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Grupo de Desarrollo Rural Subbética



#### UNDERGROUND HERITAGE AND EUROPEAN TOURIST CAVES









### C1.- TRAINING COURSE



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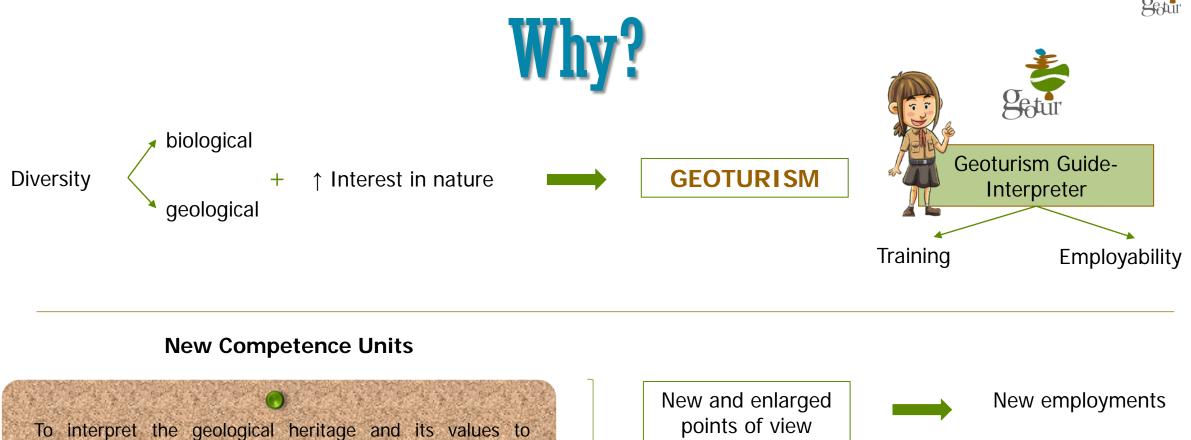
# GEOTURISM GUIDE-INTERPRETER











geotourists and visitors of European Geoparks.

To provide accompaniment and assistance services to geotourists and visitors, designing geotouristic itineraries through places of geological interest.



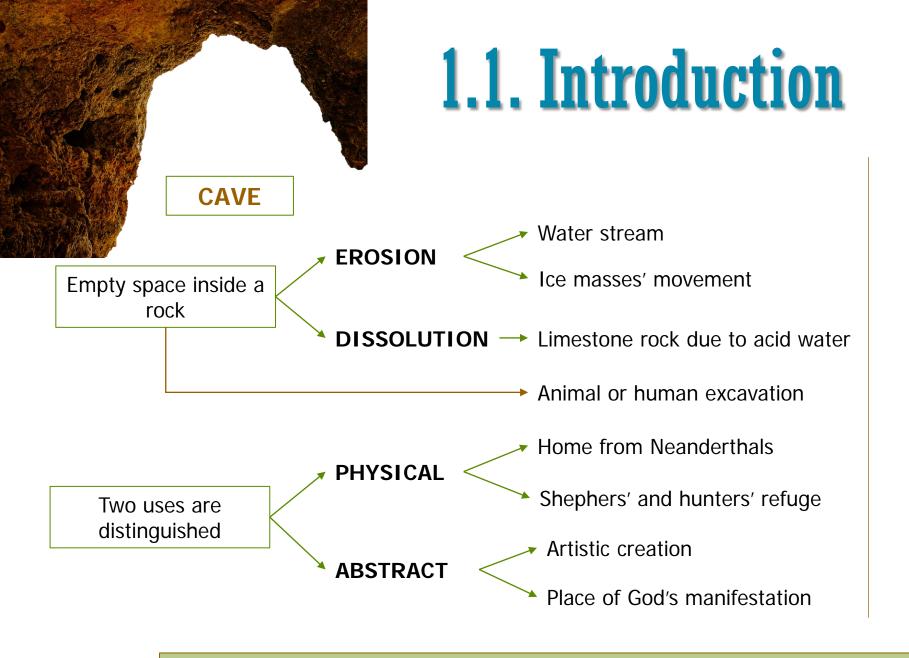
# DIDACTIC UNIT III. UNDERGROUND HERITAGE AND EUROPEAN TOURIST CAVES



In this didactic unit, different points related to **underground landscape** will be taken into account, from <u>rocks' formation</u> basic concepts to <u>karst modeling</u> and **cave's formation**, as well as, a selection of the main <u>European tourist caves</u>.

### MODULE 1: The caves' formation

- 1.1. Introduction
  1.2. Carbonate rocks
  1.3. Groundwater
  1.4. Initial stages of karstification
  1.5. Processes of phreatic and vadose regime
  1.6. Cavities' evolution
  1.7. Other processes of formation
  1.8. Non-karst cavities
- 1.9. Karst landscapes' evolution



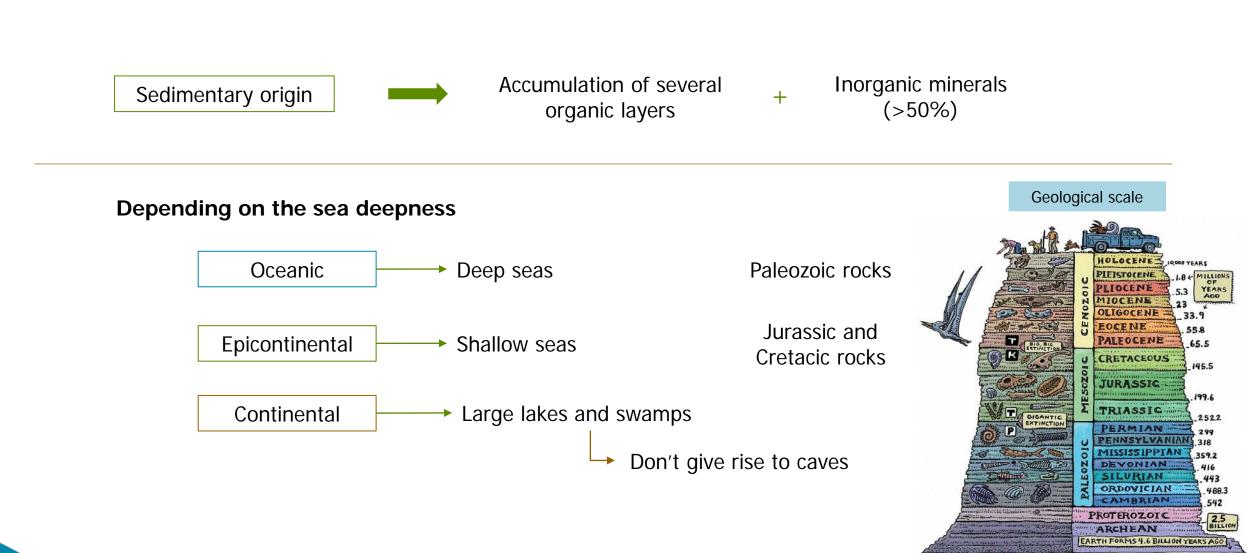
### SPELEOLOGY

This science studies underground domain, taking into account the physical part of the cave, its formation, composition, structure and the development of its speleothems (geological formations), being the most known stalactites and stalagmites.

Almost the 90 % of large caves have been developed on carbonate rocks.



### **1.2. Carbonate rocks**



https://www.meteorologiaenred.com/el-tiempo-geologico.h

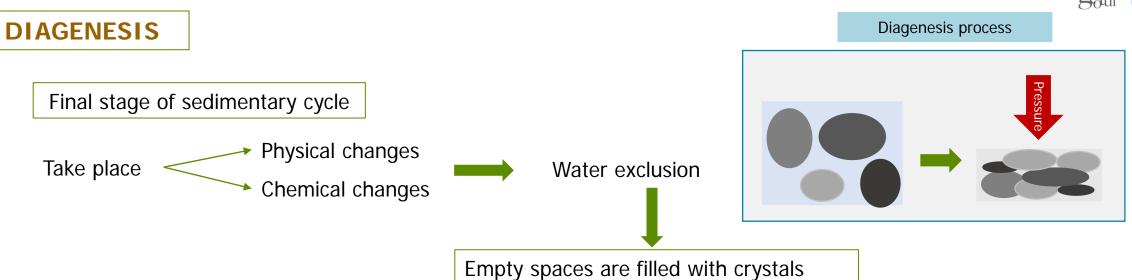
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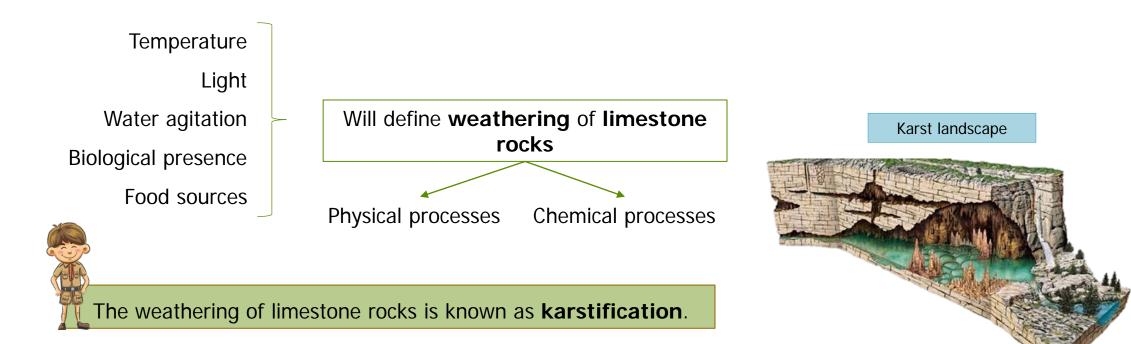




### **1.2. Carbonate rocks**

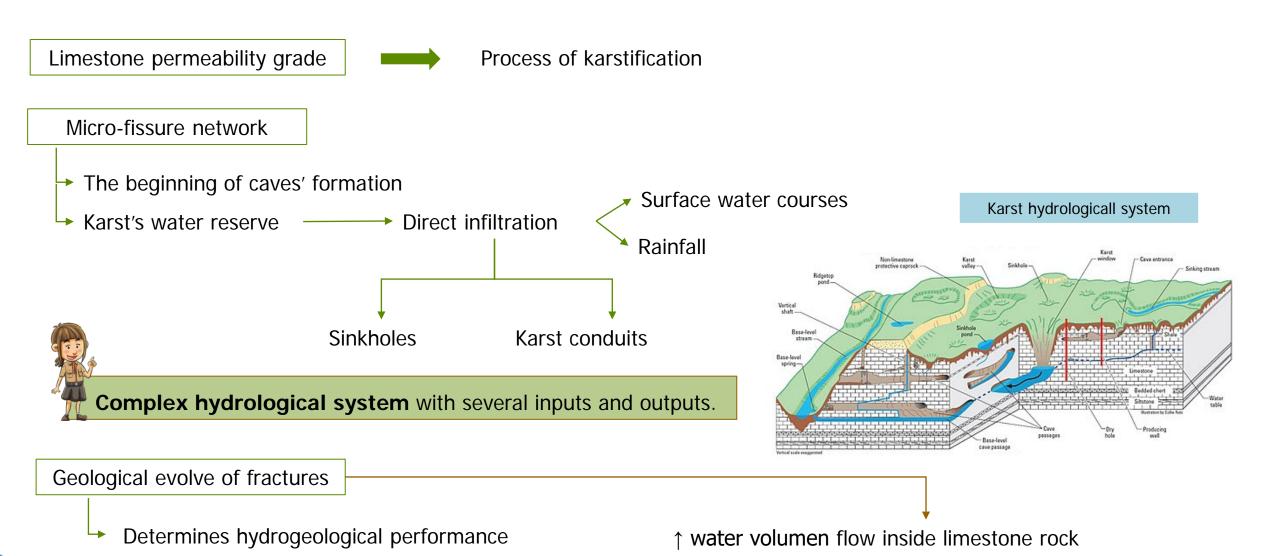








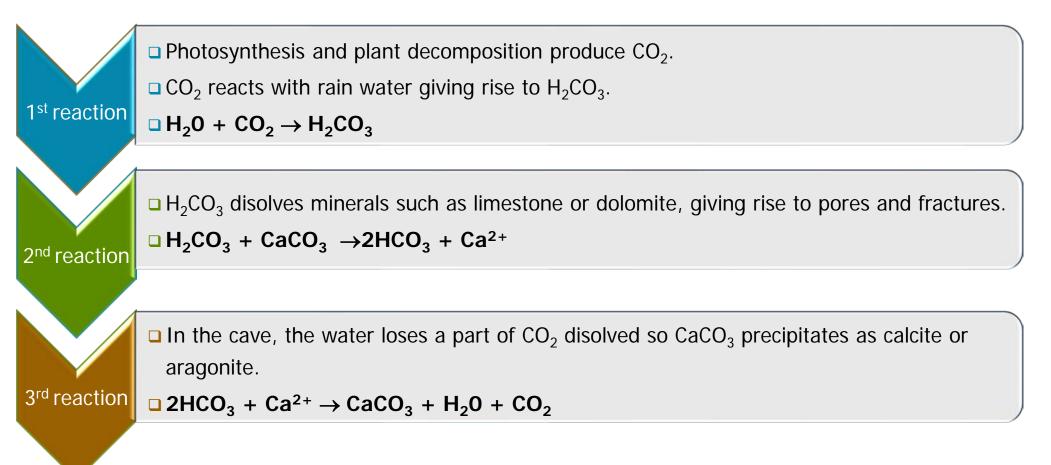
### 1.3. Groundwater





# **1.4. Initial stages of karstification**

#### From rock until molecular level



### SEVERAL YEARS LATER...



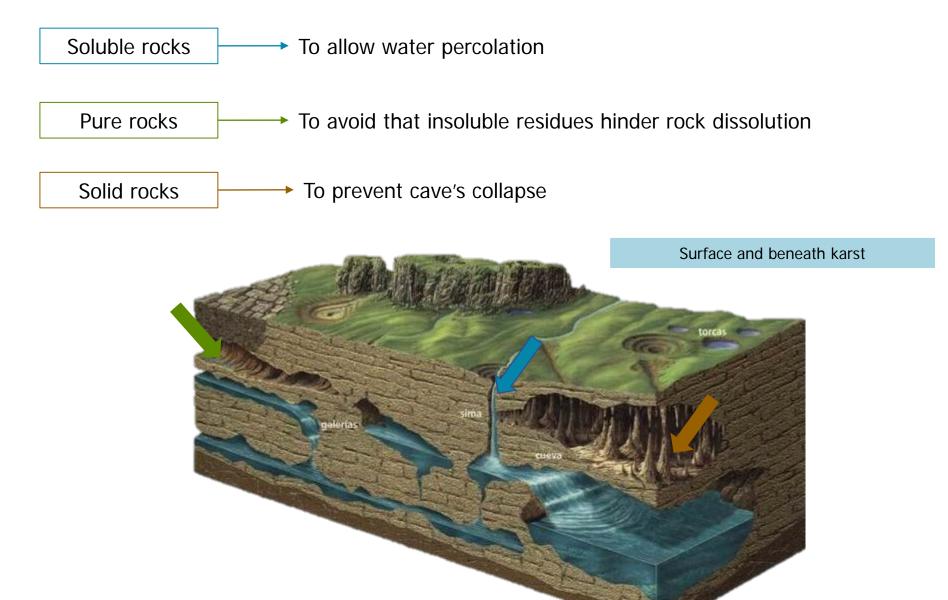




Postojna Cave, Inner Carniola (Slovenia)



#### Conduits are formed in:



#### DOLINES

Main karst formations

Circular shaped depressions with sloping walls due to

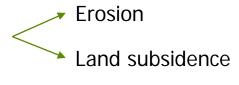
Diferent terms depending on physical features, but **sinkhole** can be used for all of them

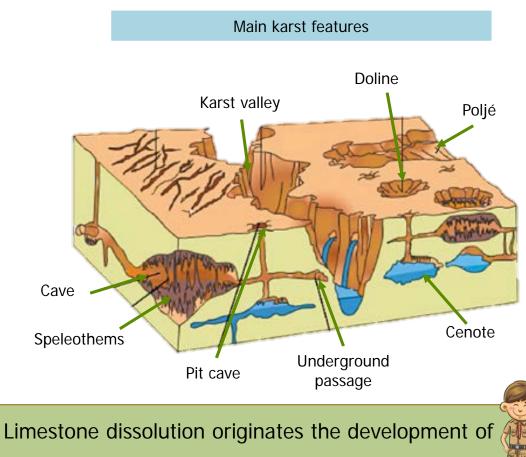
**Pit cave**. Doline connected with an underground cave

Cenote. Flood dolines

**Poljés**. Several dolines are joined which makes an elongate valley that can be flooded

A **collapse doline** is formed when the cavern ceiling is sunk.







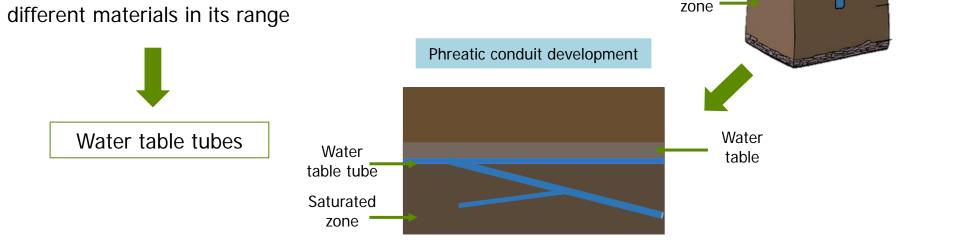
# **1.5. Phreatic and vadose regime's processes**

Hydrology determines the evolution and the development of karst systems because the water, that goes through the rocks, degrades some morphologies and enlarges other ones, connects surface karst and beneath karst and changes water table.

**KARSTIFICATION PROCESSES IN PHREATIC REGIMEN** 

Both conduits and cavities under water table are permanently filled with water

Homogeneous rock dissolution



Saturated

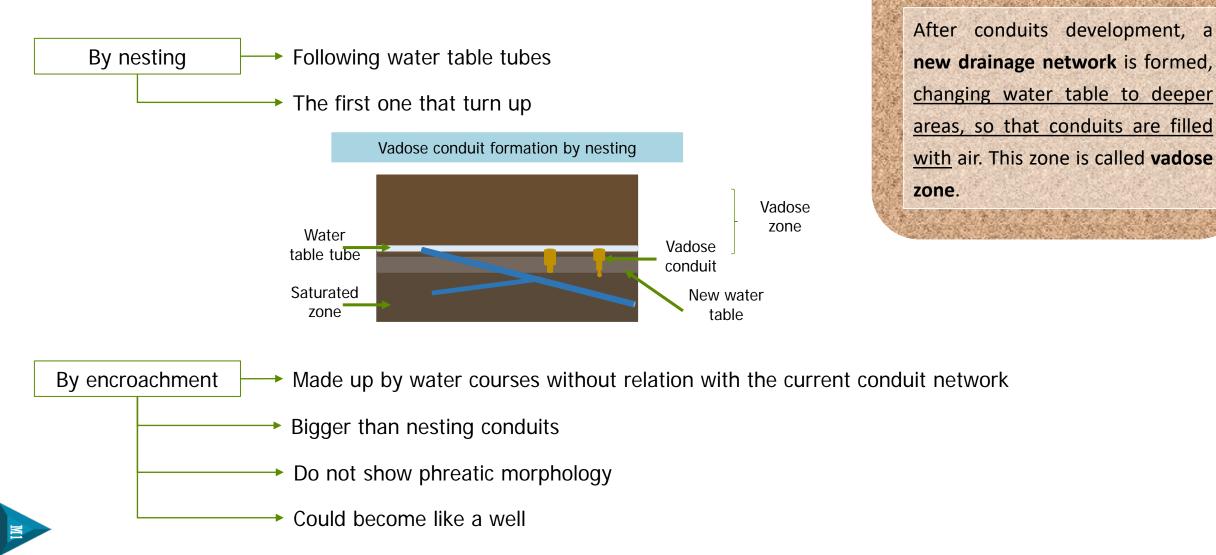
Water table

Irregularities due to the different materials in its range



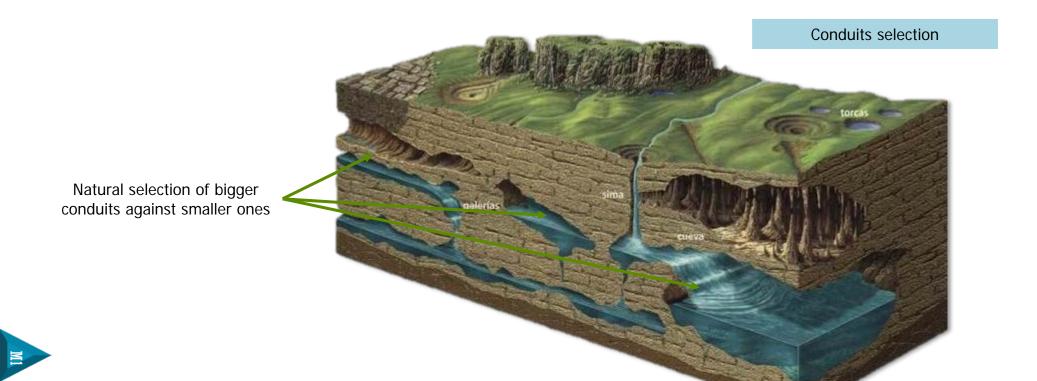
### KARSTIFICATION PROCESSES IN PHREATIC REGIMEN

#### There are two vadose conduits:





Karst is characterized by low surface runoff and high infiltrations that circulate in a hierarchical way, so that <u>caves</u> are formed due to <u>weathering and dissolution of karst conduits</u>. Bit a bit, **natural selection** of bigger ones occurs, which will give rise to caves in the future.

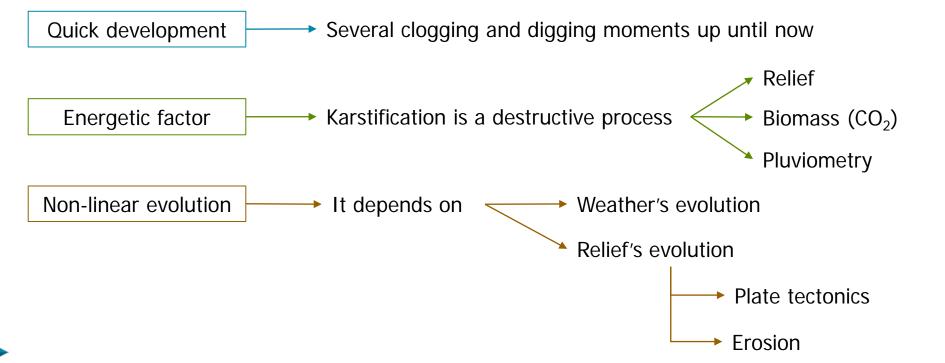




### **1.6. Cavities' evolution**

Cavities are the result of <u>complex evolution</u> where collapse, sinking and rock's dissolution are combined so that <u>determine the age of a cave is complicated</u> because traits and signs of previous phases have been lost. With dolines, their presence determines the karst landscapes.

#### **Cavities evolution:**







# 1.7. Other processes of formation

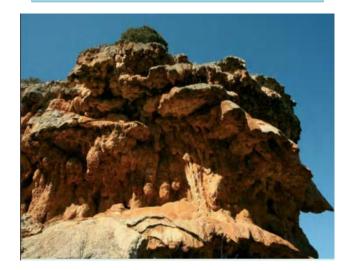
#### TRAVERTINES

Travertines are porous rocks formed of calcium carbonate precipitation

It will be explained in the point "2.2. Karstic forms"

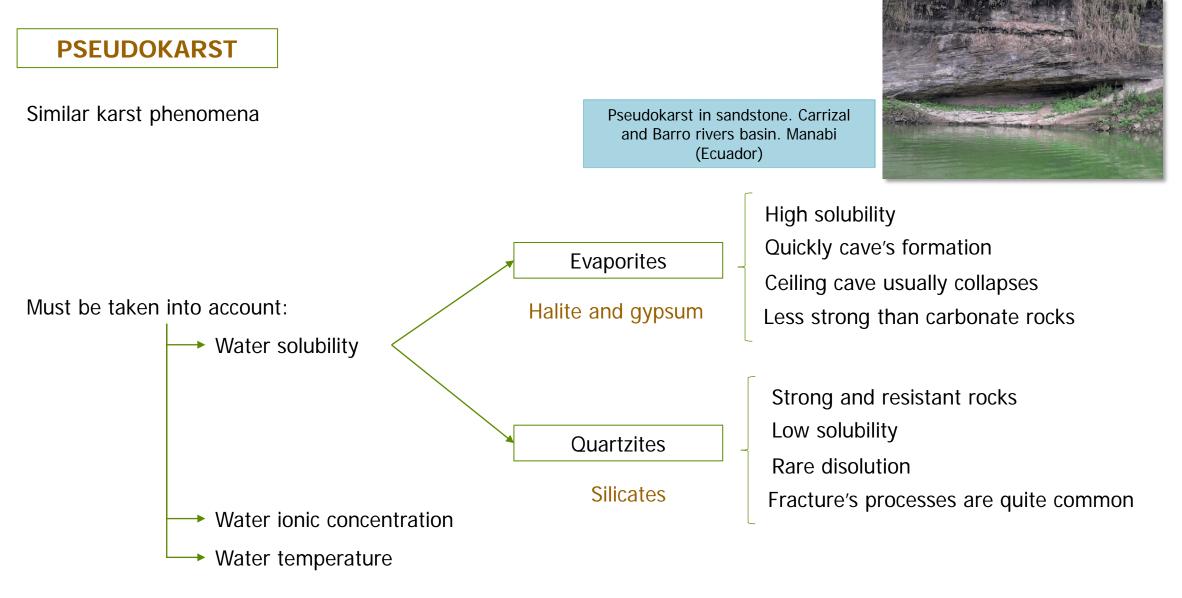
**CONDUITS' FILLING** 

Organic and inorganic materials are storaged along the surface of water table tubes which have been originated due to physical and chemical erosion of carbonate rocks Campillo's travertine, Natural Park Castille La Mancha, (Spain)





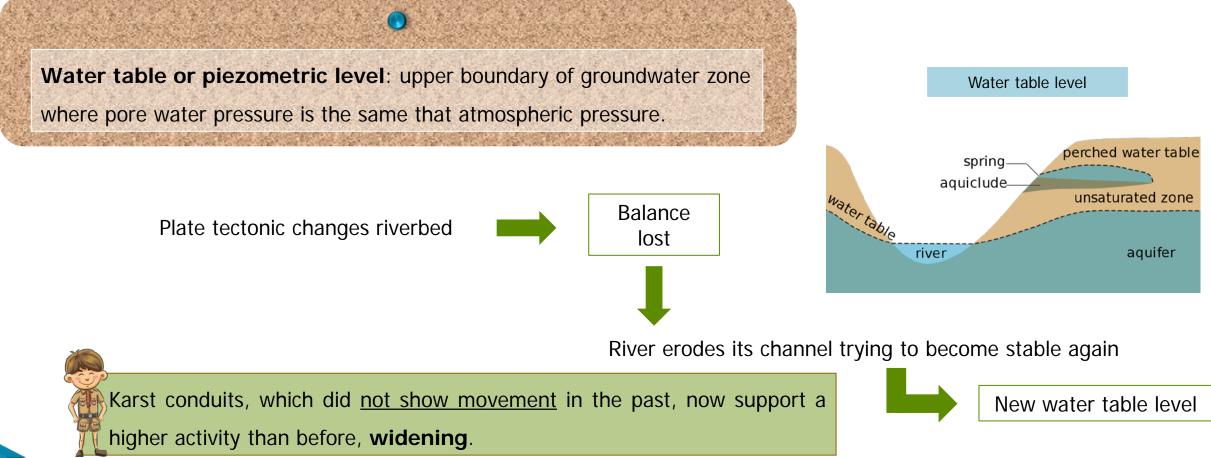
### **1.8. Non-karst cavities**





### 1.9. Karst landscapes' evolution

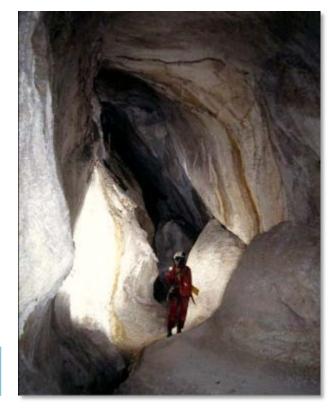
Bit a bit, water table tubes and vadose conduits are broadened, so that <u>piezometric level</u> falls until a balanced position is reached.







Piezometric level stable position over time promotes the widening of water table and vadose conduits.



Corchia Cave, Apuan Alps, Italy

Optymistychna Cave, Ucrania





### MODULE 2: The European Karstic Landscape

2.1. Dissolution and karst
2.2. Karstic forms
2.3. Karst and the Weather
2.4. Karstic panorama in Europe

It is fundamental we understand the factors which control the interaction between the water and the rock to know and analyse both karst process and its result, karst landscape.





### 2.1. Dissolution and karst

Karst is defined as the calcareous landscape with a hilly relief which has <u>cracks</u> and <u>ridges</u> and it is exposed to <u>chemical weathering</u>.

High  $[CO_2]$  dissolved ( $\uparrow$  water acidity)

↑ karstification

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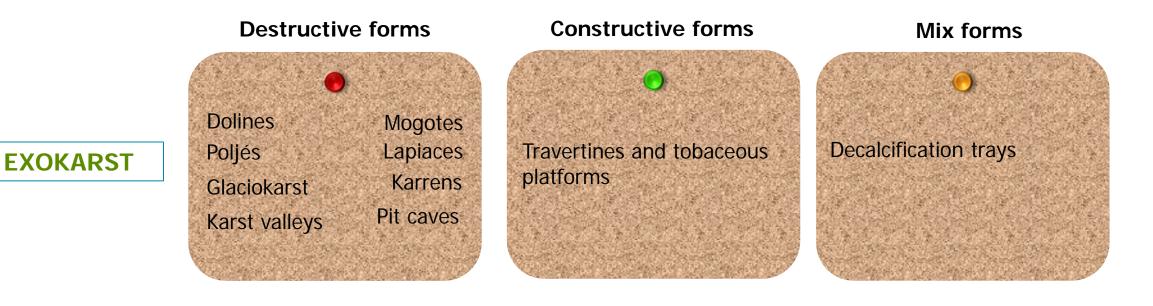
Water movement



Dissolution processes continue with mineral precipitation

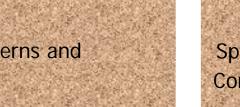


### **2.2. Karstic forms**





Speleothems Conduit filling



**ENDOKARST** 

### EXOKARST

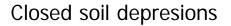
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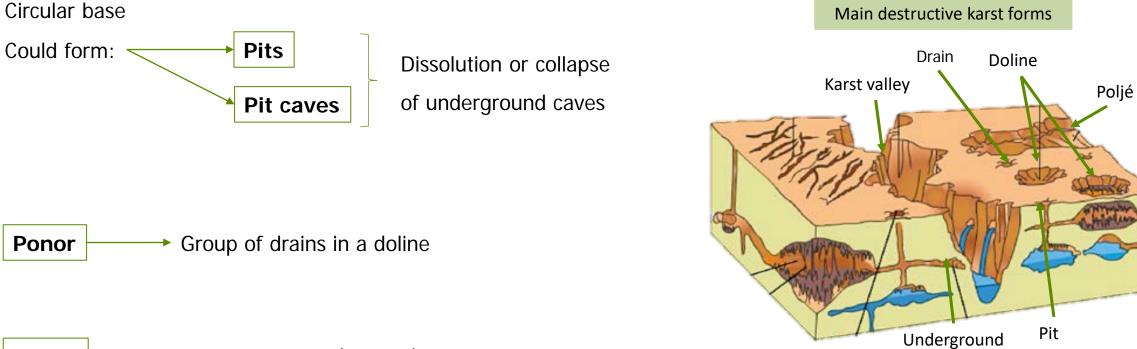
### DOLINES

Erasmus+

cave

passage





Poljes Group of dolines(> 2 km)

Botton filled with insoluble materials that close fissures

Are flooded due to water table level is near the soil surface





EXOKARST

D

### Pit cave



Ponor





M2



### **GLACIOKARST**

Wide surfaces of bare rock

High elevations

Water and ice masses have made up large canyons

### **KARST VALLEYS**

Fluvial cracks on karst rock mass Vertical walls act as a fluvial valley Out of current water stream Blind valleys



#### Glaciokarst in Orjen



Duratón Sickles







### MOGOTES

Sharp, conical and piramyd reliefs after most of rock has been dissolved

#### **KARRENS**

"Field of stones"

Blocks separete by channels as a result of soluble rock dissolution

### **PIT CAVES**

Vertical conduits which connect both surface and underground water flows Exacerbated dissolution of a doline results in a pit cave Deepness (high to low):



### Mogote



Karren



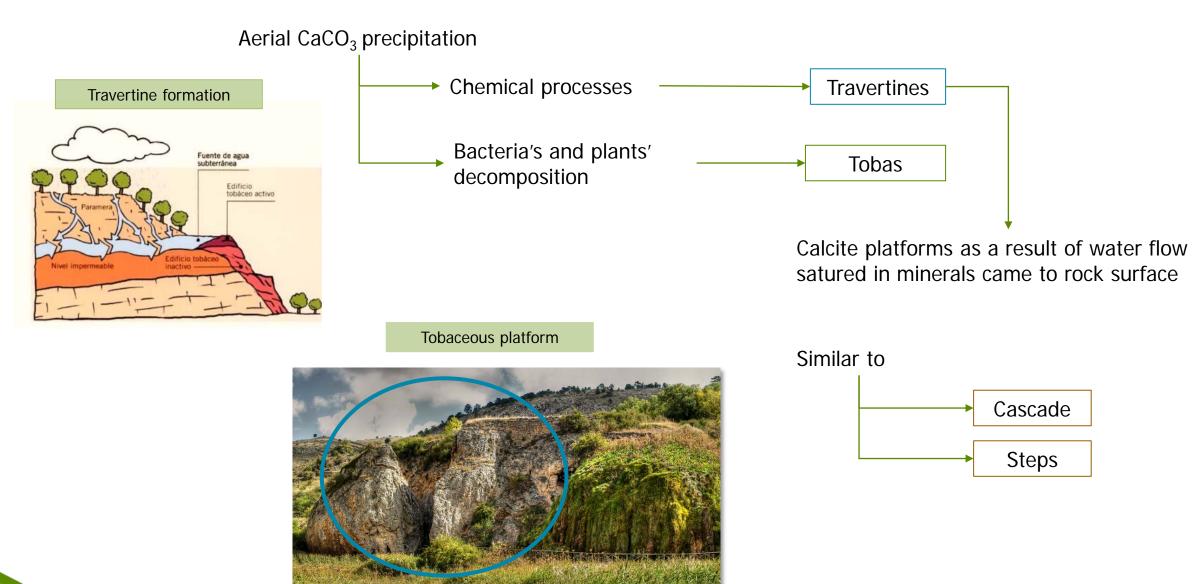
Pit cave



### EXOKARST C



### TRAVERTINE AND TOBACEOUS PLATFORMS







### **DECALCIFICATION TRAYS**

Mixed forms with depression shapes

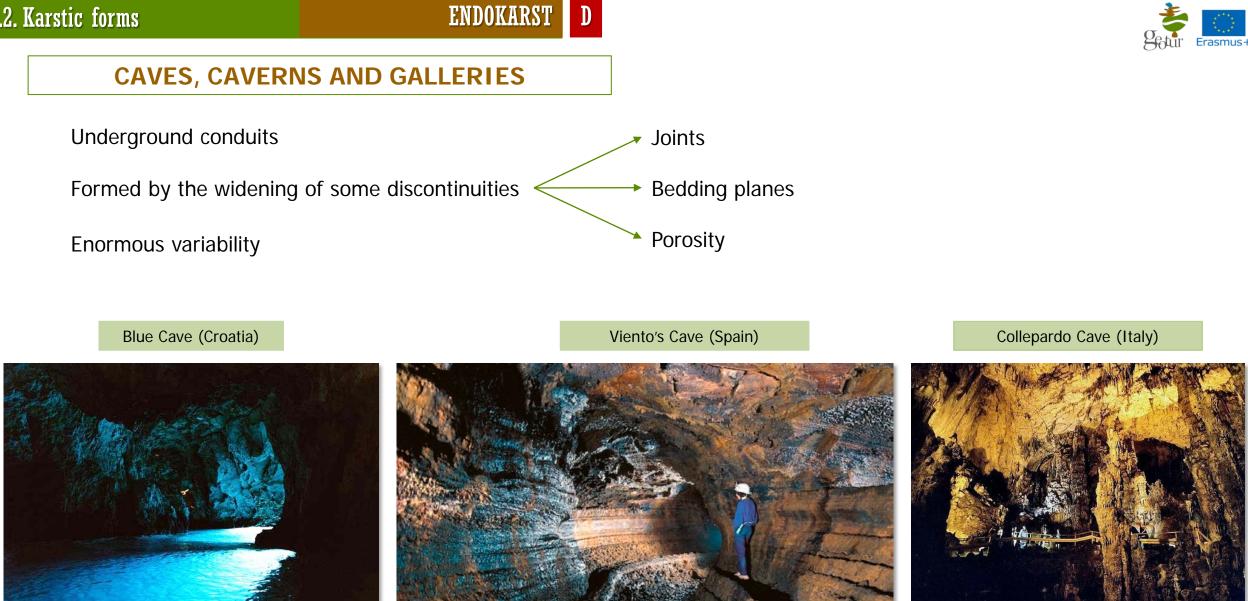


From karst bedrock erosion



Decalcification tray filled with clay

### 2.2. Karstic forms

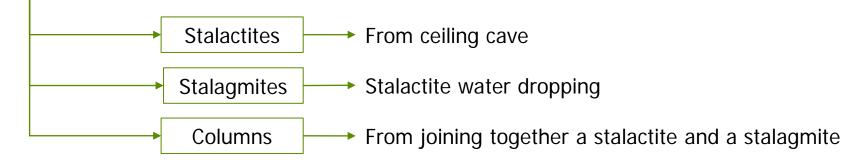




#### **SPELEOTHEMS**

Have been formed inside caves due to CaCO<sub>3</sub> precipitation

Are classified as







#### **CONDUITS FILLING**

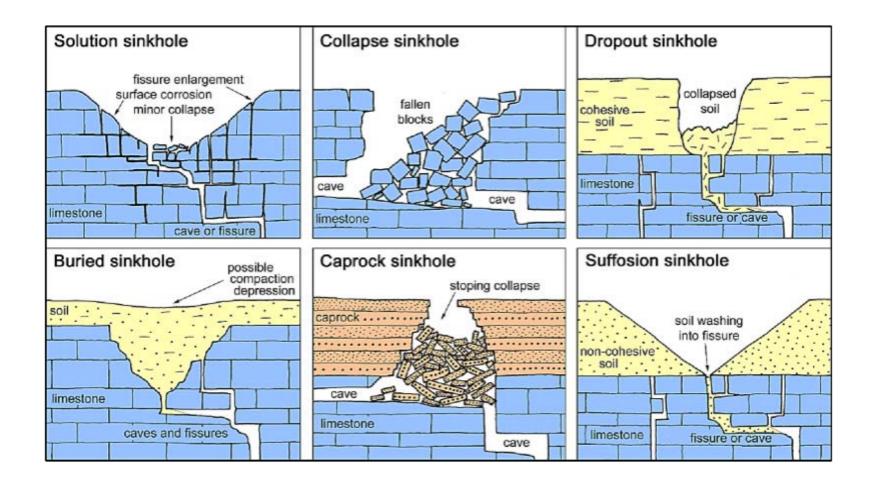
Diverse materials like organic remains of both plants and animals or decalcification residues fill conduits.





#### **CONDUITS FILLING**

#### **Dolines' categories**

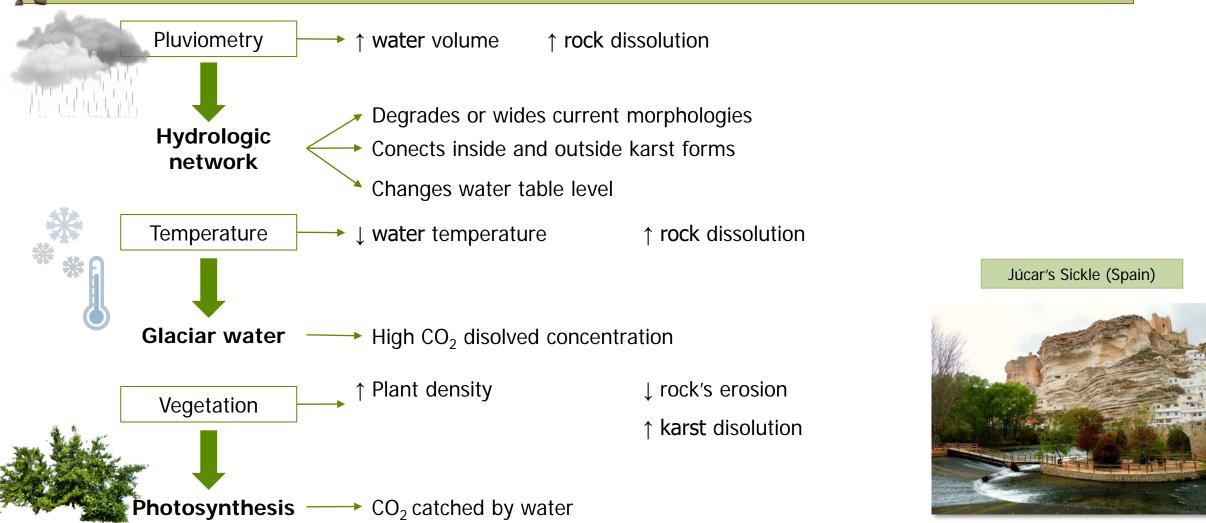


M2

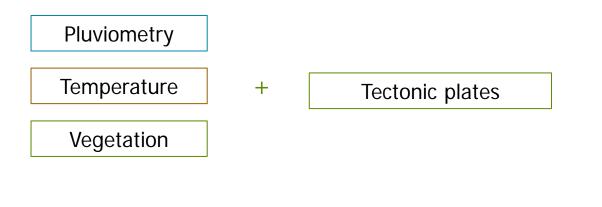


### **2.3. Karst and the Weather**

Weather is an essential factor for karst processes, so that it influences both water availability and temperature.

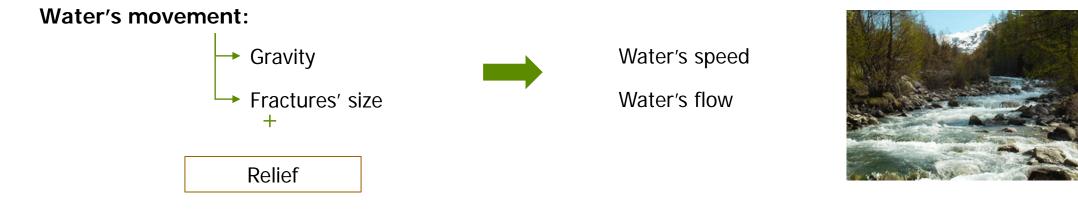






**Rock mass' fragmentation** due to <u>tectonic processes</u> which occur both vertical and horizontal way

**Discontinuities** will generate <u>fractures</u> trough which surface water will pass towards the rock.

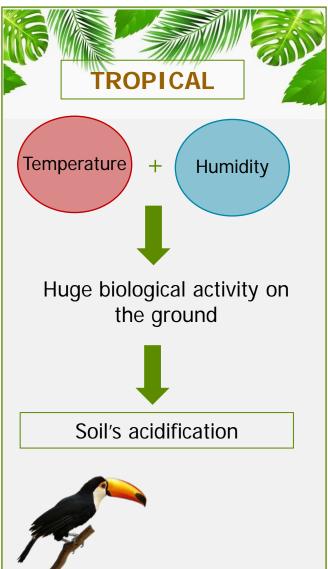


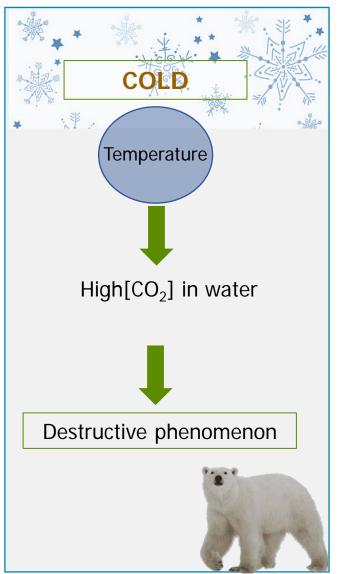
It is needed that <u>underground drainage</u> be effective for karst landscape is development, due to carbonate rocks have variable proportions of insoluble minerals which need to be <u>separated</u> and to be <u>pulled</u> by water stream, and only it { takes place when relief has got <u>slope</u>.

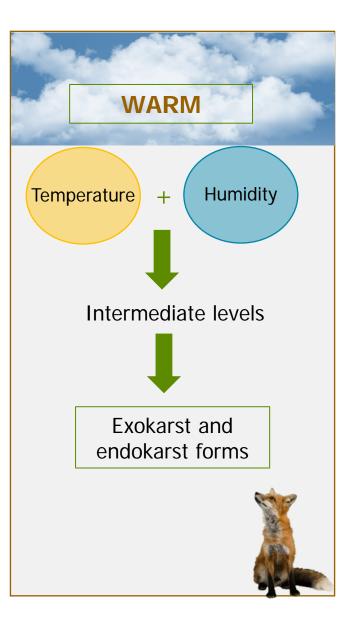
#### 2.3. Karst and the Weather



#### Tipos de karstificaciones según su ubicación











All areas with notable rainfall and tropical or similar weather are prone to karstification, as long as a carbonate massif is found.

#### LIMESTONE UPWELLINGS

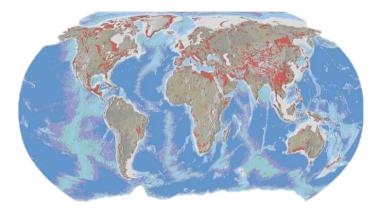
Europe

Earth surface



1337635 km<sup>2</sup> of limestone upwelling

21,8 % european surface



12 % global surface

#### 2.4. Karstic panorama in Europe



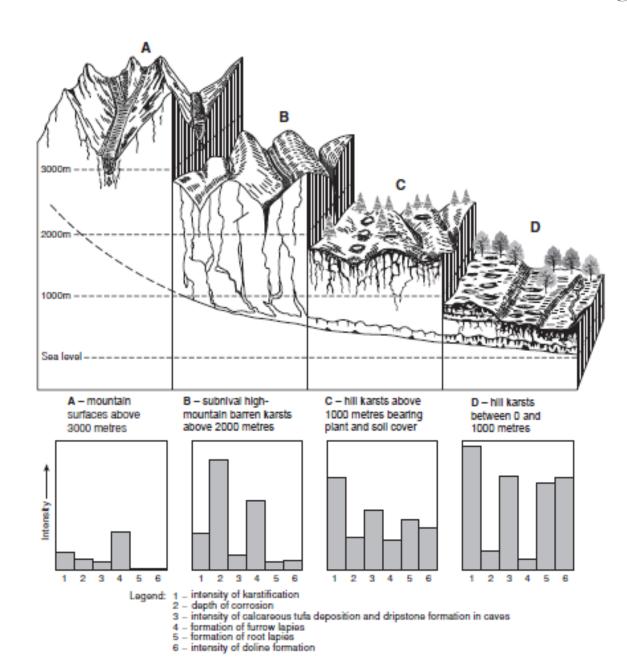
#### **KARST SCENERIES**

A: Mountain surfaces above 3000 m

B: Mountain surfaces above 2000 m

C: Mountain surfaces above 1000 m

D: Hills' karst between 0 and 1000 m





Peaks of Europe (Spain)

#### Galbena Karst (Romania)



### MÓDULO 3: THE INTERIOR OF THE KARST

- 3.1. The zoning of karst systems
- 3.2. Speleothems
- 3.3. The extraordinary troglofauna
- 3.4. Climate change and karst



## 3.1. The zoning of karst systems

There are several zones inside and outside rock mass:

A. Absorption or infiltration zone

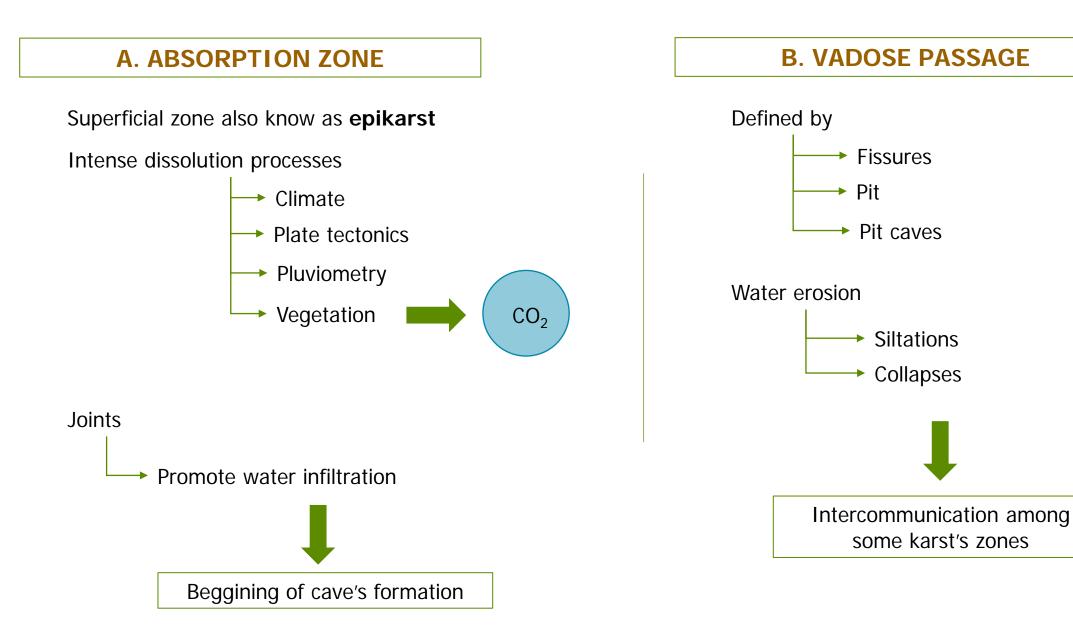
B. Vadose passage

C. Horizontal passage

D. Deep core

#### 3.1. The zoning of karst systems





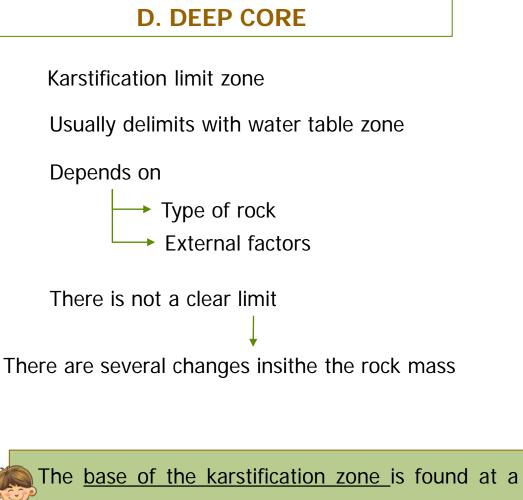


#### **C. HORIZONTAL PASSAGE D. DEEP CORE** Karstification limit zone Galleries CaCO<sub>3</sub> precipitation Rooms Depends on Type of rock External factors **Speleothems** There is not a clear limit It may appear Underground rivers, chimneys, siphons, etc

Caves are active when water goes through them and formation and development processes take place



Stalactites' dripping reveals that the cave is alive.

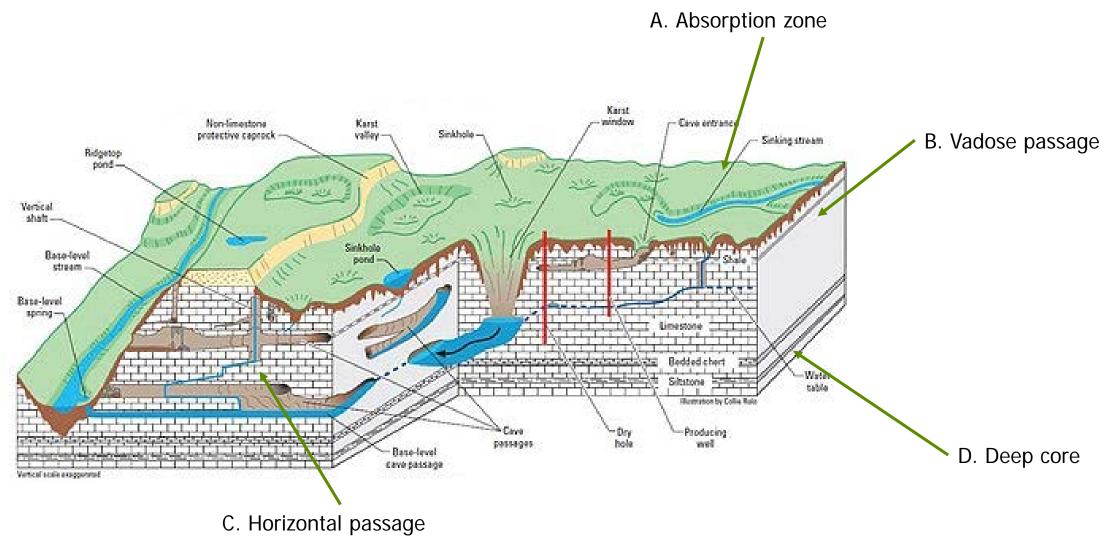


depth of **250 m in the Dinaric Alps region** (Bosnia Herzegovina).

#### 3.1. The zoning of karst systems



Karst zones



#### 3.1. The zoning of karst systems

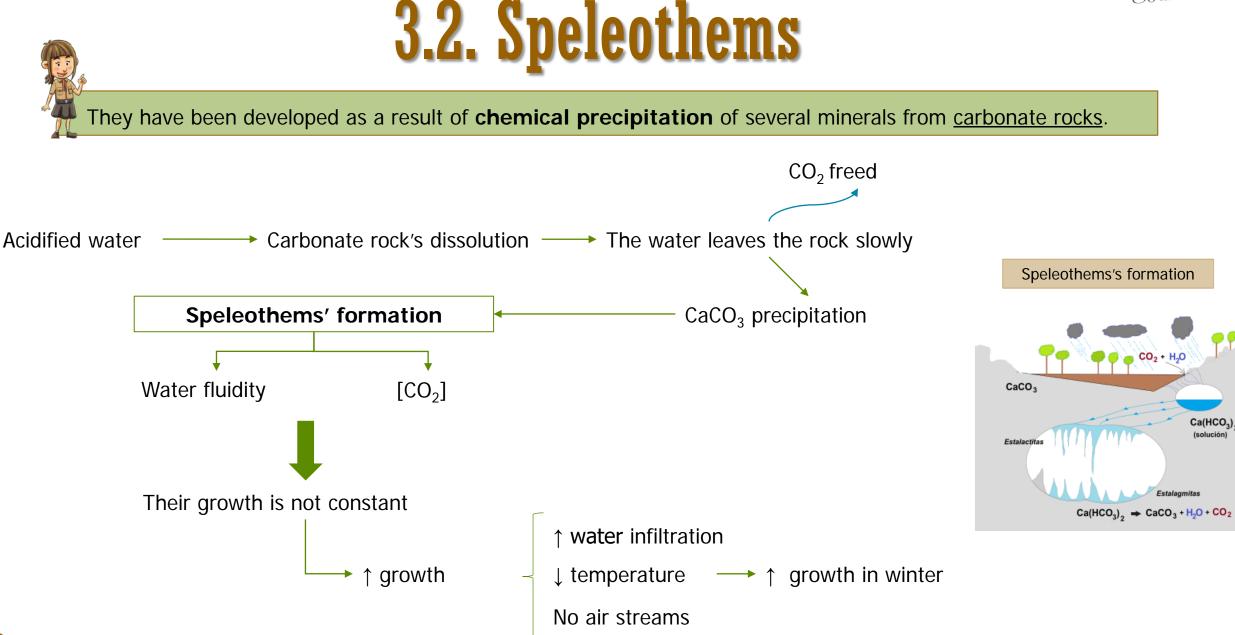


The water from **aquifers** is one of <u>the mains of fresh</u> <u>water</u> to all population, being <u>50 % of whole water</u> used in some European countries. It is important taking into consideration the <u>aquifers</u>' <u>vulnerability</u> due to <u>pollutants</u> which go through soil fissures.

COST 620 Action has been established into the European framework

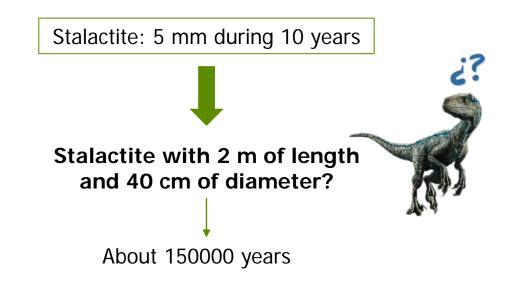
with the purpose of conserve European karstic aquifers.

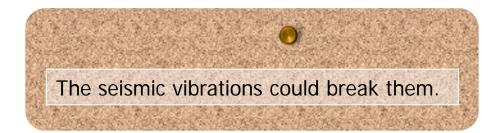


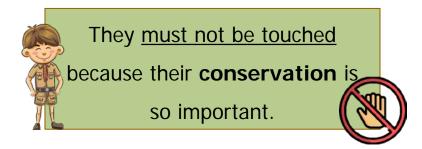




Speleothems' length growth is opposite to their thickness growth.







3



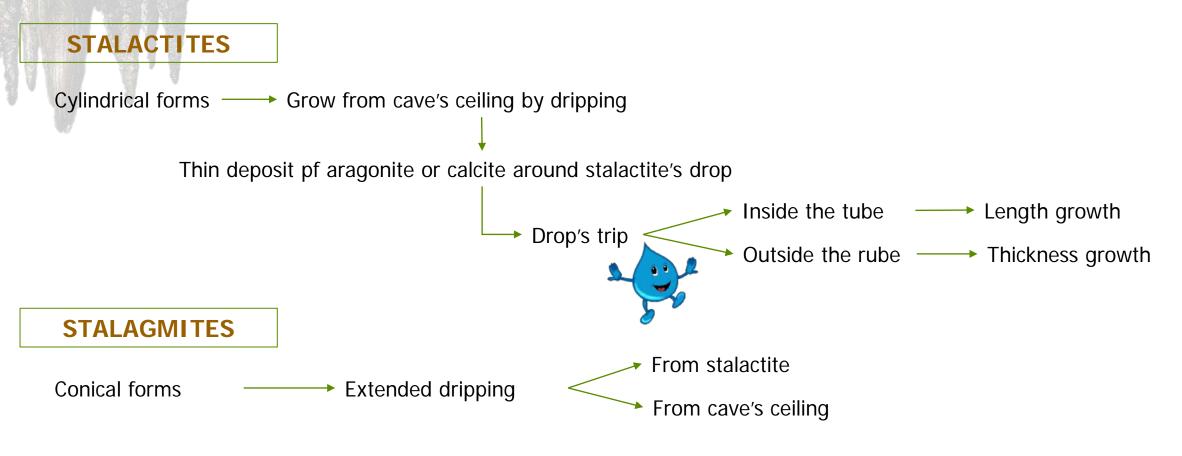
#### The most characteristic speleothems in a cave

Stalactites Stalagmites Columns Draperies Flowstones

Platelets Fibrous formations Other formations







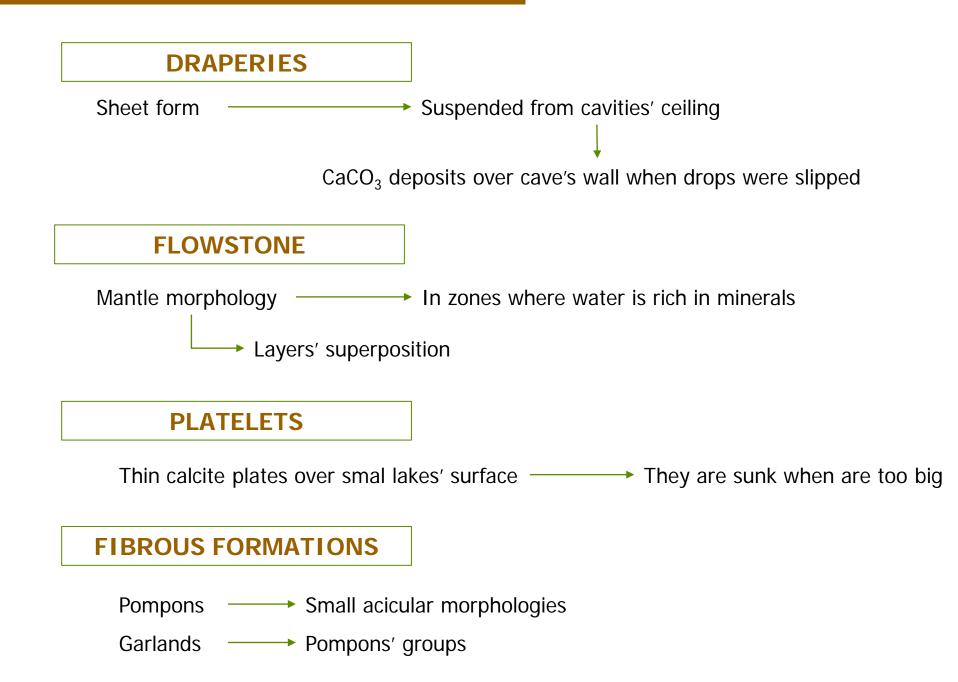
#### COLUMNS

Stalactite and stalagmite's ends are joined

M3











#### Draperies



Platelets



#### Flowstone



Pompons



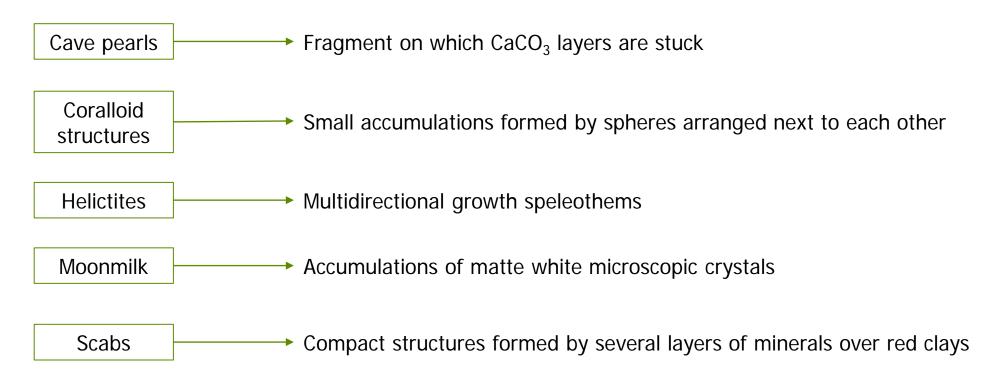


#### **OTHER FORMATIONS**

Formations similar to spirals with few development

- Changes in its surface tensions
- Weak air streams

#### Tipos de formaciones excéntricas





Cave pearls



Helictites



#### Coralloid strictures



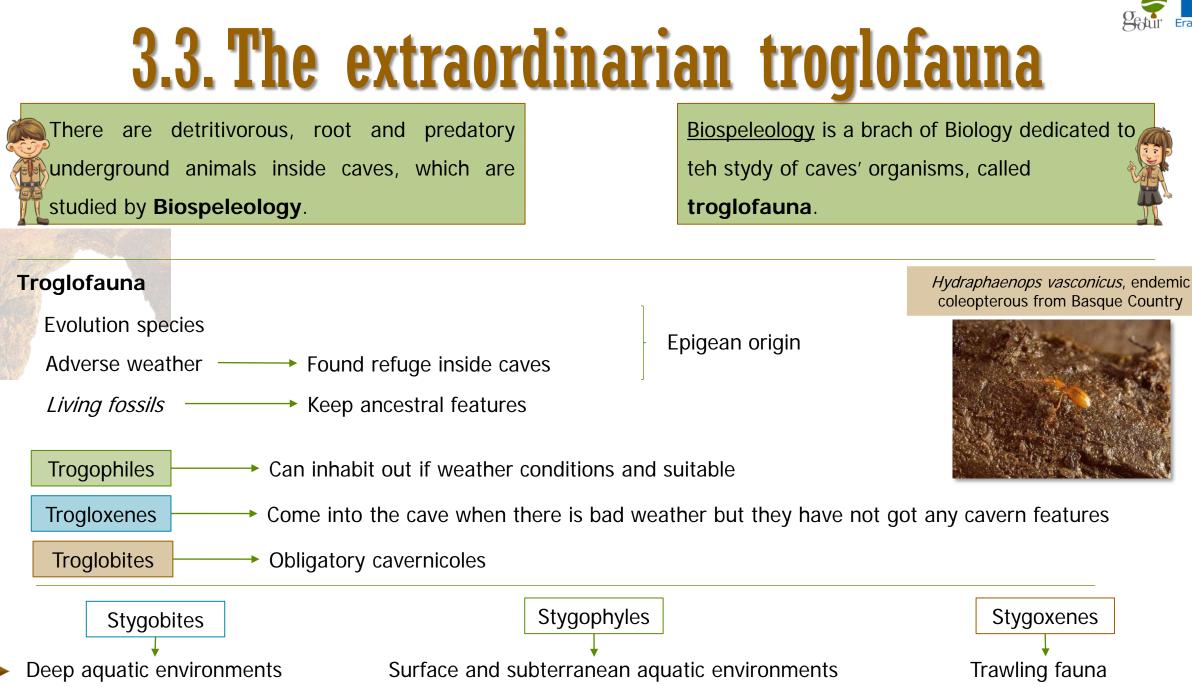
Moonmilk





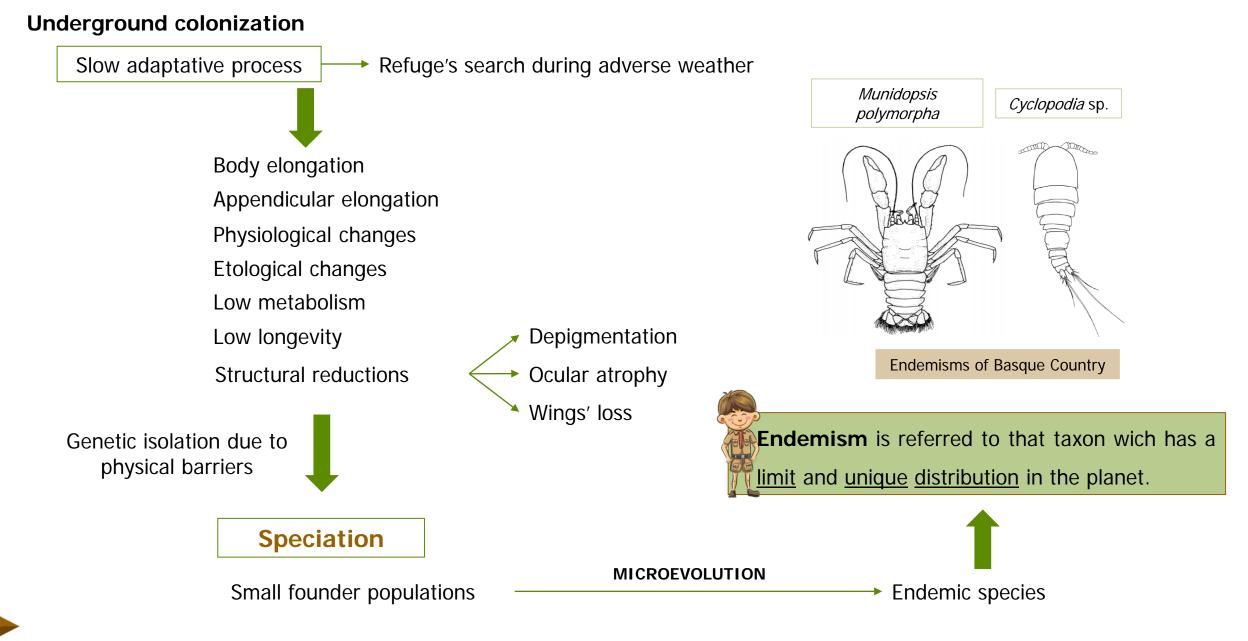
#### SPELEOTHEMS' MINERALS

Mineral	Formula	Origin	Speleothems	Picture
Aragonite	CaCO <sub>3</sub>	Primary mineral formed when there is a high concentration of Mg <sup>2+</sup> in the water	Stalactites, stalagmites, columns, flowstones, draperies, helictites, Coraloid structures, pompons, garlands and scabs	
Calcite	CaCO <sub>3</sub>	Primary mineral formed when aragonite is transformed	Stalactites, stalagmites, columns, flowstones, draperies,	
Dolomite	CaMg(CO <sub>3</sub> ) <sub>2</sub>	Primary mineral formed when aragonite is transformed	Pompons, moonmilk and scabs	
Magnesite	MgCO <sub>3</sub>	Primary mineral	Moonmilk and scabs	
Gypsum	CaSO₄·2H₂O	Primary mineral	Scabs	





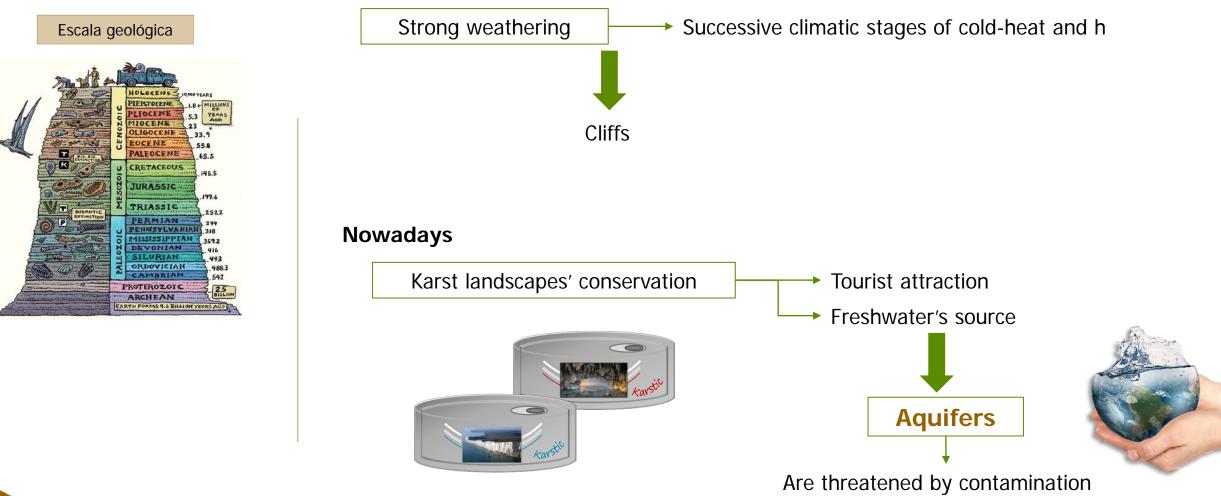






## 3.4. Climate change and karst

#### **Pleistocene and Holocene**





### MODULE 4: CAVITIES IN VOLCANIC MATERIALS

- 4.1. Introduction4.2. Igneous rocks' basics concepts4.3. Lava tubes description and origin
- 4.4. Other cavities
- 4.5. Volcanic cavities in Europe

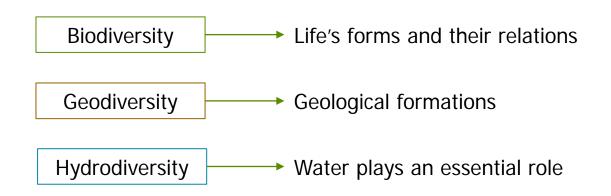


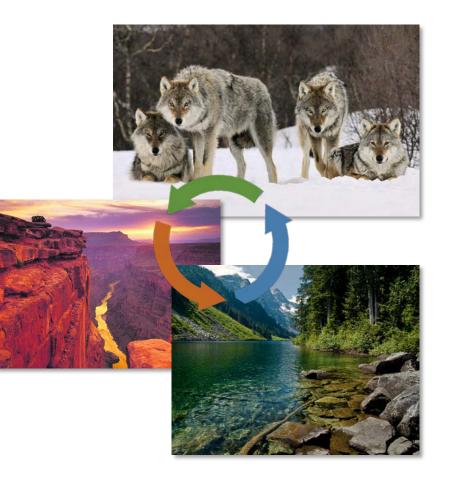
### Gotur Erasmus-

### 4.1. Introduction

**Volcanoes** are part of a highly dynamic morphogenetic phenomenon due to both their <u>geomorphological effect</u> and <u>reorganizing's capacity</u> of the ground on the area in which they are developed.

#### Volcanoes are related with natural heritage

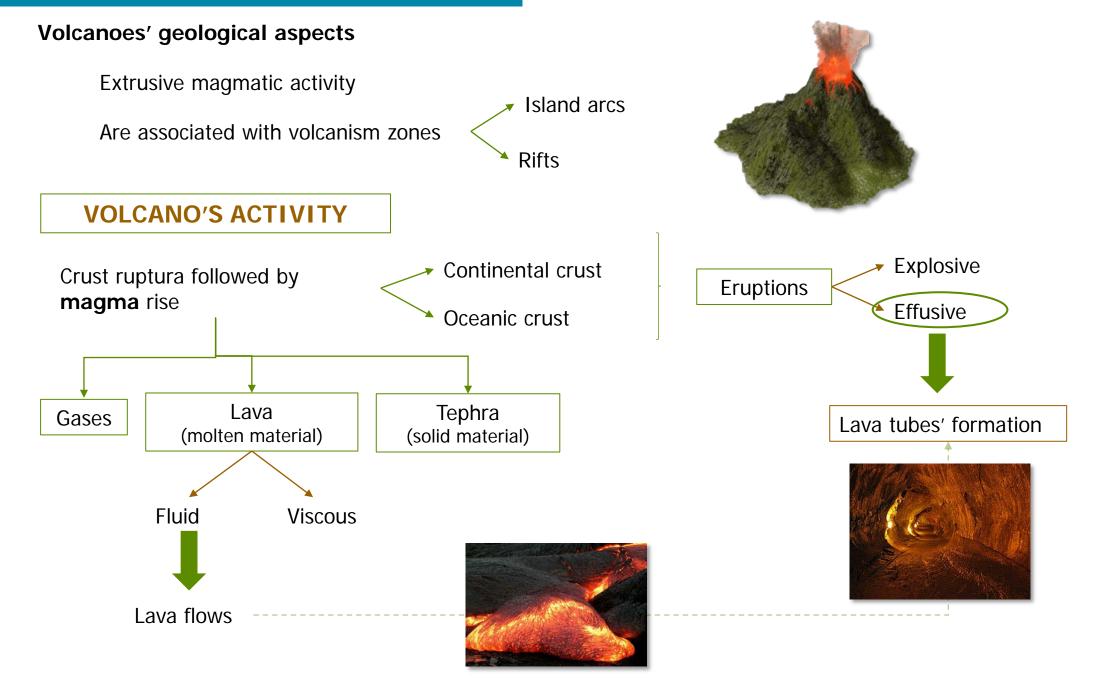




#### 4.1. Introductions

M





## 4.2. Igneous rocks' basic concepts

**Igneous** or **magmatic rocks** are originated as a consequence of <u>magma ´s cooling and solidification</u>. Magma rises and when it is cooled (outside or below the surface) it <u>crystallizes and solidifies</u>, originating the igneous rocks.

#### **IGNEOUS ROCKS**

Plutons

Magma is cold and solidified below planet crust Slow cooling

**Granite**, diorite, gabbro and peridotite



Volcanic

Quick cooling of magma Crystals are not formed Basalt, rhyolite, **trachyte and** fonolite



#### Hypabyssal

Conduit filling when magma is raising Small crystals are formed Pegmatite, diorite and diabase





## 4.3. Lava tubes' description and origin

**Igneous rocks** are formed by insoluble minerals, so that lava tubes, which have a <u>volcanic origin</u>, have not been originated due to dissolution process as karst caves otherwise due to <u>lava flows' cooling</u>.

Lava volcanic tubes' formation



Hydrogeological interest

Tubo volcánico de Guinea (España)

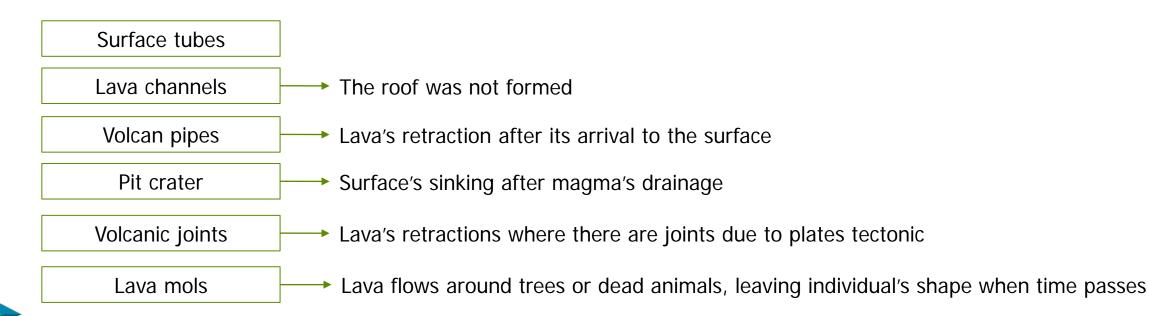


### 4.4. Other cavities

#### **VOLCANIC TUBES**

Soil Magma's composition Soil's slope

Determine the volcanic conduits' formation



#### 4.4. Other cavities



#### Volcan pipe



#### Volcanic joint



#### Pit crater



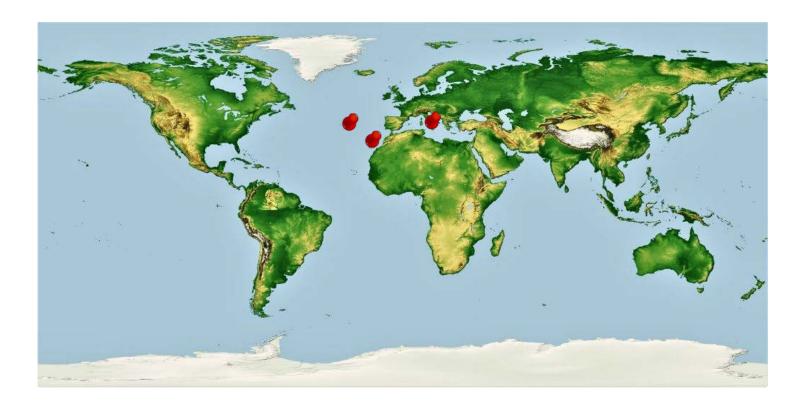
#### Lava mold





### 4.5. Volcanic cavities in Europe

Volcanic cavities are usually found in volcanic origin zones. There are several examples in the European area such as: the volcanic tubes in Canary Islands (Spain), the Geopark in Azores Islands (Portugal) or Mount Vesuvius in Campania (Italy).



#### 4.5. Volcanic cavities in Europe

China St

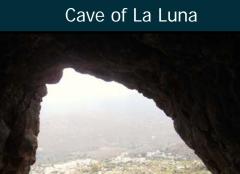


#### Aslobas' Cave



#### Los Bucios de Los Marteles' Cave







#### Los Verdes' Cave





Erasmus+



A Carton

#### The Azores (Portugal)



#### The Azores' Geoparks

121 geosites Almost 300 volcanic cavities



Vila Franca do Campo's Islet

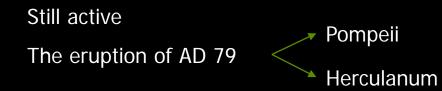


#### Do Carvao's Grotto



#### Campania (Italia)

#### Mount Vesuvius (Naples)





#### Mount Vesuvius from Naples



#### Pompeii





### ANNEX. MODULE 5: EUROPEAN TOURIST CAVES



**Speleotourism** is one of the most traditional tourist modalities based on the interest of people for caves either visiting them or learning about speleology. During the last decades, <u>Geoparks</u>, areas which promote the protection and use of geological heritage, have been become in a new tourist place.





Austria Belgium Bulgaria Czech Republic Croatia Cyprus Denmark Estonia Finland France
Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Malta

 $\bigcirc$ 

Netherlands Poland Portugal Romania Slovakia Slovenia Spain Sweden United Kingdom



EXIT





# GEOTURISM GUIDE-INTERPRETER





