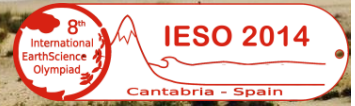


The Delicate Coastal Equilibrium

Paper 4



Canada has the longest coastline: 243791 km. The Federated States of Micronesia have the biggest coast length/surface ratio: 8706,553 m/km². Without these record figures, the Iberian Peninsula has a long coastline (9669 km). The history and economy of Spain and Portugal has been linked to the Cantabrian Sea due North, the Atlantic Ocean due West and the Mediterranean Sea due South and East. Within this paper, we will visit three segments of the Iberian coast and explore the landscapes and processes around.

From the Earth Science point of view, coastal areas are among most dynamic and fragile environments and the source of important eco-services to our societies. In addition, most metropolitan areas in the world are in the coast. The efficiency of ship transport, the sea resources (food, salt, etc.) have concentrated humans in the coast for centuries. Consequently, coastal processes affect millions of persons in the world –while the human activity affects the coastal processes in a variety of ways.

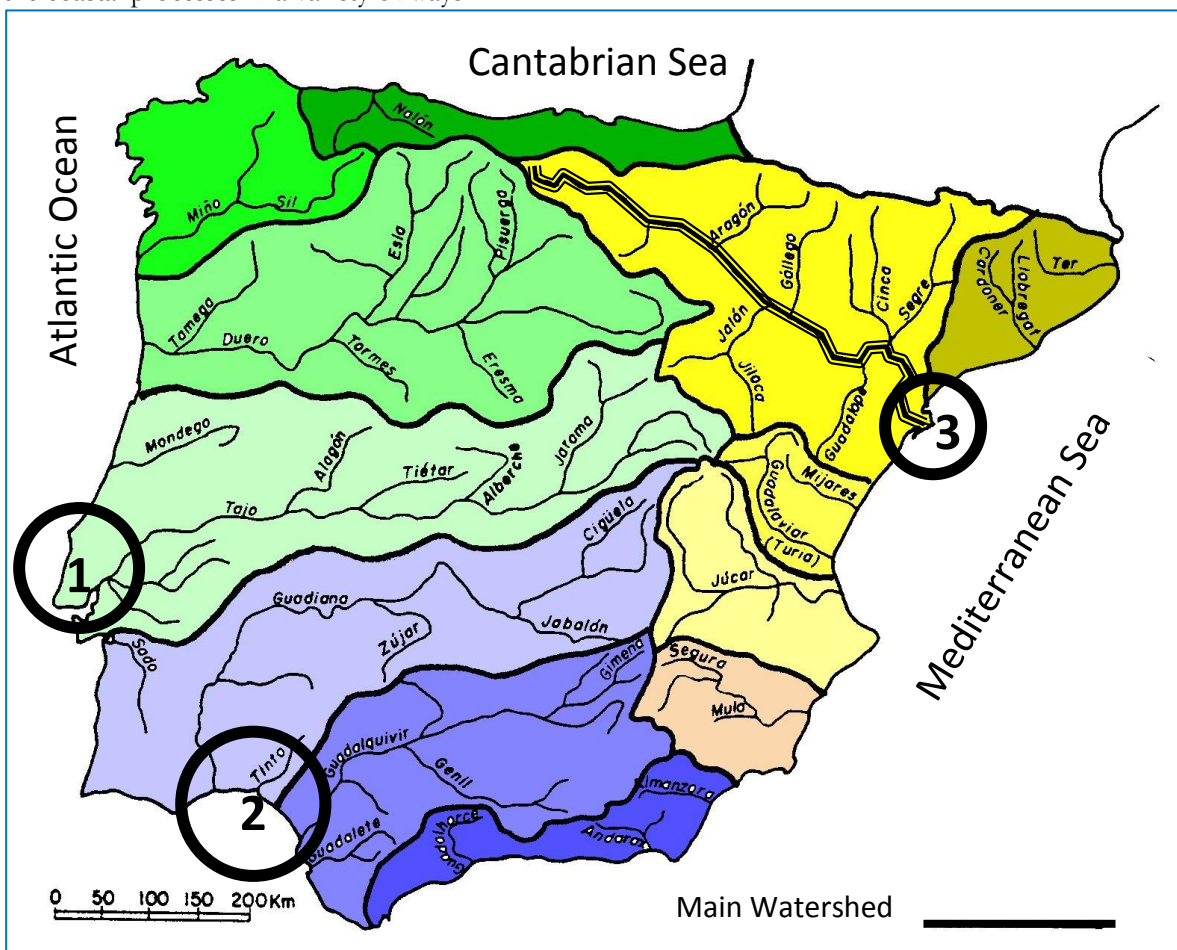


Figure 1. The Iberian Peninsula and its main watersheds. The three circles mark the areas you will have to work on in this paper: 1. The Coast off Lisbon; 2. The coast of Huelva; 3. The Delta of Ebro River. Triple line marks Ebro River. Credits: http://www.aularagon.org/files/espa/atlas/riosEspana_cuencas.htm

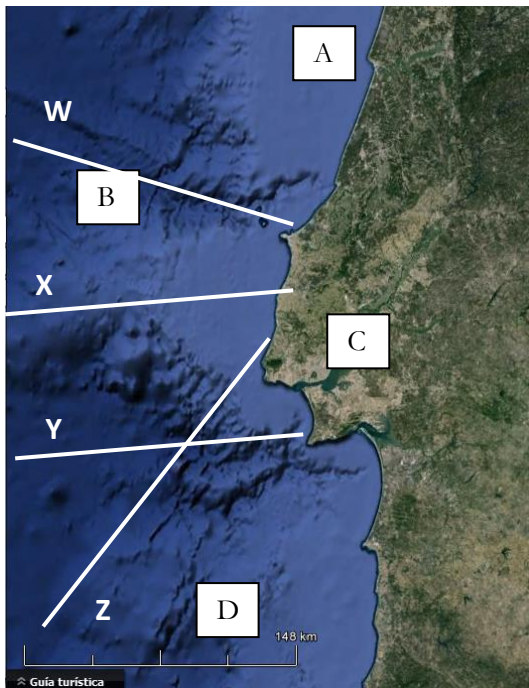


Figure 2. Image of the coastal area and sea bottom in the area of Lisbon (Portugal)

The coast off Lisbon (Portugal)

The coast in front of Lisbon (Portugal) is similar to many coast in the world, and has some element that can be found in any Atlantic Coast

1. The flat areas marked A (Figure 2), are...
 - a) Delta
 - b) Continental Platforms
 - c) Abyssal Plains
 - d) Continental Slope
2. The most likely point for turbidite formation is

a) A	c) C
b) B	d) D
3. Which point marks the position of an estuarine environment

a) A	c) C
b) B	d) D
4. If you were to lay a submarine cable, which option would be safer in terms of turbidity flows?

a) W	c) Y
b) X	d) Z
5. The Atlantic coast has this configuration because it is in...
 - a) Destructive ocean margins
 - b) Constructive ocean margins
 - c) Active continental margins
 - d) Passive continental margins

The coast of Huelva (Spain)

The coast in front of Lisbon (Portugal) is similar to many coast in the world, and has some element that can be found in any Atlantic Coast

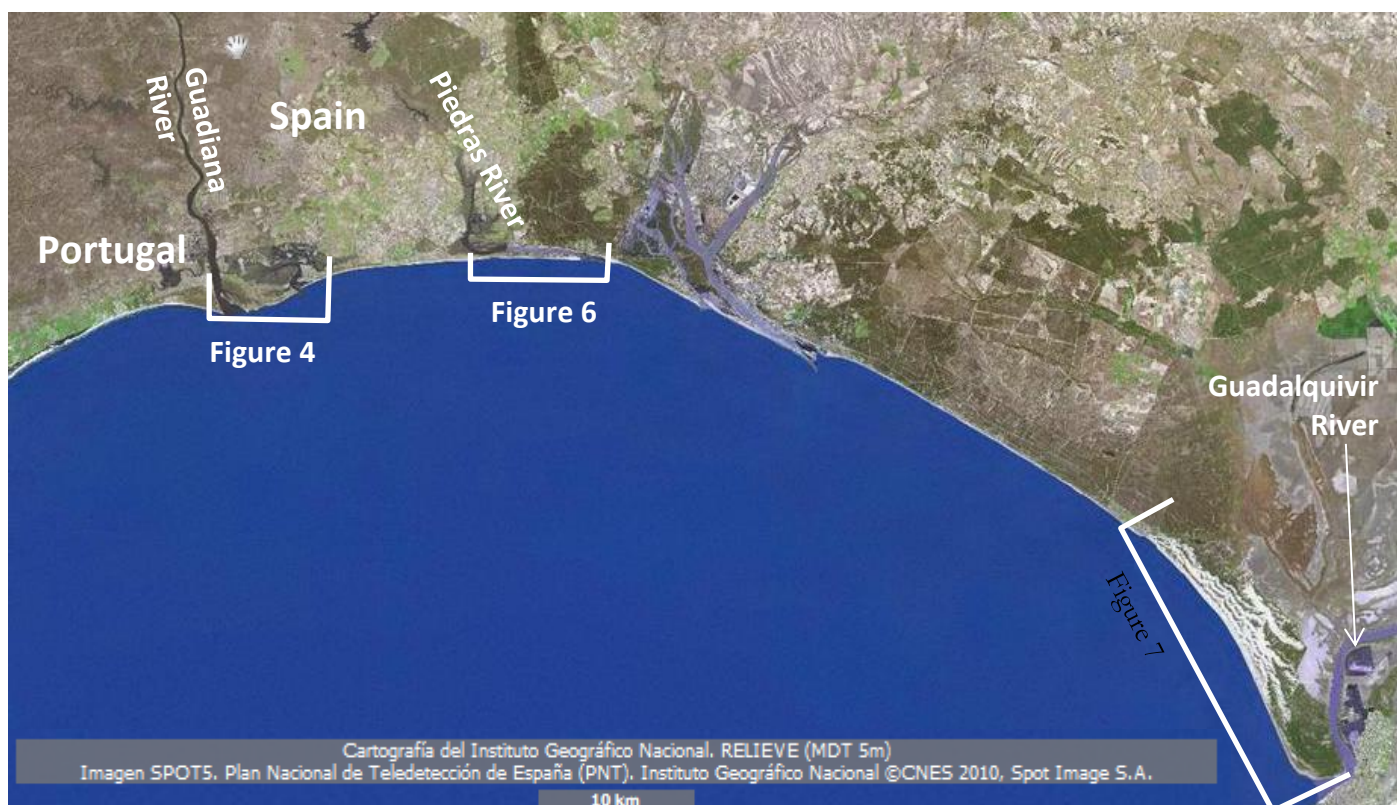


Figure 3. The coast of Huelva province (Spain) and part of the Algarve (Portugal). The border is marked by the Guadiana river –with reference to the area showed in following figures.



Figure 4. Isla Cristina-Ayamonte marshes and barbours. 1. Guadiana River Mouth. 2. Ayamonte harbour. 3. Isla Cristina harbour. 4. Salt pans. 5. Aquaculture.

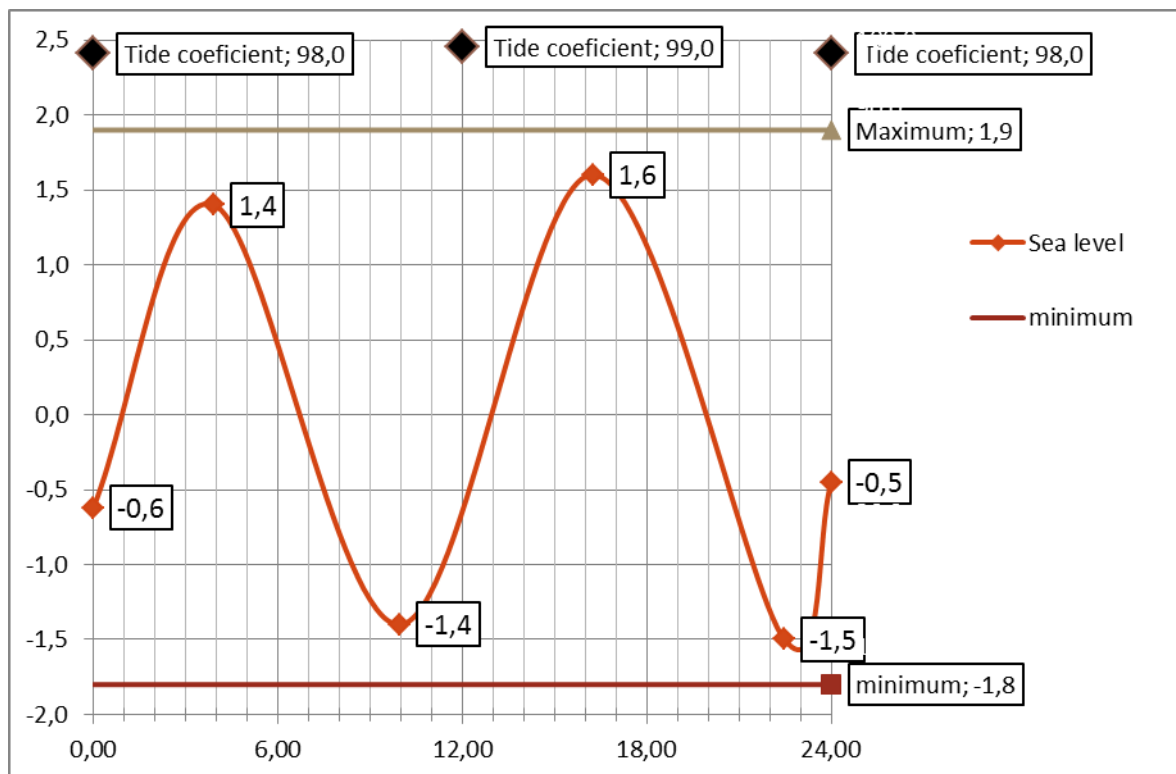


Figure 5. Tide diagram for 13 June 2014.

On 13 June 2014 a team of scientists explored the marshes of Isla Cristina to take samples of clay and organic matter tidal channels bottom –in an area with the bottom at 1 m below average sea level. The probe is a rather heavy machine transported and operate on board a small boat that needs 0,5 m deep waters. Every probe takes about one hour to be completed and the team needs three samples.

The day before, they downloaded a tide graph (Figure 5) to plan their work –horizontal axis is time, and vertical axis is elevation above average sea level.

The tidal coefficient will be 98. With such a high coefficient we will have big tides and the currents will also be very evident. The tide heights will be 1.4 m, -1.4 m, 1.6 m and -1.5 m. We can compare these levels with the maximum high tide recorded in the tide tables for Isla Cristina which is of 1.9 m and a minimum height of -1.8 m.

6. Which of the following is/are the best time to begin the exploration
 - a) 1:00
 - b) 8:00
 - c) 16:00
 - d) 20:00
7. Time in the graph is Local Time, in zone +2h. What is UMT or Z time of the first high tide of the day.
 - a) 1:55
 - b) 3:55
 - c) 5:55
 - d) 14:16
 - e) 16:16
 - f) 18:16
8. Such high tidal coefficient (see text above) indicates that the moon phase is probably...
 - a) New moon
 - b) Waxing crescent
 - c) First quarter
 - d) Waxing gibbous
 - e) Full moon
 - f) Waning gibbous
 - g) Third quarter
 - h) Waning crescent
9. The high tide is mainly produced by the Moon pull on the ocean waters. Consequently, the high tide arrives when...
 - a) The moon is in the Nadir
 - b) The moon is in the Zenith
 - c) The moon is at maximum height over the horizon
 - d) The moon is at minimum height over the horizon
 - e) Shortly after the moon is at maximum height over the horizon
 - f) Shortly after the moon is at minimum height over the horizon

- g) Shortly before the moon is at maximum height over the horizon
h) Shortly before the moon is at minimum height over the horizon
10. The answer to the previous question depends on...
- The time that light needs to travel across the space
 - The distance between the Moon and the Sun throughout the year
 - The distance between the Earth and the Moon throughout the day
 - The friction that delays water movement
 - The density of water being higher than the density of ice
11. In many regions, the vegetation of marshes includes trees with an adaptation to this changing environment. What is the name of such environment?
- Mud flats
 - Intertidal platforms
 - Intertidal
 - Mangroves
 - Coral reefs
 - Green reef
12. The salt industry and aquaculture requires the clearing of marsh vegetation, a consequence being the reduction of biodiversity and an increase of vulnerability against...
- Dune retreat
 - Storm lightning
 - Tsunamis
 - Choppy waves
 - Fish overgrowing
 - Fish overgrazing



Figure 6. "El Rompido" littoral sand spit, in the mouth of river Piedras.

13. The image of Figure 6 shows a sand littoral spit developed in front of the mouth of the river Piedras. The landform results from
- Fluvial erosion, similar to what happens in any meander
 - Fluvial sedimentation, similar what happens in a typical alluvial fan
 - The change in sea level due to global warming
 - The interaction between tides and winds, as in many semiarid coast
 - The interaction of river and littoral drift sediments
 - The contamination of rivers due to deforestation and mining.
14. To form that sand littoral spit, the prevailing waves come from...
- | | | |
|--------------|------------|------------|
| a) Any place | d) W | g) N or NE |
| b) N | e) E | h) S or SW |
| c) S | f) N or NW | i) S or SE |

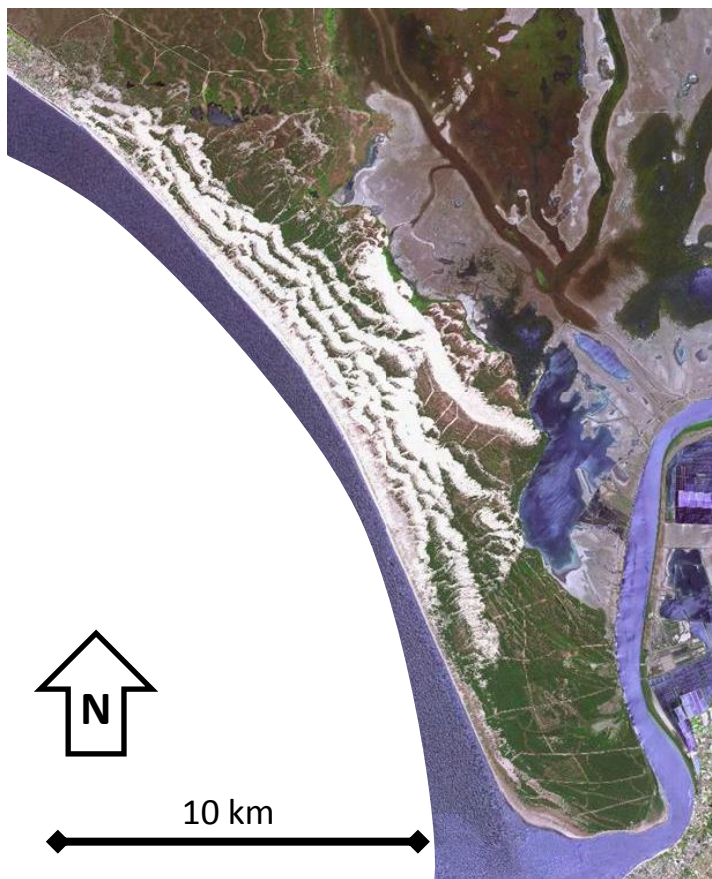


Figure 7 shows the area of Doñana National Park. From left to right, you can see: the Atlantic Ocean, a succession of white bands (the beach, a littoral-dunes field –with some vegetation areas), and the marshes. Only a deep knowledge of the geologic processes makes possible the protection of the fauna and vegetation that make world-famous this National Park. In the bottom right side of the image is the Guadalquivir River.

15. Based on Figure 8, choose the best statement:
- A represents the marshes, B is the sea
 - A represents the sea, B is the marshes area
 - A and B represents the sea
 - Impossible to decide
16. What letter in figure 8 represents the avalanche side of dunes
[Chose a letter from A to F in your answer sheet]

Figure 7. Doñana beach, dunes and marshes, west of the mouth of Guadalquivir river. Source: IGN, Spot Image.

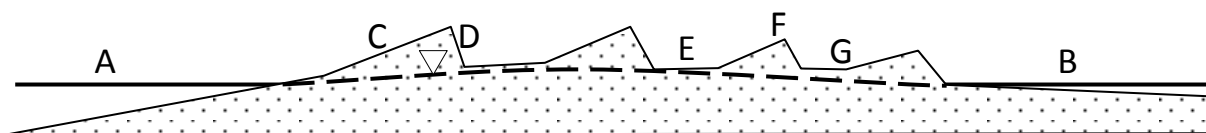


Figure 8. Simplified cross-section of Doñana National Park.

17. Which of the following describes the dashed line, marked with the inverted triangle?
- Limit between beach and dune sands
 - Avalanche side
 - Base of dunes
 - Beach
 - Intertidal zone
 - Water table
 - Maximum sea level during winter storms
 - Surf zone
18. If Figure 8 is correct, and a chemical leak happens in point G...
- Contamination will reach the sea
 - Contamination will reach the marshes
 - Contamination will remain below point G
 - Contamination will not infiltrate
 - It's impossible to forecast the flow of contaminated water

19. As you can see in Figure 7, there are vegetated (with genus *Pinus*) and sandy areas. Choose the best explanation referring to figures 7 and 8...
- C is covered by pines that use the sea humidity
 - F is covered by vegetation, that can grow far from the brackish water
 - E is covered by vegetation, that uses the groundwater
 - G does not have any vegetation because the groundwater is contaminated
20. Marshes are described as carbon sinks because there is:
- Oscillation of sea level with tides
 - Alternating of fresh and salty waters
 - Accumulation of organic matter
 - Accumulation of shells
 - Dissolution of carbon dioxide in water
 - Oxidation of organic matter
 - Erosion of dunes
 - Sand-dunes sedimentation
21. Apart from its huge biodiversity, marshes are very efficient carbon sinks, and this is one of the reasons to preserve marshes. Why are marshes extraordinarily efficient carbon sinks?
- The organic matter accumulates better in intertidal areas
 - The organic matter do not oxides under water
 - Marsh's dynamics produce very high rates of sedimentation
 - We do not build or burn fossil fuels in marshes
22. If you analyze Biological Oxygen Demand (BOD) in sea and marsh waters, you will probably find...
- Higher values of BOD in the marsh
 - Higher values of BOD in the sea
 - The same low values of BOD in the sea and the marsh
 - The same high values of BOD in the sea and the marsh
 - BOD is not a variable measurable in water.

Fishing is an essential part of the economy of the region. Its great productivity relates to several variables and fishing practices which have consequences on the environment.

23. Fishing productivity is incised by...
- Nutrients brought to the area in the water of rivers
 - Cold water brought to the area by the rivers
 - Warm water brought to the area by the rivers
 - Dilution of contamination by the river water
24. Trawl fishing is a common practice in sandy coasts, but it is environmental unfriendly because it destroys...
- Future fossil fuel deposits
 - Sedimentary structures, like ripple-marks
 - Posidonia prairies and other bottom vegetation
 - Shrimp schools
25. Building on littoral dunes and trawl fishing (through the effect that you discovered in the previous question) have the following effects:
- Both improve the accumulation of sand in the beach
 - Both improve the accumulation of sand in the dunes
 - Both increase the erosion of the beach

- d) Both increase the erosion of the dunes
- e) Trawling don't affect to the beach but do affects to the dunes
- f) Building don't affect to the beach but do affects to the dunes

Coast and Atmosphere

In many oceanic coasts, storms and storm surges are a main concern. The understanding of storms and atmospheric stability are a basic concept to forecast and prevent their effects. In the following questions, we will work on these subjects.

26. A storm surge is...
- a) A change in atmospheric pressure that destroys crop plantations
 - b) An increase in atmospheric pressure due to storm clouds
 - c) A decrease in pressure below storm clouds that attract clouds to the level of the Earth surface
 - d) A rise of the sea level due to the low pressure in the storm core
 - e) An increase of wave frequencies due to the cyclonic winds in storms
27. Which name is better for the element marked with a circle in Figure 9-left?
- a) Ice stakes
 - b) Cumulus stalactites
 - c) Anvil
 - d) Mammatus
 - e) Hail nets
28. Study Figure 9 and decide which adiabatic gradient best describes the conditions of the right part of the photograph: [Choose a letter a - d in your sheet answer]

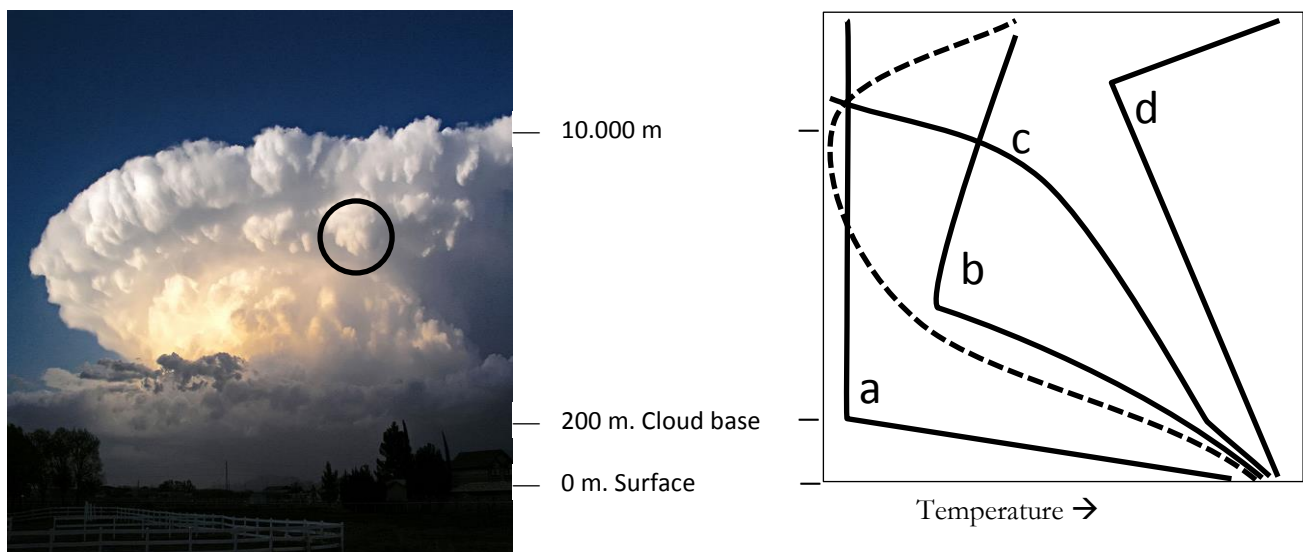


Figure 9. Left: Supercell cloud. Right: Simplified Tephigram with an environmental gradient (dashed line) and four possible adiabatic gradients (solid lines). (Image from Wikimedia Commons, http://commons.wikimedia.org/wiki/File:Chaparral_Supercell_2.JPG, visited 5 June 2014)

29. When air rise in the atmosphere, with speed enough as to avoid substantial interchange of energy with the surrounding air, the rising air changes its temperature according to...
- a) Dry Adiabatic Gradient in lower troposphere
 - b) Dry Adiabatic Gradient in upper troposphere
 - c) Wet Adiabatic Gradient in lower troposphere
 - d) Wet Adiabatic Gradient in upper troposphere
 - e) Environmental Gradient in lower troposphere
 - f) Environmental Gradient in upper troposphere

Contamination in oceans

The authors of Figure 13 “use the term *plastiglomerate* to describe an indurated, multi-composite material made hard by agglutination of rock and molten plastic. This material is subdivided into an ‘*in situ*’ type, in which plastic is adhered to rock outcrops, and a ‘*clastic*’ type, in which combinations of basalt, coral, shells, and local woody debris are cemented with grains of sand in a plastic matrix”. This material has been formally described in a Hawaii beach, although many beaches have plastiglomerates around.

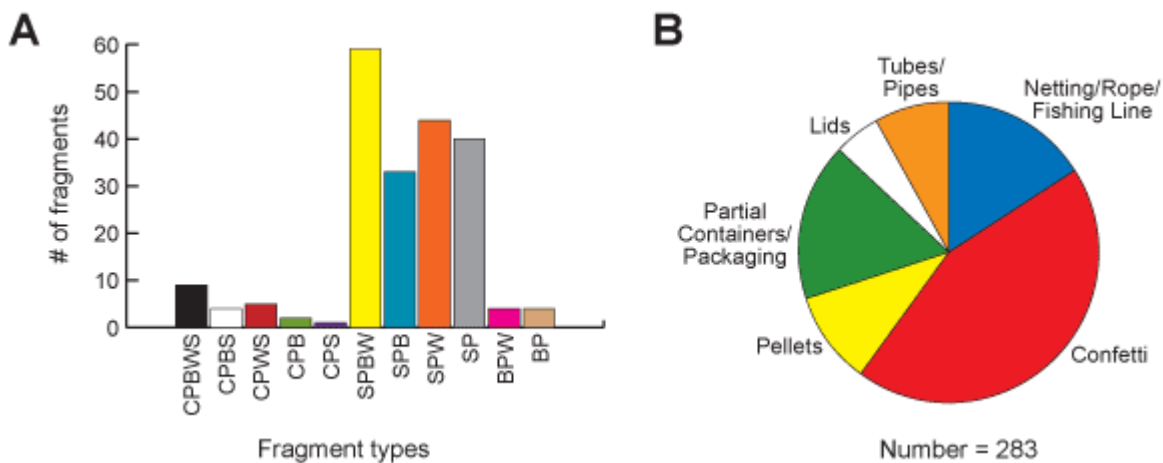


Figure 10. Diagrams illustrating the types of plastiglomerate and relative percentages of adhered plastic fragments. (A) Material composing the sampled plastiglomerate: B—basalt clasts; C—coral fragments; P—plastic; S—sand and sand-size shelly fragments; W—woody. Source: P. L. Corcoran, C. J. Moore, and K. Jazvac. *An anthropogenic marker horizon in the future rock record. GSA Today, Volume 24 Issue 6 (June 2014)* (<http://www.geosociety.org/gsatoday/archive/24/6/article/i1052-5173-24-6-4.htm>).

30. When future Earth Scientists find a plastiglomerate layer in a sedimentary profile they will be able to use it as...
 - a) Sedimentary thermometer
 - b) Sedimentary barometer
 - c) Sedimentary environment indicator
 - d) Relative dating source
 - e) Absolute dating source
 - f) Evidence of volcanism
 - g) Evidence of fossil fuels scarcity
31. For plastic to be useful as an “Index fossil”, it must...
 - a) Be easy to destroy
 - b) Be sorted in sediments with just one kind of plastic
 - c) Have existed during a long period (in geological sense)
 - d) Have existed during a short period (in geological sense)
 - e) Have been dispersed in few and sparsely distributed environments.
 - f) Have been dispersed in many and widely distributed environments.
 - g) Be scarce at a global scale
 - h) Endemic of an area

The same paper says, “researchers agree that the *Anthropocene* is a time span marked by human interaction with Earth’s biophysical system”. In the following questions, match the geological evidence with an interpretation that can be used to identify Anthropocene sediments:

32. Increase in atmospheric CO₂ at approximately 8000 yr B.P. can relate to...
 - a) Atmospheric lead derived mainly from combustion of leaded gasoline
 - b) Early agricultural practices in Eurasia
 - c) Mining activities
 - d) Early forest clearance
33. Methane concentrations measured in ice cores display an increase at approximately 5000 yr B.P. related to...
 - a) Atmospheric lead derived mainly from combustion of leaded gasoline
 - b) Early agricultural practices in Eurasia
 - c) Mining activities
 - d) Early forest clearance

34. Lead (Pb) concentrations prior to approximately 1900 AD, can relate to...
- Atmospheric lead derived mainly from combustion of leaded gasoline
 - Early agricultural practices in Eurasia
 - Mining activities
 - Early forest clearance
35. Second Pb compositional signature in soil younger than 1950 AD, can relate to...
- Atmospheric lead derived mainly from combustion of leaded gasoline
 - Early agricultural practices in Eurasia
 - Mining activities
 - Early forest clearance

The Delta of River Ebro (Spain)

In the NW part of the Mediterranean coast northwestward, one of the most prominent landforms is the delta of Ebro River (Figure 11A). The Ebro Delta is a mixed kind of delta, as shown is the classification in Figure 11B.



Figure 12A. The Delta of Ebro River in NE Spain.
Source: IGN, Spot Image.

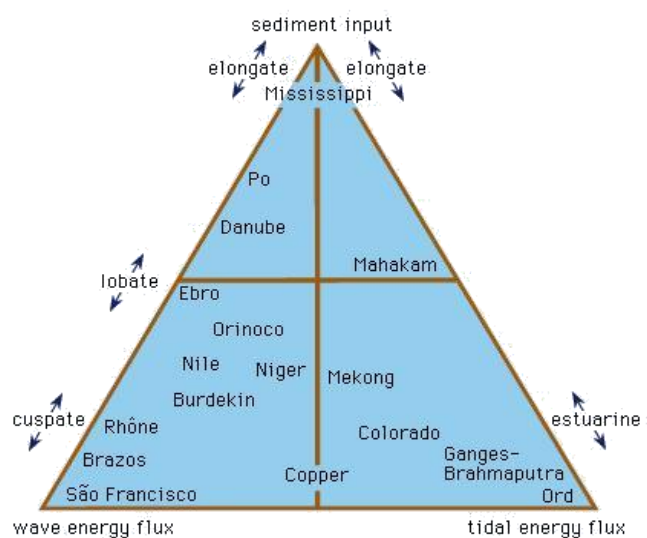


Figure 12B. Classification of river deltas based on the three dominant processes that control delta morphology. Credit: From W.E. Galloway, *Deltas, Models for Exploration* (1975); Houston Geological Society. As showed in *Encyclopedia Britanica*. See the Ebro River in the middle left side.

36. As you can see in Figure 11, the delta of Ebro is the place for intensive agriculture (rice is one of the main crops). Which of the following processes relates to the usual practices of intensive agriculture?
- Carbonization
 - Flooding
 - Eutrophication
 - Landsliding
 - Oxidation
 - Silting
 - Erosion
 - Surging
37. The position of Ebro in the classification diagram of Figure 11 means that...
- The delta is far from any estuary
 - The influence of tides is bigger that the influence of river sediments
 - The delta is in a delicate conservations equilibrium, close to the limit of destruction
 - The influence of waves is bigger than the influence of tides
 - The influence of waves is much bigger than the influence of river sediments
 - The delta will migrate so the NE along the left side of the triangle

38. The contribution of river sediments is fundamental to delta evolution, and sediment transport depends on river discharge (Q). Given the data included in Figure 12, what is the discharge in that river?
- $10000 \text{ m}^3/\text{s}$
 - $30000 \text{ dm}^3/\text{s}$
 - 20000 l/s
 - $2000 \text{ m}^3/\text{s}$
 - 1500 l/s
 - $24000 \text{ dm}^3/\text{s}$
39. What is the name of a place like the one of Figure 12?
- Discharge station
 - Flow station
 - Volume station
 - Gauging station
 - Watering station
 - Velocity station

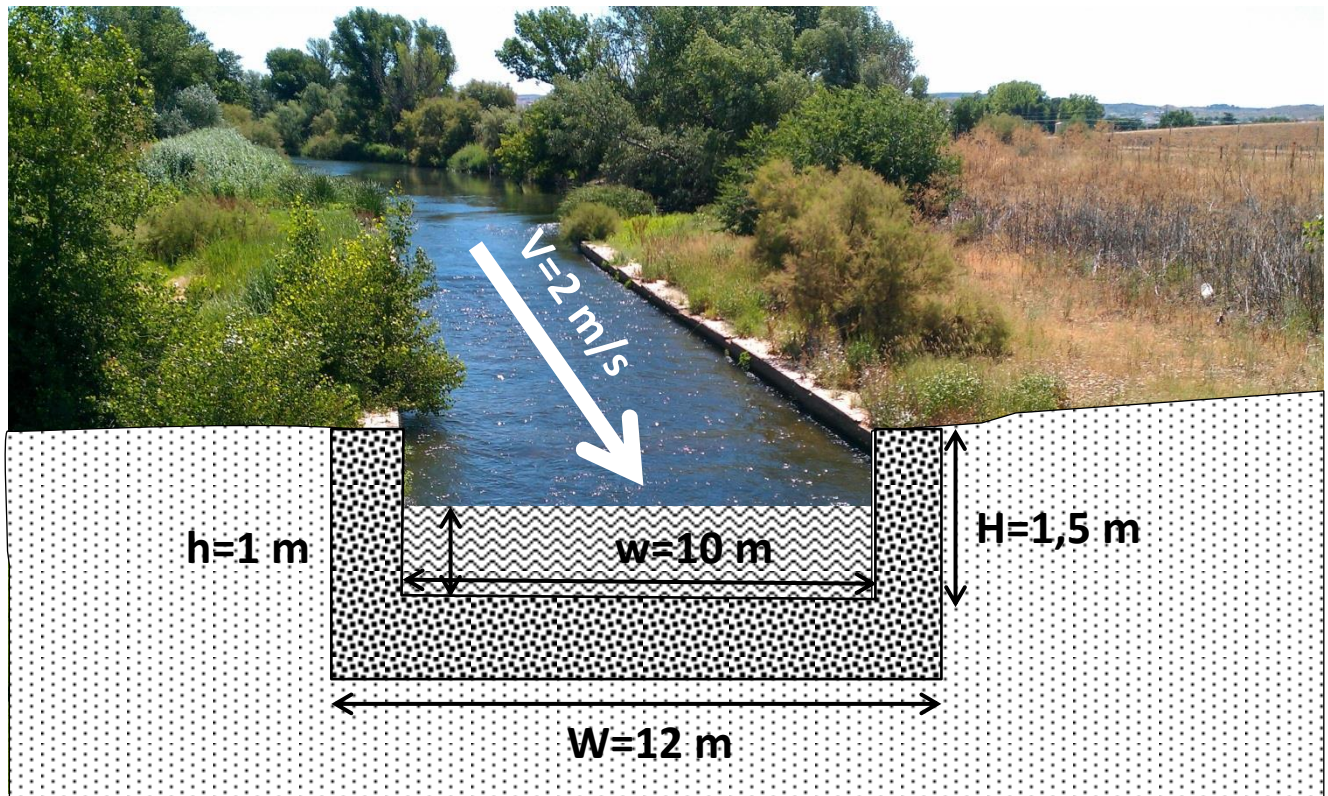


Figure 13. Data to measure discharge.

Back to Cantabria and the link between mountain and sea landscapes

If you follow Ebro River upwards, you will reach again the region of Cantabria. The sources of Ebro are located in the Cantabrian range, a land of pastures, rocks, and glacial landforms. Before returning to Santander, let's make a last exercise connecting very different environments.

40. Mountain cattle do nurture from mountain pastures, but its digestion connects with global processes. Choose the best systems-flow model.
- Pasture eating-Deforestation-Sedimentation-Sea nutrients scarcity
 - Pasture eating-Carbon fixing-Greenhouse effect-Sea water volume reduction
 - Pasture eating-Methane emissions-Greenhouse effect-Sea level increase
 - Pasture eating-Increase in soil microorganisms-Water storage-Sea level decrease