The Serra de Tramuntana as a resource for studying the environment

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INTRODUCTION TO THE SERRA DE TRAMUNTANA

GEOGRAPHIC SITUATION

The Serra de Tramuntana is located parallel to the northwestern coast of Mallorca with a length of about 90 km and 15 km wide. Oriented NE-SW the Serra extends from Dragonera to Cap de Formentor covering about 20 municipalities of the island.

GEOLOGY

During the development of the present-day geological structure of Mallorca there are three different stages: first a Mesozoic extension, then an late Oligocene to Miocene compression and finally the latest is a Neocene extension. The Serra de Tramuntana mountain range has some particular geological characteristics which are mainly determined by the disposition of the materials and its stratigraphy. On the north side of the range we can highlight sharp reliefs like thrust fronts whereas the south part has softer structures. Another geological feature is the alternation of hard materials like limestone in cliffs and massifs and softer materials like clay or calcarenites that could be found on the bottom of valleys and mountain slopes. A further outstanding characteristic for example is the difference between the miscellaneous slopes, the slopes in the Northwest are steeper then the slopes we find in the Southeast.

Different agents are acting continuously on this lithological base generating the geomorphological structure of the mountain range. These erosive processes are due to different modeling factors such torrents, rainwater or the water that acts on the coast.

Fig. 1: Main structural properties of Mallorca (Gelabert et al, 1992)
Stratigraphy of the Tramuntana range

- **Paleozoic**: Near the southwest of the Port of Valldemossa dark materials that could belong to the Carboniferous.

- **Lower Triassic** (Buntsandstein facies): reddish materials in the southern part of the mountain range, from the coast of Andratx through the coast of Estellencs ending at the Port of Valldemossa. It includes conglomerates of quartz followed by quartz sandstones, silt and clay and the rocks of this layer are detrital rocks of siliceous composition, which all are insoluble rocks.

- **Middle Triassic** (Muschelkalk facies): Between Banyalbufar and Estellencs above the Buntsandstein there is a stratum with limestone, dolomite, yellow and red marlstone.

- **Late Triassic** (Keuper facies): Multicolored marlstones with inserted gypsum that may have basalts or cinerites (volcanic ash). The rocks of this Keuper layer aren’t soluble with the exception of gypsum that forms limestone pavements and sinkholes with karstification. Keuper rocks are also responsible for depressed areas and gentle slopes.

- **Infraalias** (Rethiense-Hettangiense): characterized for its dolomite and dolomitic limestones, both very soluble materials with large cavities.

![Fig. 2: Statigraphical column of the Serra de Tramuntana (Gelabert et al, 1992)](image)
• **Early Jurassic** (Lower lias): due to very resistant and powerful materials this stratum forms the most important peaks and cliffs of the mountain range. Among these materials we find soluble limestone and dolomite as in the previous layer and calcareous breccias.

• **Early Jurassic** (Upper lias): materials like marlstone and marly limestone which do not form big areas in the Serra de Tramuntana.

• **Middle Jurassic** (Doggers): also marly limestone and marl besides limestone with silica.

• **Late Jurassic** (Malm): similar to the preceding layers this stratum contains almost insoluble marlstone and marly limestone.

• **Cretaceous**: white limestone, marly limestone, marl and clay incompatible with karstification

• **Eocene**: stratum comprising mainly limestone rich in organic matter, marine and lacustrine sediments.

• **Oligocene**: part of the upper tectonic units of the southern slope of the mountain range. This layer includes conglomerates, calcarenites, marl, clays and bioclastic limestone.

• **Early Miocene** (Aquitanian-Burdigalian) a lower unit mainly composed of calcarenites and litoral conglomerates and an upper unit. Limestone conglomerates have large cavities that we could find in the region of Lluc, the road to Escorca, Son Nebot and Mortitx.

• **Middle Miocene** (Langhian): its materials together with those of the lower Miocene are influenced by the overlaps of the mountain range. These materials are the youngest materials and affected by the definitive structuring process of the range. This layer has marls, sandstone, silica, calcarenites and conglomerates.

• **Late Miocene** (Tortonian-Messinian): with siltstones and limestone, which are soluble what means they are suitable for the karstification process.

• **Pliocene**: materials like marl, calcarenites, conglomerates and siltstones.

• **Quaternary**: containing red clays, siltstones and conglomerates among other materials. The outcrops of this layer are situated mainly at the sidewalks of the range.

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**Karst**

Mallorca is characterized by the high proportion of limestone rocks which form big karst landscapes including the Serra de Tramuntana. Karst landscapes formation is caused by dissolution of soluble rocks due to acidic water. During the rain carbonic acid picks up carbon dioxide from the atmosphere and once it is dissolved in the raindrops and reaches the ground this water it reacts with the limestone going into solution. In addition to limestone other materials are soluble like dolomites and gypsum. This dissolution process originates characteristic landforms such as dolines, sinkholes, and caves.

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Fig. 3:
Karst landscape, Coll de l’Òfre
(Photo: Clara Wuennenberg)
CLIMATE

The climate of the Serra de Tramuntana is very similar to the Mediterranean climate that can be found in the rest of the island of Mallorca but with some particular characteristics. The arrangement and exposure of the relief, slope and altitude are all defining factors for the microclimate of this area. The most outstanding characteristic is lower temperatures due to altitude and higher rainfall.

Looking at the rainfall in the range there is a significant increase in annual rainfall compared with the rest of the island. This is attributable to the increased intensity of the rainfall in addition to a higher number of rainy days. Central areas recorded the highest rainfall amounts exceeding 1200 mm. There’s a clear relationship between rainfall and the relief, areas with bigger altitudes register the highest rainfall.

The spatial distribution of rainfall is also influenced by other factors such as latitude causing that the coast of Pollença is rainier than the southern. Occasionally, very significant rainfall intensities define the monthly precipitation distribution besides being a big part of the whole registered precipitations.

High rainfall intensities are usually registered usually during the fall. For instance, in Sóller there were measured 545mm, belonging 329mm to one single day between October 20th–22th of 1959. Snowfall is scarce in comparison to rainfall, although there may be exceptions, especially during January and February and in specific occasions at the Puig Major.

Precipitation rate could be divided according to 4 subzones: from the highest point of Serra d’Alfàbia to Ternelles we find a 800mm isohyet, precipitation between 1000 and 1300mm are registered in Lluc, Puigpunyent and Pollença receive more than 800mm and areas with not much altitude are characterized by lower rainfall with isohyets around 400mm.

Therefore areas with higher isohyets coincide with the highest points of the central part of the Serra de Tramuntana.

Temperatures of the mountain range are lower than temperatures of the rest of the island and altitude is again the most outstanding factor involved. Temperature decreases gradually with altitude leading the typical vegetation belt pattern of the Tramuntana range. The gradual variation of temperature is approximately 0,65°C per 100 meters. The lowest temperatures are found in Lluc with 6,5°C and the highest ones in Bunyola during August with 31°C.

Parallel orientation of the Serra de Tramuntana makes the range act as a barrier for winds and cyclones without completely cancel the action of them on the own range or on the rest of the island. There are two types of wind acting on the Serra de Tramuntana, North wind also called Tramuntana and the Southeast wind or Xaloc. Tramuntana wind is especially intense during December in the Northeast, Pollença and Alcudia instead Xaloc has harmful effects on vegetation and humidity. This last wind dries up the air lading to aridity in the peaks of the Tramuntana range. A typical valley/peak breeze system occurs from May to September as an unique feature of the Serra de Tramuntana.

Springs and torrents are two important elements in the hydrographic network although the reduced dimensions of this elements. Torrents, in general, do not exceed a length of 10 km in length have a very irregular flow. Some are only active temporarily when big storms occur. On one hand, we find long torrents like Torrent Solleric, Estret de Valldemossa or Torrent de Sant Miquel.

Fig. 4: Barranc de Biniaraix, Torrent de Biniaraix (Photo: Clara Wuennenberg)
that disembogue in the Southeast of the range. On the other hand in the Northwest the torrents are much shorter because of the closeness between peaks and coast. The Torrent Major de Sóller stands out for the water contribution it receives from karst springs from the slopes of the valley of Sóller.

**FLORA**

As mentioned before, the climatic characteristics of the Tramuntana range like intense winds, increased precipitations and lower temperatures are a determining factor for the vegetation found in this region. Due to the fact that higher parts are cold, windy and wet, whilst the lower parts are drier and warmer different vegetation belts distinguish along the mountain. But the boundaries or limits between of these belts are not so clear, rather diffuse. Karst landscape structures like fissures and slopes homogenize the climatic differences related to altitude leading to this uncleanness between the vegetation belts. But also other factors like human activity or the annual rainfall dependence of plants can modify the vegetation belt pattern. Summer drought affects different zones of the whole island and not all the plants survive this period even though in the Tramuntana mountains receives higher amounts rain during autumn and winter.

Nevertheless vegetation can be classified into three large groups:

- **Forests**

  Lower and warmer parts have thermophilic Mediterranean vegetation that include wild olives (*Olea europaea* var. *sylvestris*) and pineries. Pineries are mainly formed by pine (*Pinus halepensis*) and a rich shrub layer according to the amount of light that is reaching these forests. From sea level to 500 m in sunny regions and to 300 m in shady ones the pine has a preference for soft substrates and a south orientation. The most common species living below pines for example are the white and the Sage-leaved rockrose (*Cistus albidus* and *Cistus salviifolius*), heather (*Erica multiflora*), rosemary (*Rosmarinus officinalis*) and the Prickly Juniper (*Juniperus oxycedrus*). In this case the herbaceous layer is less significant.

  The wild olive communities called “ullastrars” are part of a high and dense garrigue. We find them associated with shrubs and Mediterranean lianas such as mastic (*Pistacia lentiscus*), Ivy (*Hedera helix*), rough bindweed (*Smilax aspera*) or the Mediterranean buckthorn (*Rhamnus alaternus*) among others. The wild olives grow principally in rocky substrates with limestone and hard dolomite and pines can cover them.

  Holm oak forests are highly developed in places where the amount incident light that reaches the ground is low because of branch and leave density of the holm oak itself. Two predominant types of oak can be distinguished. On one hand *Quercus rotundifolia* with rounded grey leaves mainly in warm and dry places and on the other hand *Quercus ilex* with long, green leaves especially in cold and dark parts. Due to the low light amount of this forest type the upper floors are rather scarce and the undergrowth is poor in species. Plants such as sowbread (*Cyclamen balearicum*) and lichens, mosses and fungi take advantage of this shade and humidity conditions. The undergrowth of holm oaks also includes species like mastic, laurustinus (*Viburnum tinus*), *Phillyrea media*, myrtle (*Myrtus communis*), irish spleenwort (*Asplenium onopteris*) and rough bindweed.

  The holm oak forests can reach the 1200m from sea level without constituting these dense forest systems. Higher parts of the mountain range include holm oaks that grow in the rock fissures where the light amount is bigger. More light means a higher number of species including grasses. In contrast in lower parts of the mountain the oak forest develops optimally in shady places and valley bottoms.

  As already mentioned wild olive communities and pineries can stay in touch so there are transition areas between those and oak forests as well.
Mountain Vegetation

Over 1200m the weather conditions force plants to be adapted to low temperatures in winter, a hot and dry summer and strong winds. The highest sections of the mountain range are characterized by a low vegetation belt with thorny and compact shrubs and a high proportion of endemic species (35% of the total amount of species in this belt). This high proportion is related to the protection provided against aggressive and colonizing plants in these sections. Species like *Hypericum balearicus*, the Balearic bindweed (*Smilax aspera* subsp. *balearica*), a buckthorn (*Rhamnus ludovici-salvatoris*) or thorny shrubs like *Teucrium marum* subsp. *occidentale* and *Astragalus balearicus* are endemic in Mallorca. Another type of habitats that require adaptation by plants is crags, cliffs and clefts of the rocks. These habitats also include compact shrub and endemic species that attract attention of insects for their pollination through a striking coloration. Cliffs are told to conserve tree species that were part of forests in the Quaternary and today have disappeared. This trees that share habitat with species like the rocky violet (*Hippocrpis balearica*) are deciduous and underdeveloped. There are transition areas between those and oak forests as well.

Other Communities

- Mauritanian vinereed scrubland formed by “càrritx” (*Ampelodesma mauritanicus*) is a very common landscape in the mountain range, especially in the northeastern half. Mauritania grass is a food resource for goats and sheep in addition to be considered a fire resistant plant.
- The Balearic box (*Buxus balearica*) is the predominant species in regions above the 900 m, rocky coast of the central part of the range or Torrent de Pareis. It grows in form of a little shrub and not as a tree itself. Another tree that grows on rocky substrates is *Juniperus phoenicea* that together with the Balearic box suffered a lot under the action of human
because of the production of firewood suggesting that their communities were much more common some years ago.

- There are some highly specialized plants that grow in accumulations of broken rock fragments at the base of rock walls, cliffs or valleys called “rossegueres”. These are for example bindweed and parsnips (*Pastinaca lucida*) and endemic species like *Galium balearicum*, *Euphorbia fontqueriana* or *Arenaria grandiflora* ssp. *bolosi*. But species with has de best adaptations to grow between this rocks is *Linaria aeruginea*.

- The Cuber Lake and Gorg Blau are two well-known wetlands of the Serra de Tramuntana in addition to springs and torrents. This type of habitats are characterized by strict aquatic vegetation with the exception of some specific places were we find hydrophilic vegetation. In Sa Calobra two trees highlight, the tamarisk (*Tamarix* spp.) and vitex (*Vitex agnus-castus*).

- Salt and wind conditions of the coastal parts of the range produce colonization with species that are adapted, for example sea fennel (*Crithmum maritimum*).

**FAUNA**

Human activity is much lower in the Tramuntana range than in the rest of the island, this is why it conserves most of the animal species from Mallorca. A big amount of endemic animal species, invertebrates and vertebrates, could be found also.

**Invertebrates**

Invertebrates form a very large group found in most of the habitats of Mallorca so also in the Serra de Tramuntana. A big part of this invertebrates found in the range are endemic. Within the class Gasteropoda for example *Iberellus balearicus* known as “snake snail”, *Allognathus graellsianus* and various species from the Trochoidea genus are endemic species. *Allolobophora mediterranea* is an endemic oligochaete and *Hahnia hauseri*, *Malthonica balearica* or *Scotolemon balearicus* belong to endemic arachnids. Within the class Crustacea we find endemic cave isopods and *Armadillidium petrusi* and *Porcellio balearicus* only found in the municipality of Escorca.

Insects stand for their role in pollination and therefore for the dispersal of plant species that could be found in the range. *Gonepteryx cleopatra balearica*, *Polyommatus icarus balearica* and *Steroplerus balearicus* are endemic insects.

The beetles order outperforms all the other wildlife groups. The largest proportion of endemic beetles of the Serra de Tramuntana find within the family Tenebrionidae of which some examples are *Tentyria schaumi*, *Alphasida depressa*, *Pimelia criba* or *Nesotes viridicollis viridicollis*.

Crustaceans, Diplopoda and insects are classes that all include some species that is endemic and besides it is considered endangered.

**Vertebrates**

Vertebrates form an animal group that I have a lower among of species, however we can also find typical endemic species in the Tramuntana range. Although Mallorca has few species of amphibians the range is characterized by including one of the autochthonous vertebrates, the Majorcan midwife toad (*Alytes muletensis*) which takes refuge in shallow puddles and torrents of difficult access.

In the Tramuntana we find a high number of bird species. The cinereous vulture (*Aegypius monachus*) is a raptorial bird known as the largest in Europe that was about to become extinct in the Island and now only lives in the Serra de Tramuntana. Other representative birds are the osprey (*Pandion haliaetus*) the red kite (*Milvus milvus*), the common (*Corvus corax*) raven and Eleonora’s falcon (*Falco eleonorae*).
The group of mammals we find in the range include carnivores like the pine marten (*Martes martes*), the genet (*Genetta genetta balearica*), the least weasel (*Mustela nivalis*) and the wildcat (*Felis lybica*).

Rabbits (*Oryctolagus cuniculus*) and hares (*Lepus granatensis*) are two of the lagomorphs we find in the range. But we also find all the typical balearic rodents such as the western Mediterranean mouse (*Mus spretus*) or the black rat (*Rattus rattus*). The Algerian hedgehog is the only insectivore found in the Sierra instead of bats that is a mammal group with a high number of citations. We have the common pipistrelle (*Pipistrellus pipistrellus*) or the European free-tailed bat (*Tadarida teniotis*) in this group. Finally, it is typical to find feral mammals such as feral goats, oxen, pigs or sheep.

Fig. 6: *Capra hircus*, Mallorcan Wild Goat, Cami Vell, Barranc de Biniaraix (Photo: Clara Wuennenberg)

Fig. 7: Pine marten (*Martes martes*), Barranc de Biniaraix (Photo: Clara Wuennenberg)
THE SERRA DE TRAMUNTANA AS A RESOURCE FOR STUDYING THE ENVIRONMENT

JUSTIFICATION

The Serra de Tramuntana is not only the largest natural area of the Balearic Islands it also has a set of characteristics that make it a valuable teaching and learning resource. Properties such as the climate that differs from the one found in the rest of the island, a large plant diversity grouped in different vegetation communities that include a high number of endemic species, wildlife with unique animal species and the karst formations of the range make it very interesting for the study of the environment. Therefore it is proposed to see the Tramuntana range as a teaching resource to explain contents related to the environment through the development of didactic units to enable students to establish a closer relationship with the environment around them.

With this purpose I have developed a booklet of activities for the students in which they will find a set of activities that cover various aspects and contents related with The Serra of Tramuntana. This document could be applied simultaneously to the current textbook used in class as supplementary material to deepen certain content related with the immediate environment of the students.

This set of small didactic units is addressed to ESO students of the subject Natural Sciences as to high school students of Biology and Geology.

GENERAL OBJECTIVES

Conceptual objectives

1. Locate the Tramuntana mountain range and know its geographical characteristics like the boundaries, extension or what municipalities it includes.
2. Understand the importance of the Tramuntana as a World Heritage awarded natural area.
3. Know the characteristics of the typical climate of the Serra de Tramuntana and understand the differences of temperature and rainfall in comparison to the rest of the island.
4. Identify and classify the main relief features of the Serra de Tramuntana, know the geological origin and describe the geomorphological agents that act on the relief.
5. Describe the main hydrological characteristics of the Serra de Tramuntana and locate the main watercourses that can be found.
6. Observe and identify the leading vegetation found in the Serra de Tramuntana, learn their most representative species and its relationship with climate, relief and hydrography.
7. Understand and distinguish the principal animal species of the Serra de Tramuntana and understand the importance of its conservation.

**Attitude objectives**

8. Develop curiosity about the environment around them.
9. Appreciate and respect the point of view of the classmates, both within groups and classroom work in general.
10. Acquire critical attitudes in group discussions about facts, situations and ideas.
11. Raise awareness to the value of protection and preservation of natural landscape of the Serra de Tramuntana.

**Procedural objectives**

12. Interpret, understand and analyze texts, diagrams, questions, tables, images, drawings, maps, etc. used in several activities and be able to acquire information from these resources.
13. Propose and solve questions and problems from the suggested activities about the studied contents.
14. Gain skills in the use of computer tools needed for the activities such as Webquest, the network or the CmapTools for the development of a concept map.
15. Communicate clearly the knowledge acquired in lectures and activities and during the writing of notes, answers, summaries and comments.

**CONTENTS**

**Conceptual contents**

- Main geographical aspects of the Serra de Tramuntana.
- Climate of the Serra de Tramuntana. Maps and climographs.
- Hydrography of the Serra de Tramuntana. Torrents, dams and slopes.

**Attitude concepts**

- Critical and respectful evaluation of the point of view of classmates during class work or group work.
- Recognition of the significance of preserving the environment, the flora, the fauna and the ecosystems of the Sierra de Tramuntana.
- Acquisition of positive attitudes towards the environment and its study.
Procedural contents

- Making of discussions about various concepts related to the nature of the Serra de Tramuntana.
- Development of concept maps, Webquests and literature searches using IT tools.
- Representation of climographs and tables through different proposed activities.
- Analyzing and understanding of scientific and informative texts about the Tramuntana through text comments.
- Classification and identification of common animal and plant species of the Sierra de Tramuntana using various classification tools such as dichotomous keys.

PROPOSED ACTIVITIES

I. Introduction to the Serra de Tramuntana

The aim of this didactic unit is to make an introduction about the Serra de Tramuntana so that students become some basic knowledge about this natural area. Students will gain an overview of the particularities of the Sierra such as its location, different physical, biological properties, and its present status as World Heritage.

Conceptual objectives

- Get a basic or introductory level of knowledge about the Tramuntana range.
- Study the main municipalities that constitute the range, its size, orientation and location in the island.
- Identify the particular physical, biological, cultural and human traits of the Serra de Tramuntana.
- Understand concepts about the environment and the importance of their conservation.
- Comprehend the concept of scale and its importance.
- Know the role of the orientation through the use of maps.

Procedural objectives

- Situate on a map the Sierra de Tramuntana and differentiate the municipalities that comprise the range.
- Get basic abilities for the use of different map types.
- Gain skills of the correct selection of information from different sources whether written or oral.
- Get the ability to use the computer as a research tool.
- Interpret and analyze a text, an article or a book as well as images related to different aspects of the Tramuntana range and extract information from them.
- Learn the basics about interpreting images, maps and graphs.
- Acquire the ability of orientation using a map.

Attitudinal objectives

- Develop appraisement and conservation attitudes for the physical environment.
- Consider the importance of holding a respectful relationship with the environment, the different ecosystems and, plant and animal species found in The Serra de Tramuntana.
- Appreciate and respect the point of view of classmates during group work and in general in the classroom.

Key competences

- Competence in information processing and digital competence through activity 2 and 3 where students will use computer tools to search and process information. In the second exercise
students will be able to obtain information from a map and in both activities it’s required that students are able to analyze and synthesize information from different sources used.

- Competence in knowledge of and interaction with the physical world as all activities are based on geographical features of the Serra de Tramuntana, which is student’s environment. In exercise 2 students will learn to orient themselves using a map.
- Competence in autonomy and personal initiative because in all the activities the students will solve questions, do research on their own and develop their own opinions and point of view about the Serra de Tramuntana. Through solving the activities, students will be able to select the most fitting information and in activity 3 group work will be promoted.
- Competences in linguistic communication as all activities require a correct oral and written expression. It will be also required consistency during the discussions and the use of appropriate terminology.
- Social and civic competence because students have to express and defend their own ideas and point of view with autonomy respecting the ideas of others and use dialogue to reach accords for the resolution of the activities and when the teacher raises a question in class like in exercise 1 or during the group work in activity 3.
- Competence in learning to learn through activity 1 where students must make their own notes as well as in number 2 and 3 which require a special research.
- Artistic and cultural competence in all of the activities because students will appreciate the importance of contribution to the conservation of the Serra de Tramuntana.
- Mathematical competence through exercise 2 in which the students must compare different numeric values or magnitudes and make simple calculations with distances. In exercise two students need to interpret graphs and analyze information provided by a municipalities map.

**ACTIVITY 1: Brainstorming and introduction about the Serra de Tramuntana**

The activity starts with suggesting that the students say all what they know about the Tramuntana range orderly and respecting all the classmates. On the blackboard the teacher is going to write all the answers that students can copy in their notebook. Then the teacher will explain some introductory concepts with a PowerPoint about the Sierra de Tramuntana, this presentation is mainly based on a set of images that students should be able to interpret.

**ACTIVITY 2: Boundaries, extension and orientation**

In the activity booklet students will find a map of the different municipalities of Mallorca and a number of questions that must be answered with the help of this map. They will also make use of research tools like the Internet and they will need to manage materials such as a ruler to measure distances.

**ACTIVITY 3: World Heritage Status**

Students will form groups of 3 students and the teacher will order them to do research on the Tramuntana mountain range and its role as a world heritage. They may use Internet but also will have available some books and publications. The information gathered will be discussed all together at the end of the session. Finally students must think about which should be the most appropriate behavior in a natural area such as the Sierra de Tramuntana. In the booklet they find some questions about this.
II. Climatology of the Serra de Tramuntana

Through this unit the students will work on the particular climate characteristics of the Serra de Tramuntana on a practical and theoretical level using maps, climographs, data tables and text.

Conceptual objectives
- Remember the main features of the climate of the Balearic Islands.
- Review concepts related to climate as isohyet, isothermal, temperature variation, index Embberger ...
- Differentiate between the climate of the Serra de Tramuntana and the climate of the rest of the island.
- Acquire knowledge on rainfall and temperature characteristics and refer them with the relief of the Serra de Tramuntana.
- Understand the function and importance of climographs and other graphics about the climate of the Serra.

Procedural objectives
- Use climographs as a source of information about the climate of the Serra de Tramuntana.
- Interpret and create climographs with temperature and precipitation data of a specific municipality.
- Understand and analyze texts about the climate of the Tramuntana range and write a text review to reflect relevant information.

Attitudinal objectives
- Develop aware attitudes to climate features of the Balearic Islands, and in particular the climate of the Serra de Tramuntana.
- Consider the importance of maintaining a respectful relationship with the environment and its relation to the climate of the Sierra.
- Wake up interest in understanding different contents and different graphics, maps, climographs about the climate of the Balearic Islands.
- Appreciate and respect the point of view of their classmates within groups and in general inside the classroom.

Key competences
- Competence in information processing and digital competence through activities that require IT to make climographs or research on the climate of the Balearic Islands. Students with activities 2 and 5 get climatologic information through maps, in activity 3 from climographs and finally in activity 4 via a text.
- Competence in knowledge of and interaction with the physical world because there are activities that link the climatology concepts with natural phenomena of the Serra de Tramuntana.
- Competence in autonomy and personal initiative in all the activities the students will answer questions and work on their own. In addition they have to build their opinion about various aspects of the climate of the Serra de Tramuntana.
- Competence in linguistic communication in all activities as students enhance their oral and written communication during the debates on the climate of the Serra de Tramuntana in classroom activities or notebook related activities. It requires the use of appropriate scientific terminology to refer to the climate in all activities.
- Social and civic competence especially with discussions like in the first activity where students will interact, cooperate and express their own opinions while respecting those of others.
• Competence in learning to learn because all activities promote the development of those skills involved in learning about the climate of the Serra de Tramuntana. The exercises include climatographs, maps and texts as resources for learning about climate.
• Artistic and cultural competence especially in exercise 3 where students have the option to draw or design a climograph.
• Mathematical competence with simple calculations based on temperature and rainfall and through the analysis or elaboration of climographs. Also during the interpretation of a mathematical formula such as the Index of Emberger in activity 2.

**ACTIVITY 1: What do you know about the climate of the Balearic Islands?**

In this motivation activity students have to complete their exercise booklet with everything they know about temperature, rainfall related to the Balearic Islands climate. The different answers will be discussed with the other students and the teacher. Inside the booklet they also find some questions about the particular climate of the Serra de Tramuntana.

**ACTIVITY 2: Climate subtypes of the Balearic Islands**

In the booklet students will find a map designed by Jose A. Guijarro which represents the different climate subtypes that can be found in Mallorca according to Emberger. The exercise is based on distinguishing the climatic differences inside of the Serra de Tramuntana. The students also have to get information about the Emberger climate rate.

**ACTIVITY 3: Climograph**

The students will be able to interpret and elaborate a climograph. In the first part of the activity students will interpret climographs of different municipalities of Mallorca and answer the questions. The second part of the activity is focused on the elaboration of a climograph of Lluc based on real temperature and precipitation values. In addition they have to compare it with the graphics about other municipalities. Students can use graph paper or use the computer to make this climograph.

**ACTIVITY 4: Text review**

Students will find in their booklet a text from Guijarro J (1986) about the climate of the Balearic Islands.

The text is especially focused on the part that corresponds to the rainfall. Students must read the text carefully and prepare a text review. At the end of the text they find a set of questions that will help in selecting the right information.

**ACTIVITY 5: Isotherms and isohyets**

With the three isotherms and isohyet maps students will understand the difference between these two terms. They also must be able to interpret and comment on different aspects related to temperatures and precipitation in the Serra de Tramuntana. Answering the questions they will see which aspects are relevant when they have done comment on the different maps.
III. Geology of the Serra de Tramuntana

With the proposed activities for this unit the students will acquire basic knowledge about the relief of the Serra de Tramuntana. The activities are based mainly on its geological formation process, karst and other relief morphologies and which act on the range modifying this relief.

Conceptual objectives
- Get a basic level of knowledge about the different types of rocks that could be found.
- Understand the processes of formation and origin of the Tramuntana mountains.
- List the different forms and geomorphological models found in the range.
- Understand the characteristics of karst topography and karstification and identify the landscape that results after such a process.
- Distinguish between the different types of rocks and materials that form the Serra de Tramuntana.
- Identify the geomorphological factors that act on the mountains and their effects on the relief.

Procedural objectives
- Identify the different geological elements that form the Tramuntana range through images and pictures.
- Develop drawings and a summary table of several karst forms.
- Prepare schemes or concept maps based on knowledge about the relief of the Tramuntana range.
- Participate actively and with motivation in the proposed activities in class.
- Acquire skills in the use of IT tools or programs such as CMAP tools used to build concept maps.

Attitudinal objectives
- Analyze and comprehend the importance of limestone and its relationship with the relief of the Serra de Tramuntana.
- Appreciate and respect the point of view of the classmates in work groups and in the classroom in general.
- Treasure the importance of relief of the Tramuntana mountains and the aspects that differentiate it from the rest of the island.

Key competences
- Competence in information processing and digital competence as students must interpret the information given by maps, texts, tables, concept maps, photos and drawings. Moreover IT tools such as CMAP Tools are required to develop the concept map on karst forms or to find information about geology concepts.
- Competence in knowledge of and interaction with the physical world especially with the activity 2 in which students will have samples of minerals obtained directly from the physical environment, in this case the Serra de Tramuntana.
- Competence in autonomy and personal initiative during the development of different activities where students will enhance their personal initiative and interest to communicate appropriately their knowledge of the geology of the Serra de Tramuntana both in group work or individually.
- Competence in linguistic communication students will describe orally and in written form particular features from the landscape of the Tramuntana range in a suitable and consist way using the appropriate vocabulary.
• Social and civic competence especially during the second activity where students have to respect the opinions of all group members to prepare the property table about limestone.
• Competence in learning to learn for example with activity 4 in which students will develop a conceptual map that summarizes and organizes information about karst topography to ensure apprenticeship.
• Artistic and cultural competence in activity 4 where students can show their creativity when they elaborate the map.

**ACTIVITY 1: Geological origin of the Tramuntana mountains and the materials that integrate it**

This activity of the booklet begins with a text taken from the textbook BIOLOGIA I GEOLOGIA 4ESO, McGrawHill that talks about the different formation processes of the Serra de Tramuntana. This text is complemented with an image that represents the lithology of the range so that the students have to identify the different materials that make up the Serra de Tramuntana. The students will prepare a brief summary about the origin and formation of the range.

**ACTIVITY 2: Limestone**

The teacher will bring to class different types of rock with the purpose to explain the most relevant aspects about the materials that form the Tramuntana mountains. Students will develop table in groups that includes the main properties of limestone such as porosity, hardness, colour, composition, fracture, streak, luster and its reaction with acid.

**ACTIVITY 3: Geomorphological agents that affect the Serra de Tramuntana**

There is a set of factors acting on the geomorphological structures of the Serra de Tramuntana; this activity from the booklet is intended that students link these factors with the effect that they produce on the relief.

**ACTIVITY 4: Concept map on karst topography**

The teacher will introduce karst geomorphology. Students have to identify the figures of several karst formations that can be found in the Serra de Tramuntana and design a concept map with the content they learned.

**ACTIVITY 5: Comparison chart**

In addition to the concept map, the students will also prepare a comparison table of the various karst forms. They must identify the structures through different graphics and complete the table they find in their booklet. Students besides this identification will have to make a brief description of each structure. This comparison chart will be useful for students as a synthesis about all karst formations found in the range.

**ACTIVITY 6: Other geomorphological formations**

The first part of this activity suggests a review of the karst landscape with true or false exercise and some questions. Students will be able to remember not only several karst formations, also the process of carbonation and atmospheric
phenomena involved in karstification. Since the Tramuntana mountains also has other geomorphological formations, students in the second part of this activity may differentiate these modifications through some pictures. With these photographs of the range students will briefly describe each of the modifying processes in the booklet.

IV. Hydrography of the Serra de Tramuntana

The unit about hydrography consists of activities based on watercourses that form the Sierra de Tramuntana, its location and distinctive features. Moreover it is intended that students are aware of the importance of proper use of a resource as water.

Conceptual objectives

- Understand the different characteristics of the hydrography of the Tramuntana range.
- Distinguish between the Tramuntana torrents from other streams of the island and know the properties that characterize their morphology.
- Understand the main torrents that are part of the Serra de Tramuntana.
- Explain concepts such as slope and torrents.
- Discuss the reservoir/dam as a form of accumulation of water in the Tramuntana range.

Procedural objectives

- Locate on a map of the Serra de Tramuntana torrents and hydrographic slopes.
- Identify images that reflect ways of storage of water in the Tramuntana range.
- State reasonably about the different characteristics of the torrents of the Serra de Tramuntana and the climate and relief factors acting on these streams.

Attitudinal objectives

- Appreciate the importance of water storage in the Tramuntana range.
- Appraise the elements that have an influence on the characterization of the hydrography of the range.
- Tolerate and respect the point of view of the others within the work groups and in class.

Key competences

- Competence in information processing and digital competence in both activity 1 and activity 2 because the students will interpret information about the hydrology of the range through photographs and maps. For solving these activities they can also use tools such as the network or other sources of information.
- Competence in knowledge of and interaction with the physical world as all concepts of hydrography worked in the activities are directly related with the physical environment of the students.
- Competence in autonomy and personal initiative because all activities about the hydrography of the Tramuntana range require that students be able to undertake, develop and evaluate their work independently and with a confident and critical attitude.
- Competence in linguistic communication because students will express themselves in a safe and smooth way for a coherent development of the activities using vocabulary and lexicon related to hydrography.
- Social and civic competence with activities that are discussed in the classroom. Students must respect their turn and listen to other opinions to discuss the answers to the activities based on dams, torrents or slopes.
• Competence in learning to learn during the development of several activities students will consider what you know about streams, slopes and dams and what they need to learn about it to improve.
• Mathematical competence because students will work with a map where they should compare the length of different torrents of Mallorca.

**ACTIVITY 1: The slopes and torrents of the Serra de Tramuntana**

In the booklet students will find a map where they must situate the slopes and torrents of Mallorca. Students will be asked to review concepts like “torrencialitat” and hydrographic slope. In another part of the question students must think reason of the particular hydrographic properties of the island (in terms of climate and relief). With the map students will locate the torrents from the mountain range and compare them with the other torrents of the rest of the island.

**ACTIVITY 2: Storing Water**

Students will find a picture of a dam that they have to identify and answer to several questions about water storage.

**V. Fauna of the Serra de Tramuntana**

This didactic unit let the students know about particular fauna of the mountain range, they will investigate what species are or were there years ago and also are familiar with certain conservation and reclamation plans that take out now.

**Conceptual objectives**

• Understand concepts such as biodiversity, endemic, invasive species or extinct species.
• Know the different animal species that can be found in the Serra de Tramuntana and locate them in their natural habitat.
• Understand the relationship between animal species and the environment they are found in.
• List the various conservation and recovery plans of species related to the Serra de Tramuntana.
• Distinguish the Mallorcan wild goat as a species that can be found in the Tramuntana mountains and know their habits and diet.

**Procedural objectives**

• Identify different species that are representative of the Tramuntana mountains in images, figures or in the environment.
• Acquire skills in the use of IT tools required during the activities such as the internet or Webquest.
• Use of a scientific publication as a source of information, in this case about the Majorcan goat.
• Become familiar with the methods of sampling, processing and interpretation of data in a scientific study.

**Attitudinal objectives**

• Understand the value and importance of mountain wildlife.
• Evaluate a scientific publication as a resource of relevant information and raise awareness with the execution of a scientific study.
• Demonstrate positive attitude with regard to the protection and preservation of fauna.
• Appreciate the importance of conservation and regeneration plans of species that could be found in the Serra de Tramuntana.

Key competences
• Competence in information processing and digital competence with activities that invite students to interpret information about the fauna of the Tramuntana mountains through a scientific publication as in activity 3. In activity 1 students will carry out an Internet search to resolve the proposed questions of the Webquest and activity 2 students need to observe and comment on the images that give information about the particular fauna of the range.
• Competence in knowledge of and interaction with the physical world especially when students are asked to assess and sensitize with the importance of protecting the wildlife of the Serra de Tramuntana.
• Competence in autonomy and personal initiative in all activities as students have to solve the exercises on their own and stay motivated to achieve success in the proposed tasks about the animals of the range.
• Competence in linguistic communication because in all activities the students should list and describe the fauna of the Serra de Tramuntana using appropriate vocabulary and terms and put into practice scientific names of different species.
• Social and civic competence during the participation in workgroups where students have to express their own ideas and defend them on a self-reliant way, but also respect the ideas of others and use them to enhance dialogues on issues related with the fauna of the Serra de Tramuntana.
• Competence in learning to learn during the effectuation of the activities the students get awareness of one’s own abilities and they will maximize several learning techniques such as attention, concentration, memory and speech.

ACTIVITY 1:  **Webquest “Fauna of the Sierra de Tramuntana”**

This activity should be done in the computer room and the students will have to acquire the theory solving a Webquest. The main objective is that students should be able to do a research about the fauna of the Serra de Tramuntana. The students have to get together in different workgroups with a maximum of 4 students and follow the instructions indicated by the Webquest page. It consists of two parts, the first activity is focused on that the students must investigate what species of animals are found in the range and which of those are endemic. And also this part introduces concepts like conservation and recovery and asks for an interpretation of a conservation plan. In the second part of the activity students will be able to select four species from the list and they should complete a table in the booklet with some properties of the animals.

Link: https://sites.google.com/site/lafaunadelaserradetramuntana/

ACTIVITY 2:  **Invasive, extinct, endemic and protected species**

In the booklet students will find a set of photographs of animals that must be classified as invasive species, extinct, endemic or protected. Students must also answer questions propounded below.
ACTIVITY 3: *Majorcan wild goat*

Another method to obtain certain information are articles in scientific magazines or publications. Students will have a paper related to one of the species found in the Serra de Tramuntana such as mountain goats. Students must read the article and with the provided information they should be able to answer the questions. By reading the article students can also acquire some basic knowledge of sampling and processing techniques and interpretation of results during a scientific study.

VI. Flora of the Serra de Tramuntana

This unit is focused on the study of the characteristic vegetation of the Serra de Tramuntana. Students will learn the characteristics of different ecosystems and plant communities and the most representative species of plants found in them. The students will be able to classify some plant samples and know about the principal endemic species of the Tramuntana mountains.

**Conceptual objectives**

- List and locate the different vegetation that can be found in the Sierra de Tramuntana.
- Observe and identify different plant species that are predominant in the Serra de Tramuntana.
- Know the main categories that plant species are classified into.
- Learn and distinguish the main morphological and anatomical characteristics of plants that are useful to identify plants.
- Understand the concept of endemic species and know the main endemisms found in the Serra de Tramuntana.

**Procedural objectives**

- Make sheets or tables that summarize the main characteristics of different species of plants found in the Serra de Tramuntana.
- Analyze and identify the morphology and anatomy of plant species.
- Acquire basic knowledge about the use of dichotomous keys and a virtual herbarium to identify different plant species.

**Attitudinal objectives**

- Understand the value and importance of mountain vegetation.
- Gain awareness and respect for the plant species found in the Serra de Tramuntana.
- Evaluate in positive way species diversity and develop favorable attitudes related to their conservation and protection.

**Key competences**

- Competence in information processing and digital competence through activities that promote the use of IT tools, files, photos and dichotomous keys to learn the different plant species found in the Serra de Tramuntana.
- Competence in knowledge of and interaction with the physical world especially when the students learn the main vegetation layers in the Serra de Tramuntana or when they should think about the relationship between human activity and flora. Students are also asked to analyze the importance of conservation and protection of plant communities.
- Competence in autonomy and personal initiative in the development of all the activities when the students have to search for information independently and represent the content related to plant the Serra de Tramuntana with initiative, creativity and organization.
• Competence in linguistic communication because all activities require consistent and appropriate use of scientific terms and vocabulary related to the flora of the Tramuntana range both orally and in writing.
• Social and civic competence especially in activities that are developed in groups such as the plant classification where students have to present and defend their point of view respecting the opinions of other students.
• Competence in learning to learn during the resolution of activities where students should be aware of what they have known about the different plant species and detect the contents about plants that need to be improved.
• Artistic and cultural competence during the plant classification where students can develop their creativity by drawing the leaves and other structures of different plant species.

**ACTIVITY 1: Plant classification**

For this activity are needed different samples of the characteristic plants of the Balearic Islands and the Serra de Tramuntana. It begins with a review of the categories in which plants can be classified. Students must define the different plant life forms like shrubs, liana, herbs or trees. Once established the differences between these terms in the booklet students will find a tab that must be completed in workgroups. The aim is to classify plant specimens with a dichotomous key. The groups will also have access to some sheets about plant anatomy and morphology and to the virtual herbarium of the UIB.

**ACTIVITY 2: Plant communities**

This activity of the booklet suggests that students should remember the different plant communities found in the landscape. Different species must be attributed to the community in the Sierra de Tramuntana to which they belong. In addition students should complete the exercise with the scientific name of the plant using the available tools or resources.

**ACTIVITY 3: Endemic plants from the Serra de Tramuntana**

If in the Tramuntana range some animals are endemic, endemic plants could also be found there. With this activity students will review the concept of endemism but above all they will learn the different features of the endemic plants from the Serra de Tramuntana. The activity on the one hand refers to the previous activity (plant communities) and on the other hand students find a set of questions that they must answer also with the help of the available reference material.
ASSESSMENT

Due to that the evaluation is formative and continuous along the development of the different proposed activities there are three types of evaluation: an initial evaluation through activities that are useful to review the previous knowledge about the basic concepts, second a process evaluation that coincides with the general evaluation criteria and finally a final evaluation carrying out a final exam with questions such as proposed below.

General evaluation criteria

- Locate the Serra de Tramuntana in relation to the rest of the island, know its limits and dimensions and list the municipalities that comprise it.
- Understand the main features of the climate of the Serra de Tramuntana and explain the factors that determine the climate.
- Identify the relationship between the climate of the range, its geology and its flora and fauna.
- Situate and characterize the major torrents, dams and slopes of the Tramuntana range.
- Understand the geological origin and describe the materials and rocks that comprise the Serra de Tramuntana.
- Identify and characterize the relief of the Serra de Tramuntana and the factors that modify this relief.
- Identify the main plant formations that can be found in the Serra de Tramuntana.
- Learn the fauna of the Serra de Tramuntana in its diversity of species.
- List and describe the major endemic flora and fauna of the Serra de Tramuntana.
- Understand the function of conservation and regeneration plan for any animal species.
- Know how to use and interpret maps, texts, figures, sheets, tables etc. to know and understand the major characteristics of the Serra de Tramuntana.
- Learn to handle several tools that are useful for finding information.
- Create a climograph, tables, concept maps and summaries of the studied contents.
- Be able to work in teams or on their own always respecting the opinion or point of view of other classmates and the teacher during discussions, dialogues and theory sessions.
- Develop appraise attitudes to the different elements that comprise the Serra de Tramuntana, and reflect about the importance of protection, conservation and a good behaviour with the environment.

Exam models

*Multiple Option*

1. Which of these towns is not part of the Serra de Tramuntana?
   a. Sóller
   b. Pollensa
   c. Sineu

2. Which of these peaks does not exceed the 1000 m?
   a. Òfre
   b. Namarch
   c. Massanella
3. **Which of these animal species from the Serra de Tramuntana is endemic?**
   a. Cyclamen balearicum
   b. Alytes muletensis
   c. Atelerix algirus

4. **Which of these shrubs can be found in the Tramuntana mountains?**
   a. Hypericum balearicum
   b. Quercus ilex
   c. Linaria aeruginea

5. **Choose the correct option regarding the climate of the Serra de Tramuntana.**
   a. The maximum rainfall occurs in the highest areas of the Sierra due to the higher number of rainy days.
   b. The temperatures of the Serra de Tramuntana are increased compared to the rest of the island because of its altitude.
   c. Rainfall in the Sierra de Tramuntana exceeds 1200 mm in areas such as the Santuari de Lluc.

6. **Related to the high mountain vegetation ...**
   a. You can find a continuous oak forest system.
   b. The plants are subject to weather conditions that are uniform, similar in both winter and summer.
   c. The “Coixinet de monja” develops spines to survive versus herbivores and grows adapted to the rocks to protect themselves from the wind.

7. **During the process of carbonation**
   a. Rainwater is able to dissolve metamorphic rocks can be found in the range.
   b. Rainwater combines with CO2 forming carbonic acid that dissolves the limestone.
   c. Holes and cracks called stalactites appear on the surface of solid limestone.

8. **What exokarstic structure is formed by the collapse of the roof of a cavern?**
   a. Lapiaz
   b. Cave
   c. Stalactites

9. **Choose the correct option related to the hydrology of the Sierra de Tramuntana**
   a. Torrents in the northwest have a very short course, a pronounced incline and some examples are Torrent de Pareis, de Mortitx and de Soller.
   b. In the Tramuntana mountains we find a natural reservoir called Cúber that supplies water to the Palma.
   c. Torrents are characterized by having an irregular flow but they are always active.

**True or false**

1. The Serra de Tramuntana is aligned in NW-SE direction, has a length of about 100 km and is about 15 km wide.

2. The climate of the Serra de Tramuntana is different from the one that occurs in the rest of the island by only having a higher rainfall register.
3. The maximal temperatures are recorded while the rainfall also is the highest.

4. The grey colour of the Tramuntana is due to the abundance of limestone, a rock not modified by the action of water.

5. Fluvio-torrential modeling is responsible for forming the cliffs and coves.

6. The rivers we find in the Tramuntana range are shorter compared to them of the rest of the island.

7. An endemic species is this one that is unique in a geographical area and is particularly vulnerable to changes in their environment.

8. An invasive species like the coati is an exotic species that gets established in natural or semi natural habitats and ecosystems and that’s why its conservation is necessary.

9. The Majorcan wild goat has a similar diet to the one of a domestic goat and with preference for *Olea europaea*.

10. “Pa porcí” is an endemic plant mainly found in coastal communities. In contrast *Linaria aeruginea* that also is representative of rocks and moving stones.

**Short answer**

1. Where is the Sierra de Tramuntana located? Make a list of the municipalities that made it up.

2. What do you think about its declaration as a World Heritage?

3. What features would you highlight related to the climate that we find in the Tramuntana range?

4. What do you know about the origin of the Serra de Tramuntana? What is the main material that makes up the range?

5. Found the relationship between climate, relief, wildlife, vegetation and hydrography of the Serra de Tramuntana.

6. What hydrological features are typical of the Tramuntana range?

7. What animal species are part of the fauna of the Serra de Tramuntana? Mention which of them are endemic. Why do you believe it is important that these endemic animals are preserved? What behaviors can we adopt to enhance conservation?

8. In which habitat could we find the Majorcan wild goat? What can you say on the selection of its diet?

9. Lists the plant communities that can be differenced in the Serra de Tramuntana and what are its most representative species.

10. Choose a plant endemism of the Serra de Tramuntana and describe its anatomy and morphology.
MATERIALS

1. **Textbook and activity booklet**: In the textbook the students will find all the basic content and concepts they should know to be able to solve and understand the activities of the booklet. The activity booklet will be used when it’s appropriate, for example if pupils are studying the plants in general the last session could be dedicated to complete the unit “Flora de la Serra de Tramuntana” of the notebook.

2. **Moodle platform**: students being already familiar with the use of IT tools (Information and Communication) will find a set of resources that will help consolidation of the concepts seen in class:
   - **PowerPoint**: the platform, the student will find the PowerPoint presentations used during the lectures so they can use them once the session is over.
   - **Worksheets, solution keys, other sheets used in the different activities**: these resources are also available on the Moodle platform. Students can access, review and repeat them as many times as needed.
   - **Visual elements**: there will be available videos and other visual material on the Moodle platform related to the explanations given in class about the Serra de Tramuntana.
   - **Forums**: are useful for solving doubts among students and teachers
   - **Web Links**: in the Moodle platform the students find a set of links to useful websites about the Serra de Tramuntana.

3. **Practice part**: in some actives real samples are needed to be able to develop them so the teacher is responsible to bring material such as the rock and mineral samples, plants that should be classified and other objects and samples needed to exemplify any concept explained during the lessons.

BIBLIOGRAPHY

**Books, book chapters, publications**


**Websites**