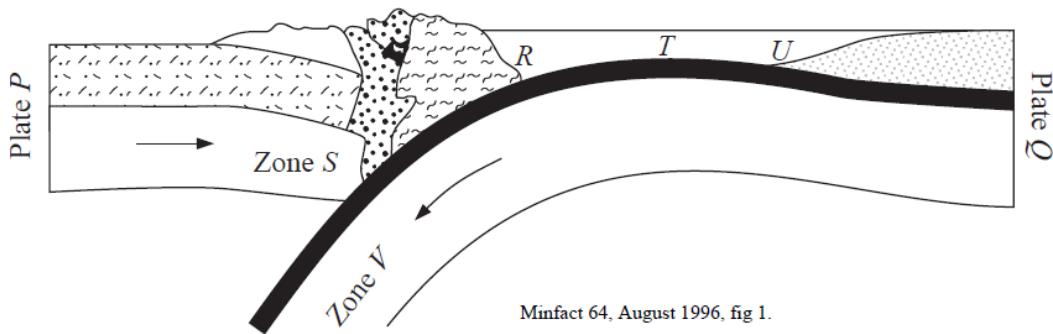
- a) Underwater currents erode the surface and thus increase the depth of the surface at Y more than at X.
- b) The thickness of the lithosphere decreases from X to Y as it cools and is not compensated by the addition of sediment.
- c) The density increases; so, it sinks progressively into the asthenosphere.
- d) The addition of sediments increases the weight and makes the plate sink into the asthenosphere.

**18) Among the explanations that you chose as logical, which is the MOST LOGICAL hypothesis ? (Use your knowledge of the geological processes) (Just ONE answer):**

- a) Underwater currents erode the surface and thus increase the depth of the surface at Y more than at X.
- b) The thickness of the lithosphere decreases from X to Y as it cools and is not compensated by the addition of sediment.
- c) The density increases; so, it sinks progressively into the asthenosphere.
- d) The addition of sediments increases the weight and makes the plate sink into the asthenosphere.

We shall now follow the tectonic plate in the subduction zones. Subduction zones are regions where a lot of exchange and transformation occur, mainly inside the geosphere, on a global scale.

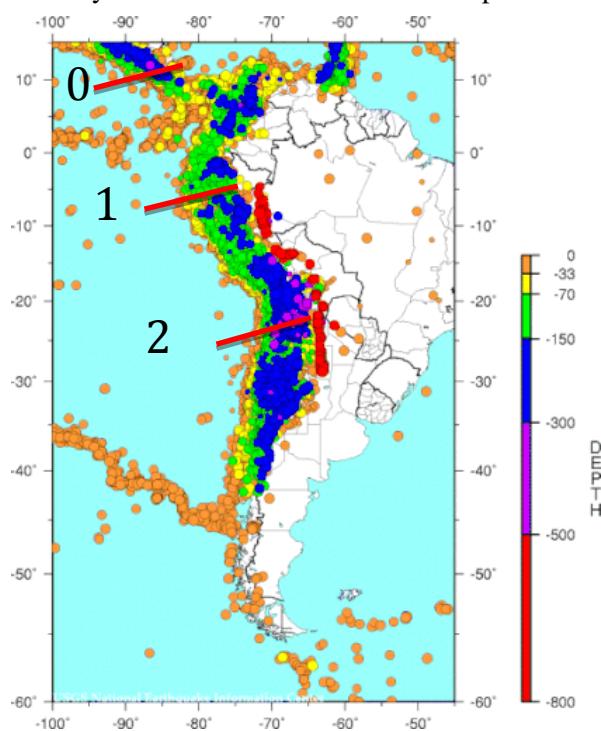
You have probably seen a drawing similar to the one given below in your textbook; but in this case, the author forgot to give the information about the meanings of the different letters.



**19) Knowing the characteristics of subduction zones, which of the following interpretations are correct (several possible answers) :**

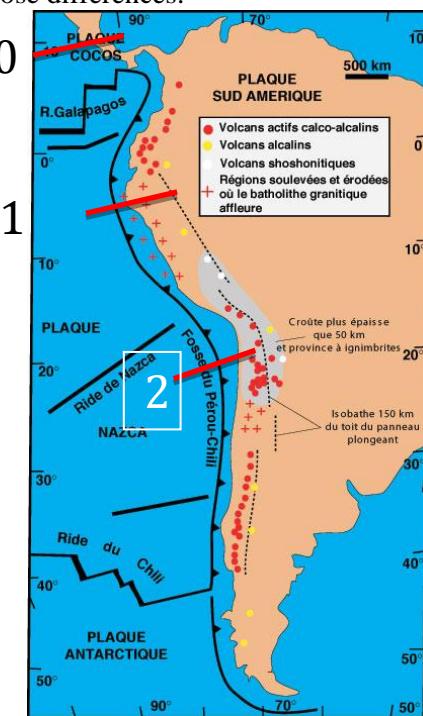
- P is an oceanic plate, Q is a continental plate, and an island arc is located below T.
- P is an oceanic plate; a subducting plate is located at Zone S, and a trench is located at U.
- Q is an oceanic plate, P is a continental plate, and a trench is located at R.
- Zone V is the subducting plate; a trench is located at R, and an island arc is located at T.
- The thick black line on top of plate Q probably represents oceanic lithosphere.
- The dotted /dashed layer above zone S, on top of plate P probably represents continental crust.
- Showing the lower part of plate P and plate Q in the same color (white) is certainly a mistake because they do not belong to the same layer of the globe.
- Showing the lower part of plate P and plate Q in the same color (white) is a good choice because it is considered to be “upper mantle”.

The western coast of South America is a subduction zone. The cordillera along this coast has zones with different characteristics; we will call them ‘type A zones’ (or Zone A) and ‘type B zones’ (or Zone B). We shall try to find some clues and some explanations for those differences.



#### MAP 1 Earthquake location

The color indicates the depth of the hypocenter



#### MAP 2 Red dots indicate volcanoes

Only the red dots in this map will be used and all other indications (crosses, yellow dots) will be ignored for reasons of simplicity

#### 20) Choose the correct answers using the information from maps 1 and 2 (several possible answers):

- The subducting plate dips at a greater angle along line 1.
- The subducting plate dips at a greater angle along line 2.
- Only zones with a high dip angle are associated with volcanism.
- Only zones with a low dip angle are associated with volcanism.
- Volcanism occurs irrespective of the subduction dip angle.

Schematic diagrams A and B below show two different types of subduction zones.

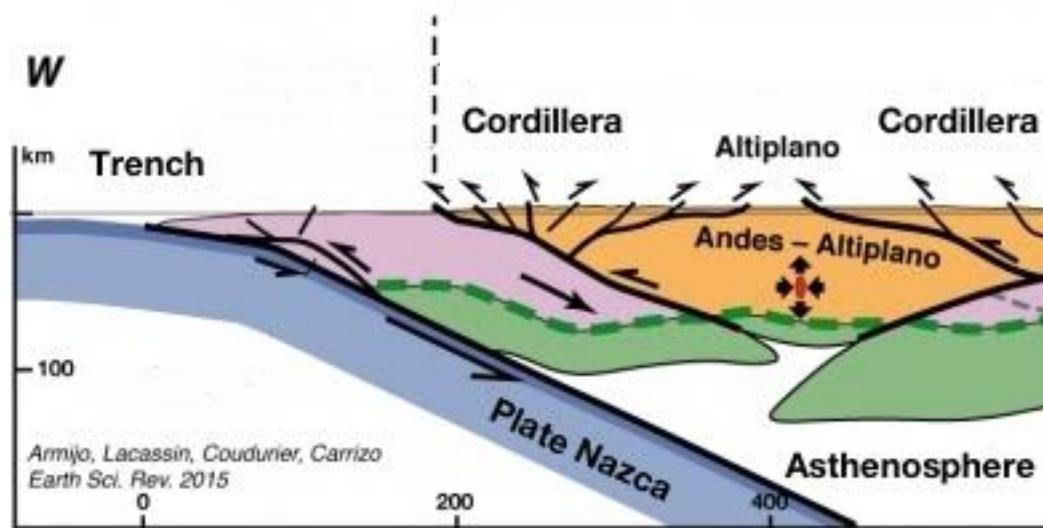


Diagram A : ‘Zone type A’

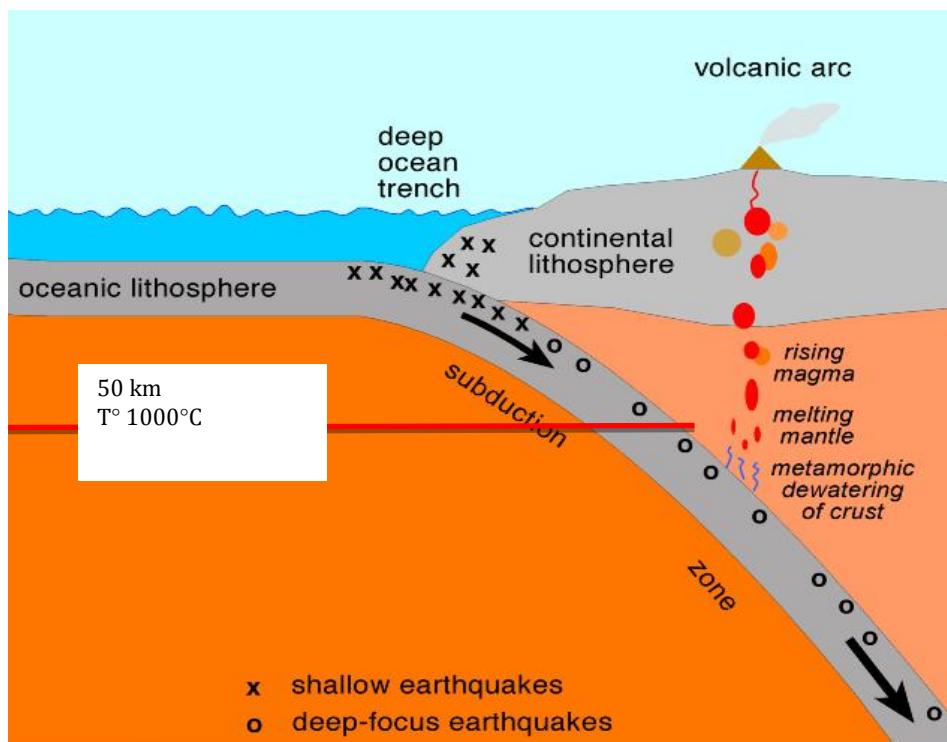
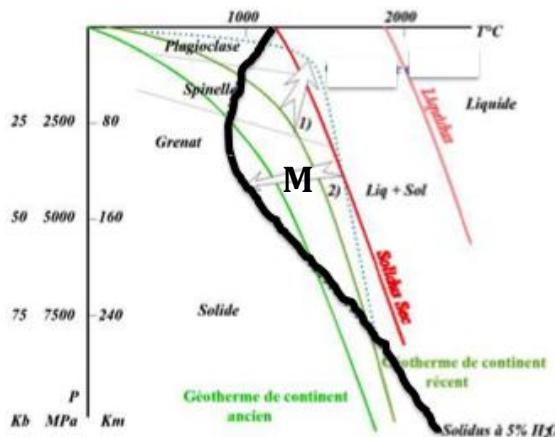


Diagram B: ‘Zone type B’ (total width = 200 km)



**Diagram C: Conditions of pressure (in terms of depth in km) and temperature ( $T^{\circ} \text{ C}$ ) for melting peridotite.**

- The red line (solidus) indicates the conditions where dry (waterless) peridotite starts melting.
- The black line (solidus at 5%  $H_2O$ ) indicates the conditions when slightly hydrated peridotite begins to melt.

Other indications in this diagram may be ignored for answering the questions.

**For questions 21, 22 and 23, choose the correct answers using the information from Diagrams A, B and C.**

**21) Which layer undergoes melting to produce magma?** Circle all hypotheses that **should be DISCARDED** (i.e., Circle the wrong answers) (*several possible answers*).

- Magma is generated mainly from the melting of the mantle.
- Magma comes mainly from the melting of the lower crust of the subducting plate.
- Magma comes mainly from the melting of the sedimentary upper layer of the subducting plate when it warms up in the subduction zone.

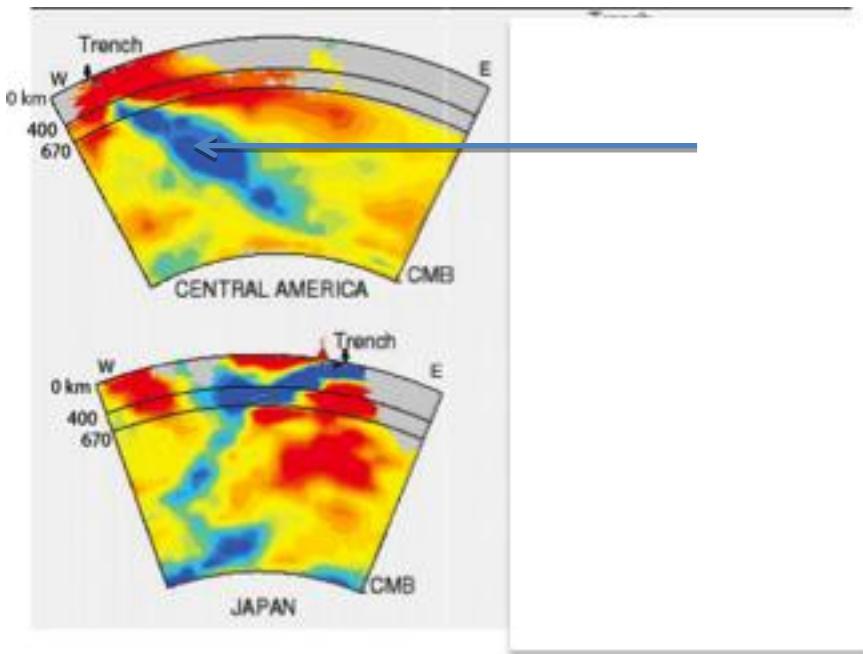
**22) Circle ONE hypothesis about the influence of metamorphism on magma production that cannot be proved to be wrong and requires more study.**

- Metamorphism of the sedimentary layer of the subducting plate provides water, which allows the mantle to melt.
- Melting of the mantle may be possible in the conditions of point M; hydration by the metamorphism of sediments is not necessary.
- If the sedimentary layer of the subducting plate loses water by metamorphism, the melting of the sedimentary layer is made easier.

**23) Please study lines 0 and 2 in Maps 1 and 2 on page 12. Circle the correct option (either line 0 or line 2) in (a) as well as in (b):**

- Diagram A is a good interpretation of a transect along: line 0 / line 2.
- Diagram B is a good interpretation of a transect along: line 0 / line 2.

The upper image in the diagram below represents a section across Central America (location 0 on Maps 1 and 2 on page 12). The lower image represents a section across Japan.



*Note: Seismic tomography is a technique of computerized images of sections of the globe, which is based on models that use the velocity of seismic wave propagation. It uses a conventional code of colors for different velocities of seismic propagation:*

*Blue for high velocity/low temperature ; Red for low velocity/high temperature; Yellow and orange for medium velocity/temperature.*

**24) Choose ALL THE CORRECT STATEMENTS.** (*Several possible answers*):

- a) The blue zone under the arrow on the diagram above is a cold zone, which is related to the subducting plate.
- b) Fragments of oceanic plates undergoing subduction progressively melt and mix with the upper mantle.
- c) Fragments of oceanic plates undergoing subduction progressively melt and mix with both the upper and lower mantle.
- d) Fragments of oceanic plates undergoing subduction progressively mix with the upper and lower mantle although they stay solid.
- e) The addition of material from the surface to the mantle is compensated by the addition of material coming from the mantle to the surface.
- f) The tomographic image of Japan is similar to 'Type A' zone of the document given for Question 20.
- g) The tomographic image of Japan is similar to 'Type B' zone of the document given for Question 20.

**Which among the 3 hypotheses below is supported by the information on seismic tomography? (Choose ONLY ONE ANSWER which you consider the MOST APPROPRIATE.)**

**25) The energy for plate movements comes mainly from**

- a) The friction between the mantle convection cells and the lithosphere makes the lithospheric plates move. The addition of magma in accretion zones pushes apart oceanic plates.
- b) Subducting oceanic plates have a higher density than the mantle; so, the plate is pulled due to gravity. (potential energy)
- c) Addition of sediments on the oceanic lithosphere increases its weight and pulls it down.

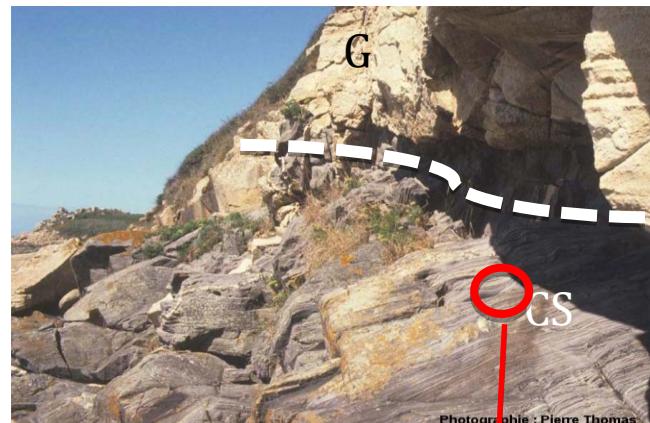
*After going down to the depth of geosphere, some material will eventually come up to the surface...*

*Back to granite - →*

The granite (G) shown in the first document (photo A below) is surrounded by a bedded rock; the white dotted line marks the junction between the two rocks. White beds are sandstone (S). Grey beds resulted from the diagenesis of a mixture of sand and clay (C). So, we will call this rock (CS). Letter (A) stands for andalusite, which can be found in (CS), but only near the contact with the granite.

Far away from the contact, rock (CS) does not contain andalusite.

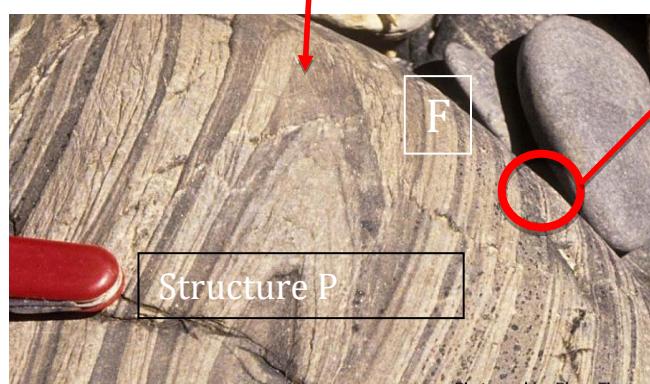
Some structures like structure P or F can be observed even far from the granite in all the (CS) formation.



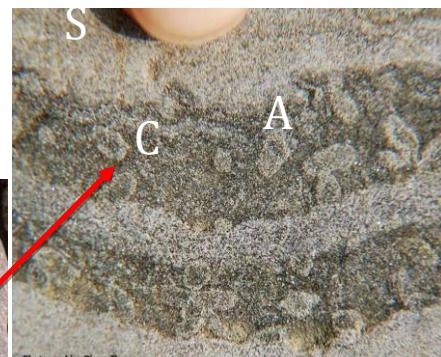
← Photo A.

The other two photos are enlargements of the circled zones.

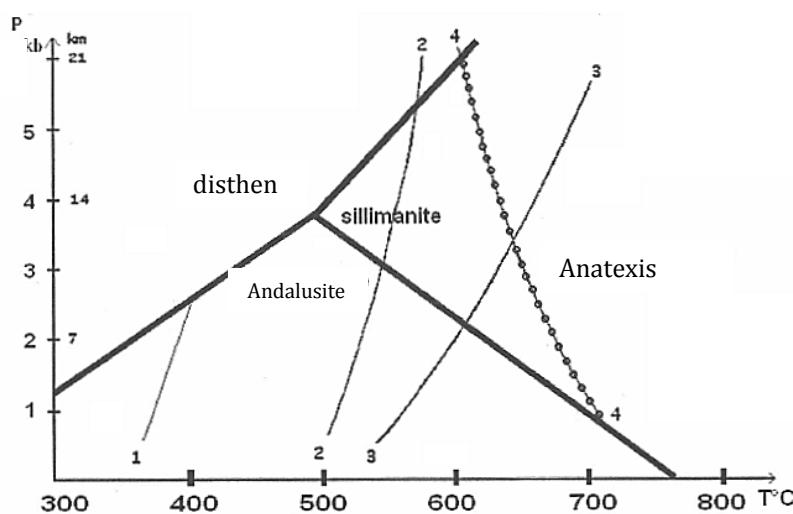
Contact CS / granite



Structure P



Details of CS in contact zone with the granite



**Diagram:** This diagram illustrates the conditions of pressure and temperature which can lead to the formation of andalusite, sillimanite and disthene. These three minerals have the same chemical formula of  $\text{Al}_2\text{O}(\text{SiO}_4)$ .

This rock (CS) tells us a long story of interactions and transformations, all of which take place in different locations of the geosphere.

**26) Choose ALL the plausible (credible) statements. (Several possible answers):**

- a) The bedding in CS seems to be related to metamorphism and the associated deformation, which separated beds C from beds S.
- b) The bedding in CS is, in all probability, due to alternate sedimentation/deposition of sand and clay.
- c) Andalusite formed simultaneously with the sedimentation/deposition of clay.
- d) Andalusite is a mineral associated with contact metamorphism and it formed after the deposition of rock (CS).
- e) The presence of Andalusite in a rock may be used to deduce ‘high temperature’ metamorphism.
- f) The presence of Andalusite in a rock may be used to deduce ‘low pressure’ metamorphism.
- g) Andalusite could not have formed in beds S for chemical reasons.

**27) Which of the following events influenced the entire history of the rock "G"(several possible answers)? (0.5 for each correct answer ; - 0 .5 for each wrong answer)**

- a) Erosion
- b) Slow cooling
- c) Fastcooling
- d) Sedimentation
- e) Metamorphism
- f) Crystallization
- g) Folding
- h) Uplift
- i) Burial

**28) Which of the following events influenced the entire history of the layers S in rock "CS" (several possible answers)? (0.5 for each correct answer ; - 0 .5 for each wrong answer)**

- a) Erosion
- b) Slow cooling
- c) Fast cooling
- d) Sedimentation
- e) Crystallization
- f) Folding
- g) Melting
- h) Uplift
- i) Burial

**29) Which of the following events influenced the the entire history of layers C in rock "CS" near the contact with the granite ?** (several possible answers) (0.5 for each correct answer ; - 0 .5 for each wrong answer)

- a) Erosion
- b) Slow cooling
- c) Fast cooling
- d) Sedimentation
- e) Metamorphism
- f) Crystallization
- g) Folding
- h) Melting
- i) Uplift
- j) Burial

**30) Which of the following statements is correct in relation to the age of these three rocks (G, S, CS) (*several possible answers*)?**

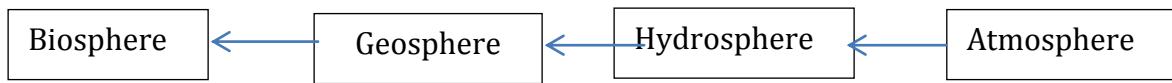
- a) The granite is the oldest rock since the other two are layered.
- b) The granite is older than the CS rock since the granite was not folded.
- c) The CS rock is the oldest rock, since it contains andalusite.
- d) The granite is younger than CS as its intrusion metamorphosed C.
- e) The granite crystallised after CS was folded.

**31) Which of the following statements is correct in relation with the tectonic history (Just one answer) ?**

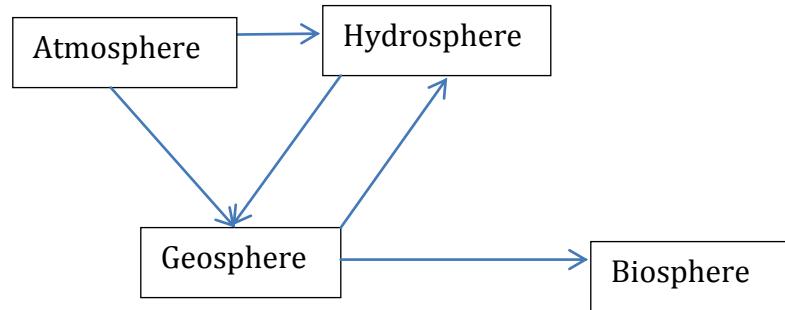
- a) The structures observed at P show that some compression occurred some time in the past.
- b) The structures observed at P show that some extension occurred some time in the past.
- c) The structures observed at P show that rock CS was neither compressed nor extended.

**32) In accordance with the geological phenomena shown in this test, which of the schemes below best summarizes the interactions among the earth systems in that site along its geological history? (Just one scheme)**

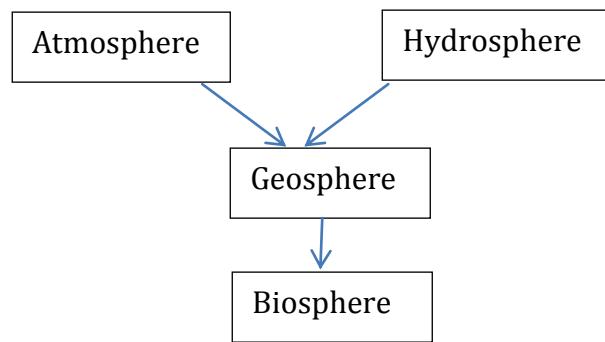
a



b



c



d

