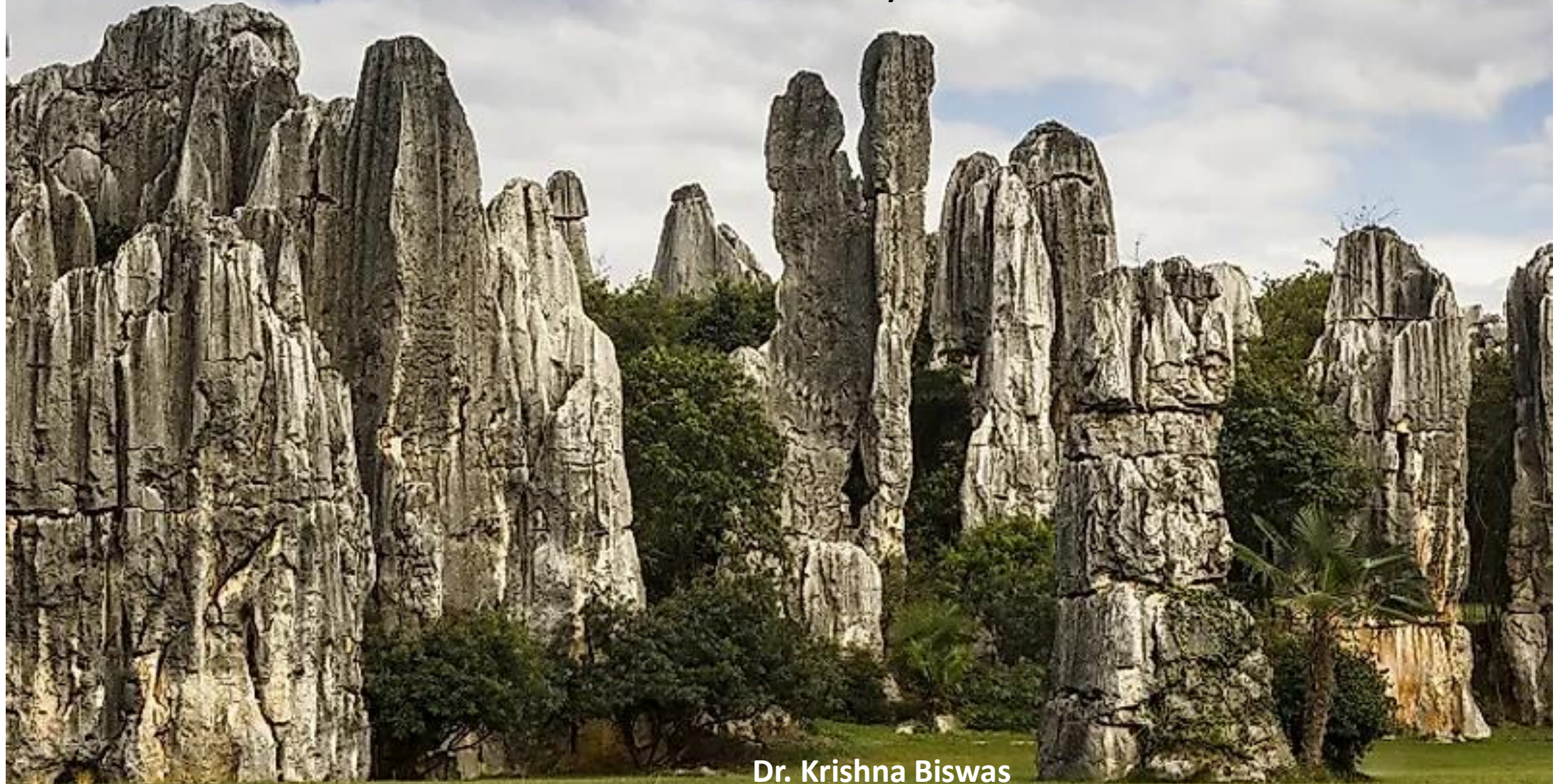


PROCESS OF LANDFORM DEVELOPMENT IN KARST ENVIRONMENT

UNIT 2: Landform Development
Saltora Netaji Centenary College
Bankura University



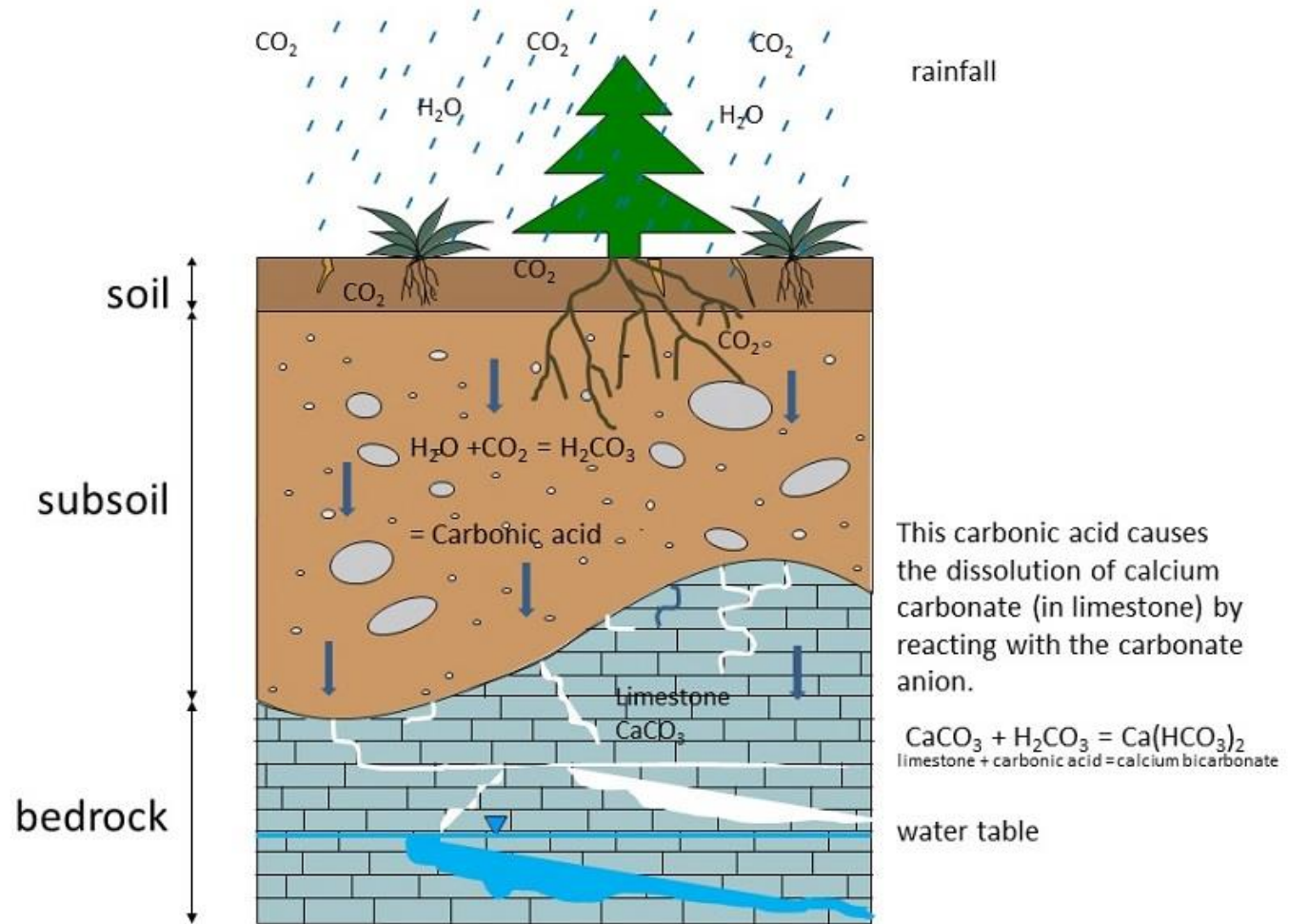
Dr. Krishna Biswas
(geokrishnawb@gmail.com)

KARST ENVIRONMENT: 'Karst' is a distinct landform shaped largely by the **dissolving action of water on carbonate rock** such as limestone, dolomite and marble which are **thinly bedded** and **highly fractured**.

- The word **karst** is the German form of the Slovene word **kras**, meaning **crag or stony ground** and especially the **bare rock surfaces** of what is now northern Yugoslavia.
- Karst landforms are characterized primarily by **underground drainage** in areas of **massive limestone**, and the formation at the **ground surface of hollows and pits** where water enters the rock and enlarges joints and fissures by solution.
- Karst landscapes owe their existence to the removal of bedrock in solution and to the development of underground drainage without the development of surface stream valleys.

How does karst form and develop?

- **As rain falls through the atmosphere it picks up carbon dioxide (CO₂).**
- When this rain reaches the ground and passes through the soil it picks up more CO₂ and forms a weak solution of carbonic acid.
- **As the acidified rain water trickles down through cracks in the limestone, it begins to dissolve the rock.**
- Over time it progressively enlarges the cracks and openings in the ground and an underground drainage system starts to develop.



EXAMPLES OF KARST AREAS: Approximately **15 percent** of the Earth's land surface is karst. The distribution of karst is essentially the same as the distribution of carbonate rocks, which means that karst terrain occurs mostly in the great sedimentary basins of the world.

- The world's largest limestone karst is **Australia's Nullarbor Plain**.
- The most extensive karst area of the United States occurs in the limestones of Mississippian age (about 325,000,000 to 345,000,000 years old) of the **Interior Low Plateaus**.



- A few areas of limestone topography have been identified in the Himalayas (mainly in Jammu and Kashmir), Eastern Himalayas (Meghalya), coastal area near Visakhapatnam (**Bora cave**).



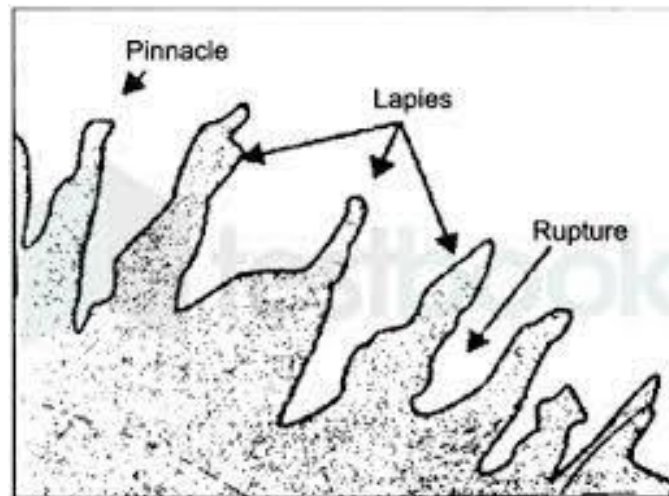
LANDFORMS: We can classify karst landform into two broad category a) **Minor** and b) **Major** features.

Minor features are small landforms created by solution of the **surface of the rock** and major features include enclosed depressions, landforms produced by fluvial erosion, and **underground landforms** of caves.

1. Karren/ Lapiés: Lapiés, **weathered limestone surface** found in karst regions and consisting of **etched, fluted, and pitted rock pinnacles separated by deep grooves.**

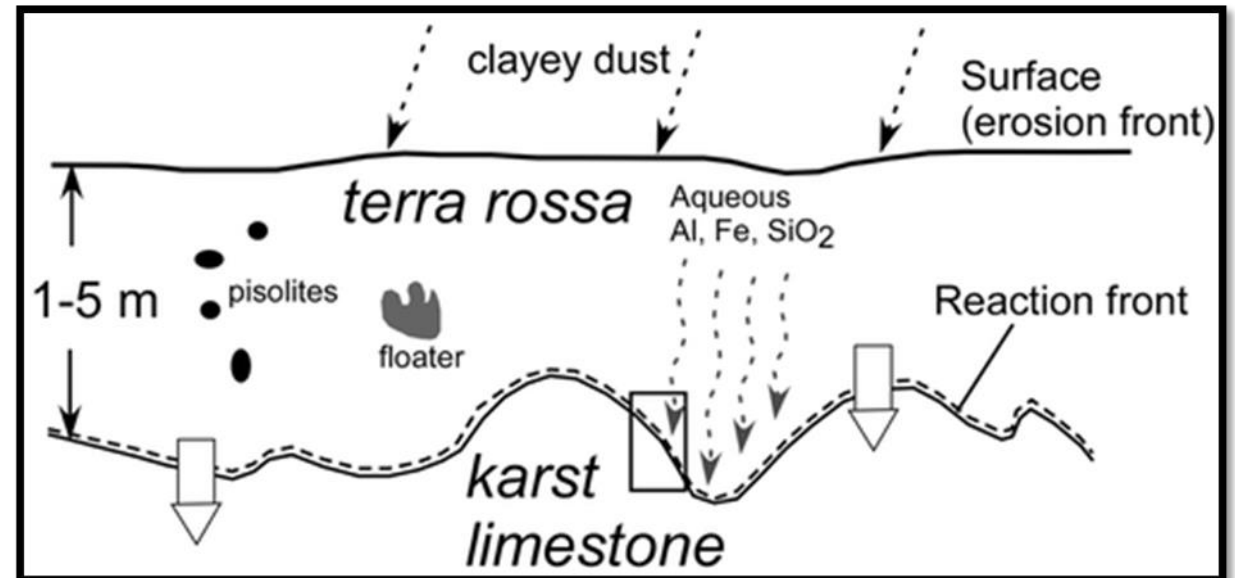
- This rugged surface is formed by the **solution** of rock **along joints** and areas of **greater solubility** by water containing carbonic and humic acids.
- It is not clearly understood whether lapiés forms on bare rock or forms under soil mantle and is exposed later.
- The grooves of the lapiés may **vary in depth from a few millimetres to several metres.**
- Lapiés commonly forms on **tilted** rocks, and the limestone base becomes extremely hard.
- **Grikes** are solution widened and clay/debris filled fractures systems found in weathered limestone areas that are separated from one another by narrow ribs of relatively unweathered residual bedrock known as lapiés or karren.

Controlling factors: Presence or absence of soil and vegetation, Rock type and climate.



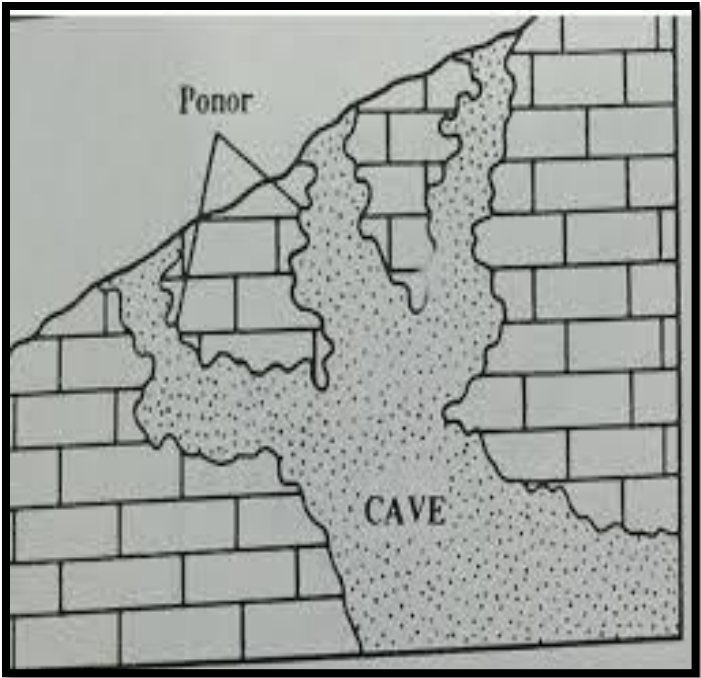
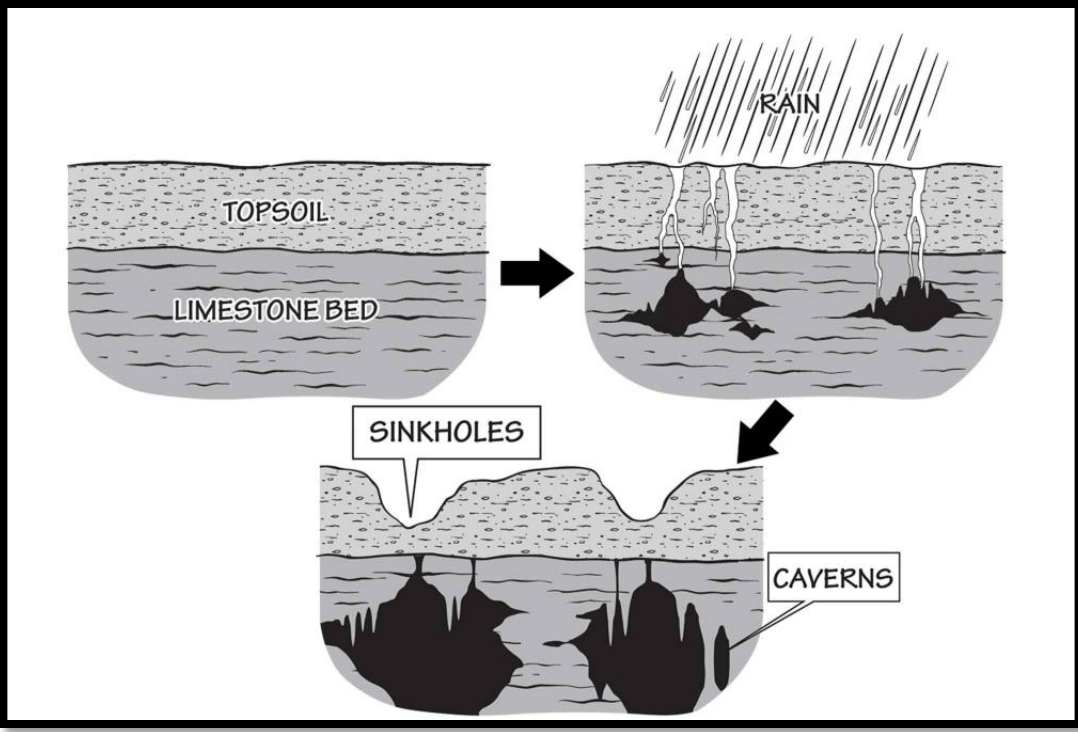
2. TERRA ROSA: Terra rossa (Italian for "red soil") is a well-drained, reddish, clayey to silty soil with neutral pH conditions.

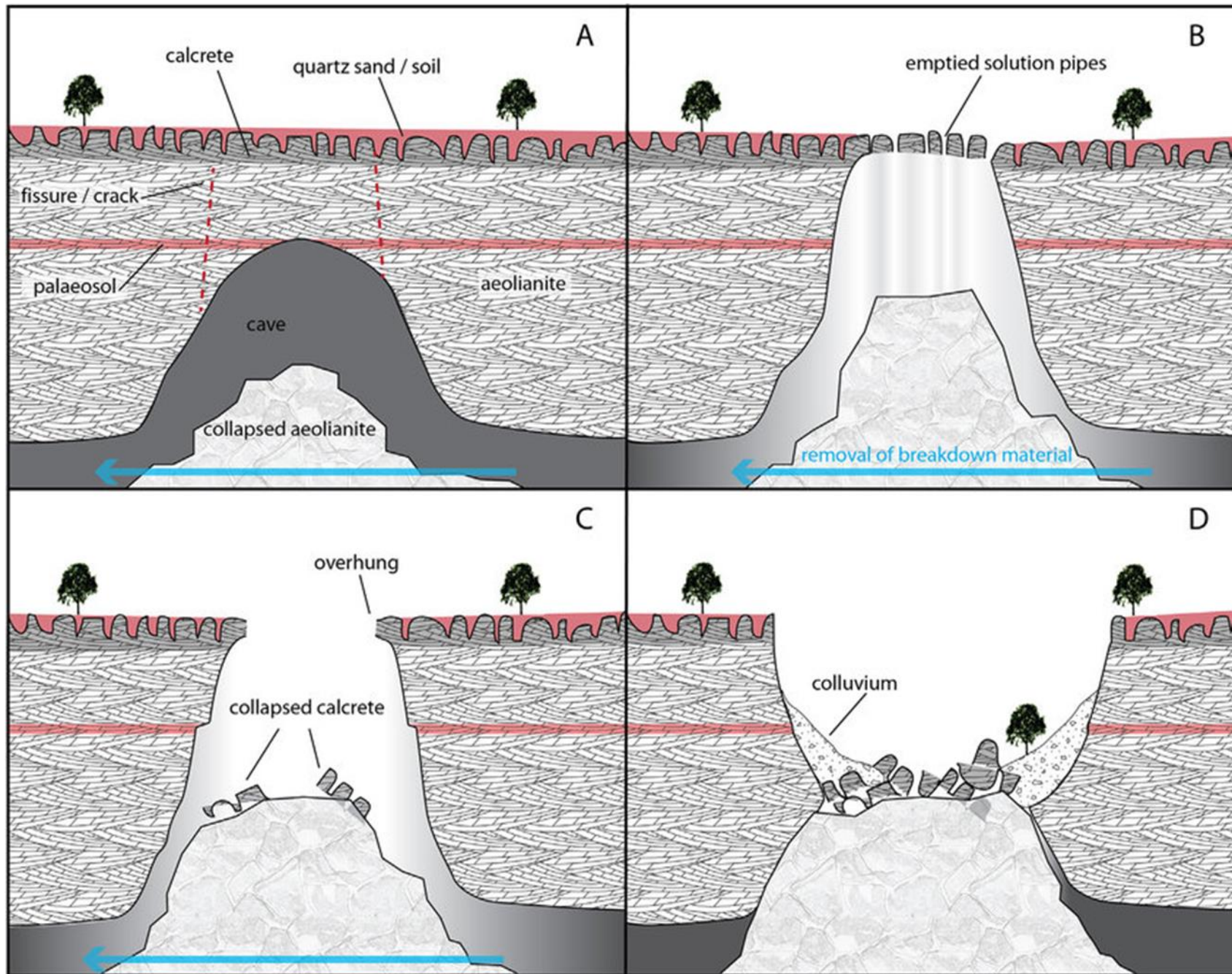
- This soil type typically occurs as a discontinuous layer that ranges from a few centimeters to several meters in thickness that covers limestone and dolomite bedrock in karst regions.
- The high internal drainage and neutral pH conditions of terra rossa are a result of the karstic nature of the underlying limestone and dolomite.
- Terra rossa is also found associated with Mediterranean climates and karst elsewhere in the world.
- The origin of terra rossa, its parent material, and its relationship to underlying limestones and dolomites has been greatly debated over recent decades by geologists, geomorphologists, and soil scientists. A general concept is that when rainwater dissolves part of the surface rock and enters the subsurface particles of red clay soil are deposited on the surface as well as in the open joints. This is called terra rossa, and very much resemble lateritic soil.
- It may not be present on steep slopes but can be seen in areas which are either flat or have gentle slope. Sometimes it may be several feet thick entirely cover the rocky surface.



3. SINKHOLES OR DOLINES and Associated Features

- Sinkhole, topographic depression formed when underlying limestone bedrock is dissolved by groundwater.
- The term is sometimes used to refer to **doline**, enclosed depressions that are locally also known as vrtače and **shakeholes**.
- The cylindrical openings where surface water enters into underground passages known as **swallow hole** or **swallet** as these surface openings completely swallow the surface drainage during the rains.
- Vertical or inclined shafts leading from the sink-holes or dolines to the underground caves are known as **ponor**.
- It is considered the most-fundamental structure of karst topography.
- Sinkholes vary greatly in area and depth and may be very large.
- There are two main varieties, one caused by the **collapse of the roof of a cavern**, the other by the **gradual dissolving of rock under a soil mantle**.
- Collapsed sinkholes generally have steep rock sides and may receive streams that then flow underground. The soil-mantled sinkhole is generally shallower than the collapsed sinkhole and receives local drainage; it may become clogged with clay and hold a small lake called **karst lake** or **sinkhole ponds**. These lakes are seasonal .
- A **cenote** (pronounced "seh-NOH-tay") is a type of sinkhole that **exposes groundwater** underneath, generally forms when the roof of an underground cave collapses, exposing the water to the surface. Cenotes are very common on the Yucatan Peninsula of Mexico. There are more than 2,000 cenotes on the Yucatan, and they are a main source of fresh water for people there.

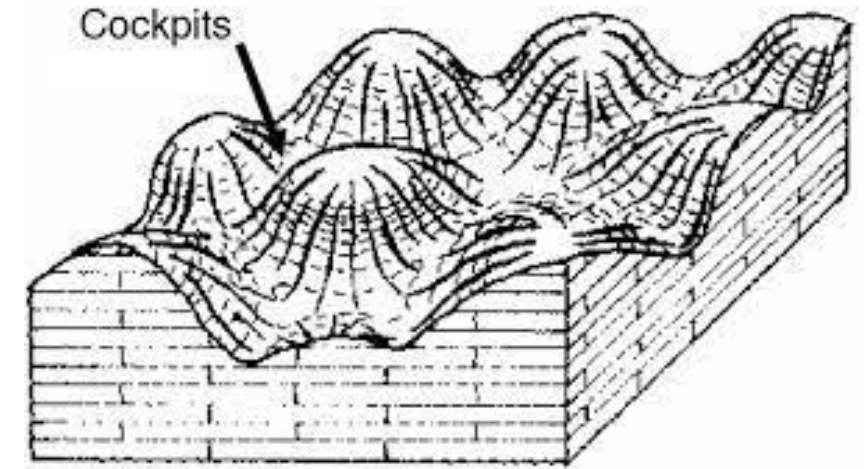




A diagram illustrating four stages of collapse doline formation in Stockyard Gully with relatively strong removal of collapsed material

4. **COCKPIT KARST** is a succession of cone-like hills or “kegel: with alternating close depressions or “cockpits”.

- The term “cockpit karst” refers to a densely packed area of closed depressions and residual hills.
- This pattern is also called polygonal and kegel karst.
- Cockpit karsts are found in Jamaica, Indonesia, the Caribbean and Central America, Papua New Guinea, Vietnam, China, and the Philippines.
- The most prominent hydrological characteristic of cockpit karst is the rapid transmission of rainfall to the karst aquifer through individual closed depressions.



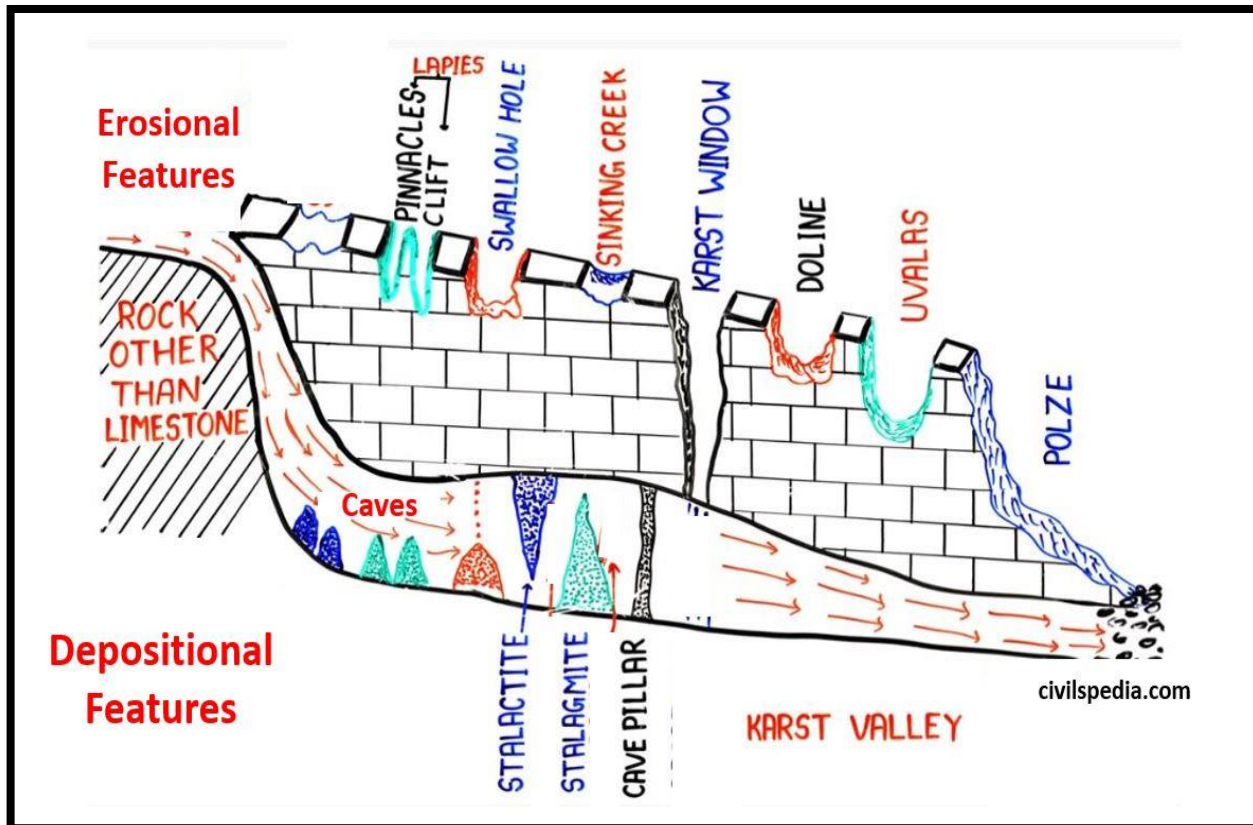
Tower karst are tall rock structures made up of soluble rock such as limestone. Tower karst forms as near-vertical joints and fractures are eroded downward by solution leaving parts of a previously coherent rock mass isolated from each other. Tower karst is most common in **tropical regions**, although it may form in other climates as well.



5. **Karst Window:** A karst window, also known as a karst fenster, is a geomorphic feature found in karst landscapes where an underground river is visible from the surface within a sinkhole.

FORMATION

- The water, which enters Dolines goes underground by percolation and down-flow, and eventually takes the form of an underground stream.
- where the land separating two adjacent dolines collapses, a portion of the underground stream may become unroofed, and the stream can be seen from the surface flowing out of a cavern on one side, across an open space into another cavern on the other side.
- Search an opening through which the course of the underground stream is visible, is called a karst window.



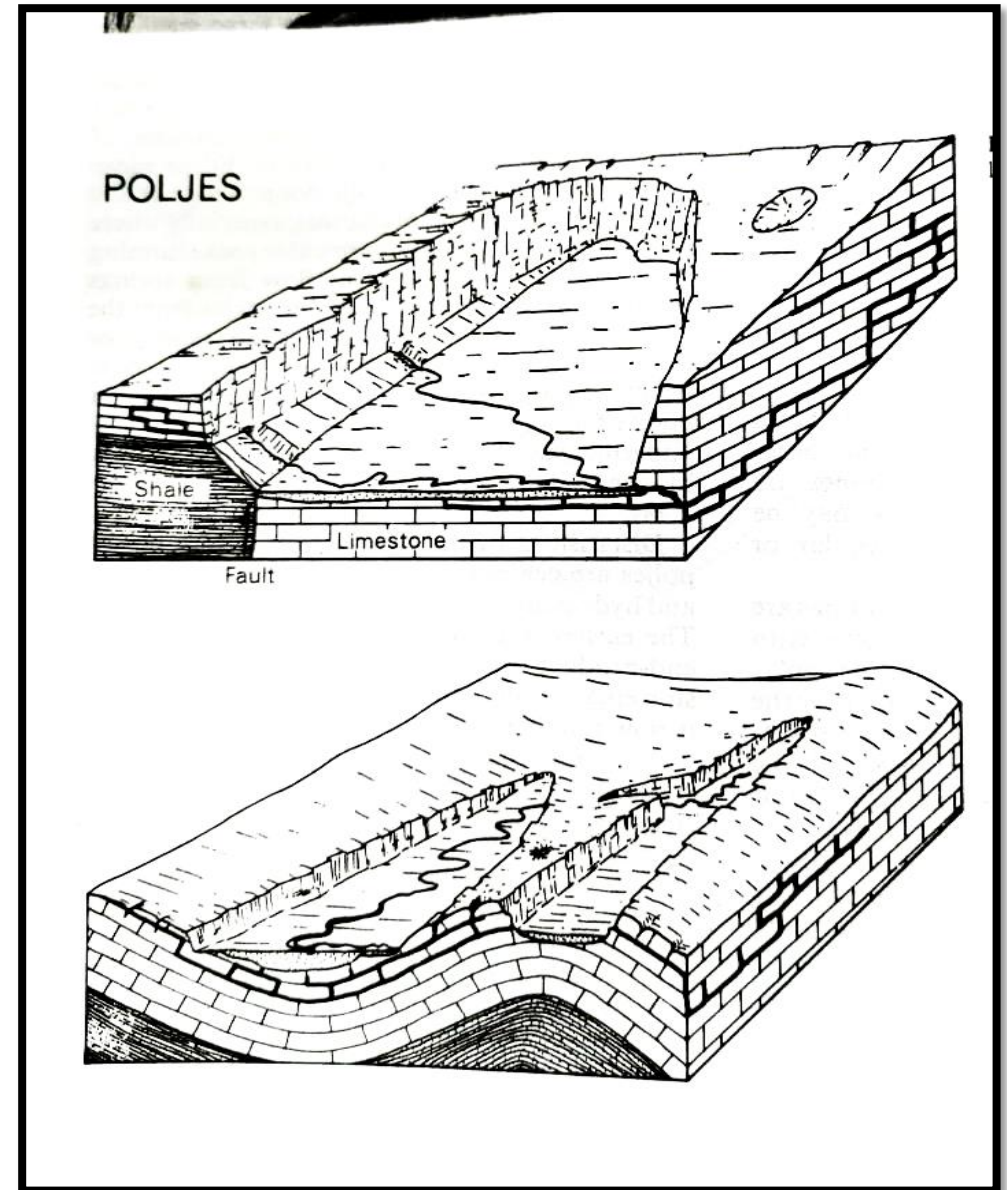
6. **UVALA:** Uvalas are a particular type of karst enclosed depression. This karst depressions are much larger than sinkholes and display gentler slopes and more complex three-dimensional shapes.

- It a large elongate sinkhole resulting from enlargement and coalescence of a linear group of small sinkholes.
- In a region where there are many dolines or sinkholes, they frequently expand in the diameter and coalesce and form compound sinkholes or compound swallow holes. They usually consist of a large solutional depression, with the collapsed roof and walls of several dolines merged into them. These large depressions or compound sinkholes are called Uvalas.



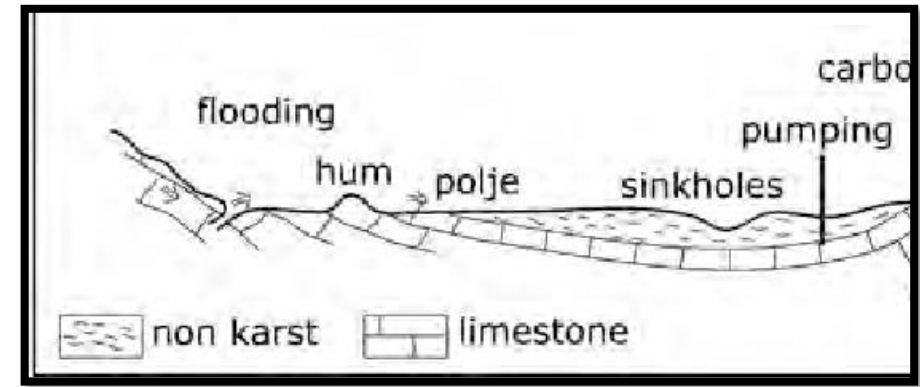
7. **POLJE**: Depressions even larger in size than uvala, which owe their origin to solution of down-faulted or down-folded limestone blocks have been called POLJE.

- It resembles an uvala in appearance, but difference in **extent and origin**. The area of a polje may cover several square kilometers.
- The largest polje in Yugoslavia in the western Balkans is the **Livno polje**, which is 70 kilometers long, and 5 to 11 kilometers wide.
- A typical polje is an **elongated basin with a flat floor and steep sides**.
- It is believed that it has been formed by the **solution of down-faulted or down-folded limestone blocks** and is thus a **structure controlled** solutional form.
- In Yugoslavia Poljes are given extensively to maize cultivation on account of the flat surface and easy availability of water.



8. **HUMS:** Residual hill of limestone on a fairly level floor, such as the **isolated hills of limestone in poljes**.

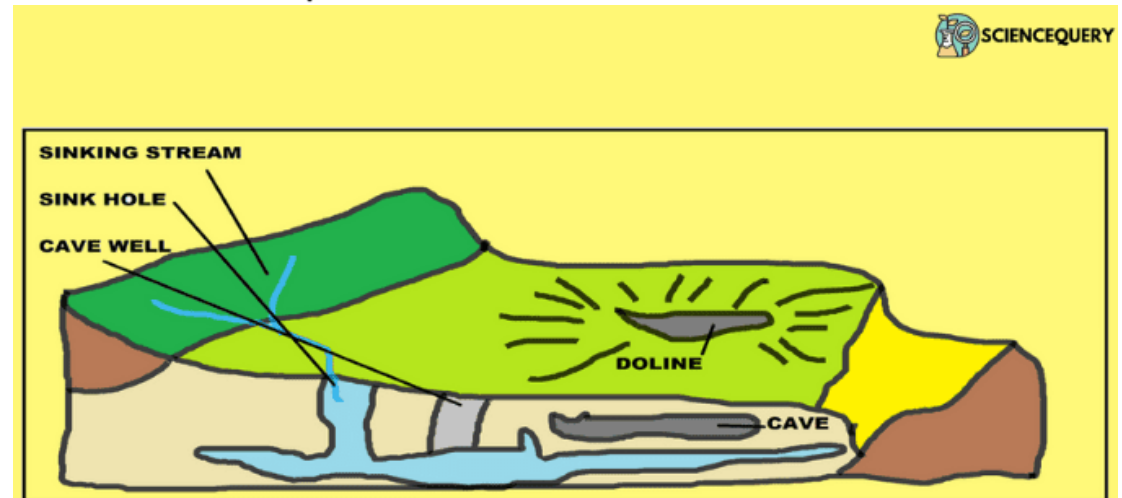
- These are curved relicts of limestone rocks after erosion.
- These residual hills and hillocks, which resemble monadnocks and bornhardts, are known as **hums** in the Karst region of **Yugoslavia**. They are called **pepino hills** or **haystack hills** in **Puerto Rico**. In some **tropical areas** (Cuba), the term **mogote** is used loosely as synonym for hums.



SURFACE RIVER AND ASSOCIATED FEATURES:

9. **Sinking Creeks:** Surface rivers are usually few in karst. Through the sinkholes the surface water sinks and is conveyed through underground roots. This sinkholes are so effective in collecting the surface runoff that hardly any surface stream exists and almost entire drainage is underground. It is only the largest streams which raise in the highlands beyond the plain and have cut deep valleys that are even to flow through the Plain. The smaller streams lose their water in one or more sinkholes, & are thus called **sinking creeks** And the point at which water sinks below is called its **sink**.

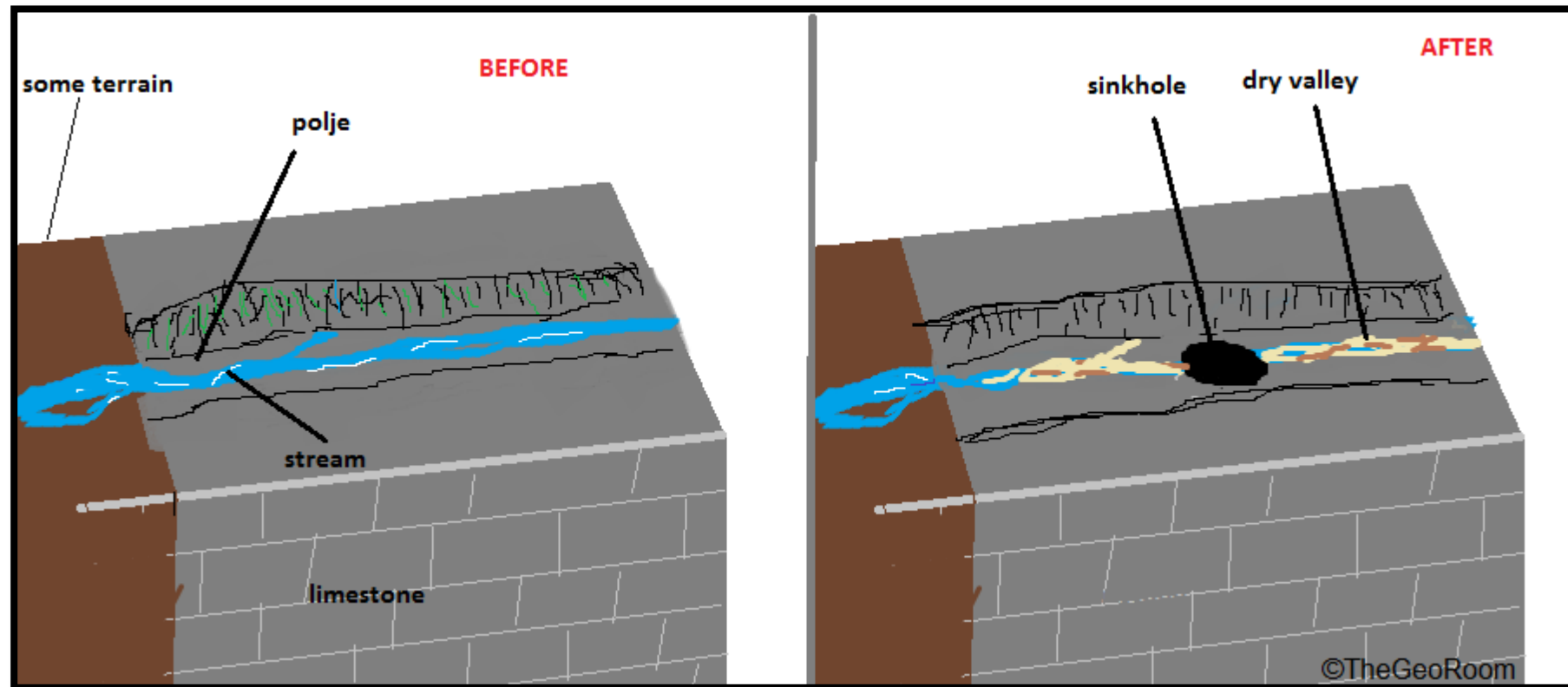
- The Lost river in southern Indiana, U.S.A. flows underground for 13 kilometres before it again starts flowing on the surface.



Sinking Creek

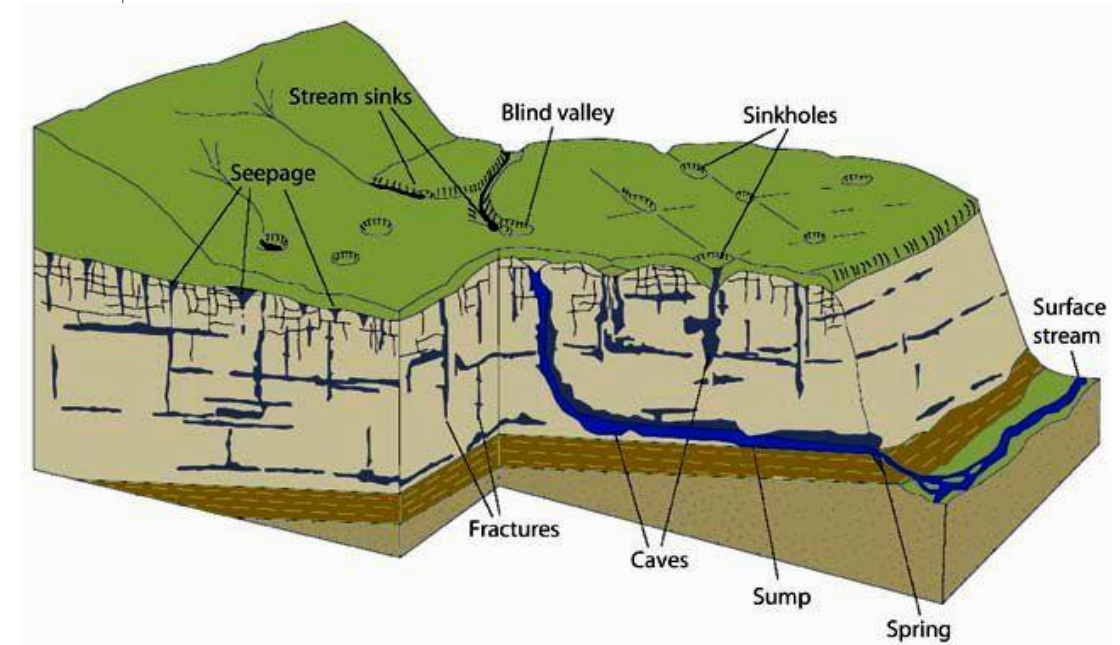
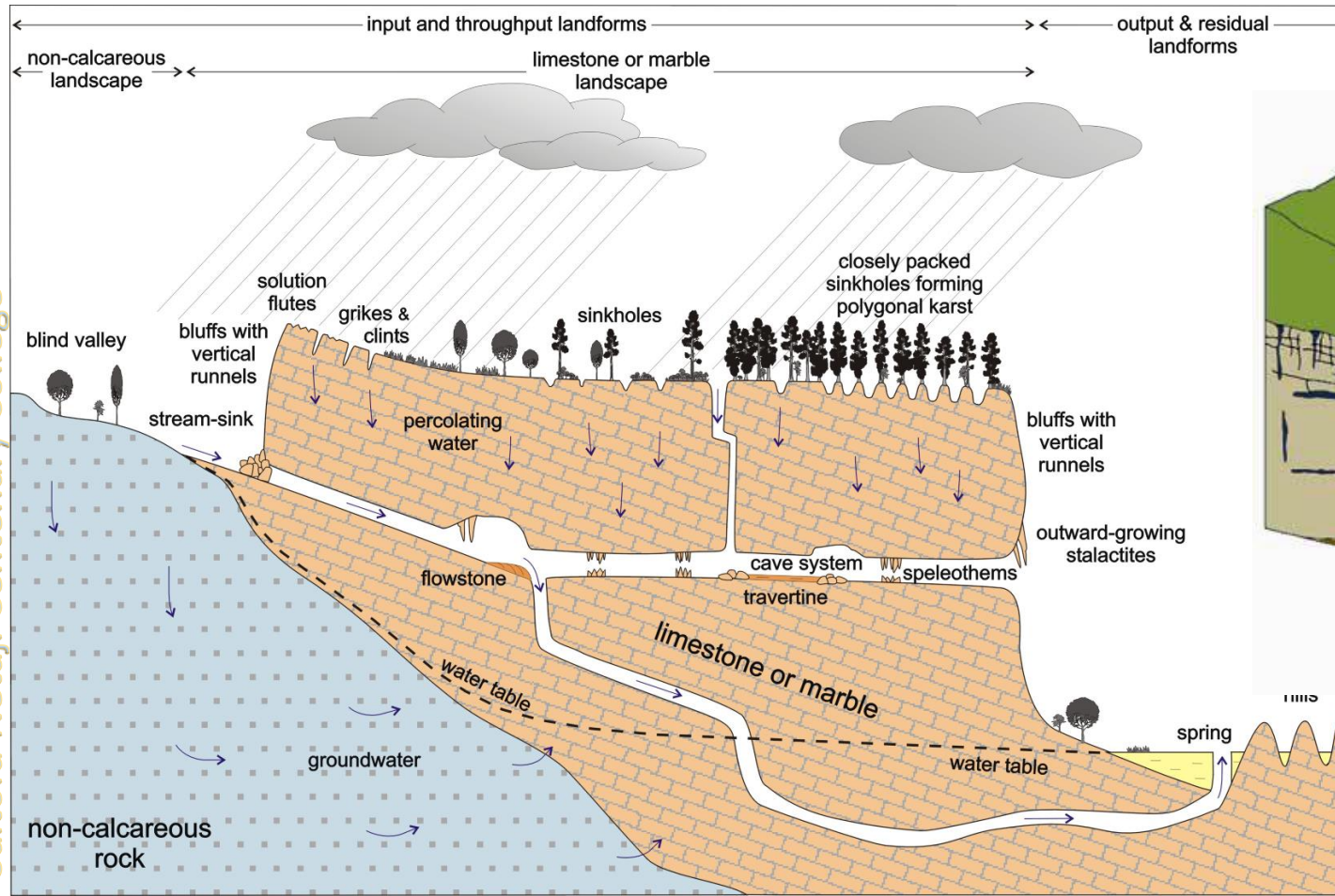
10. **DRY VALLEY:** These are traces of a prior river flow. When streams originating elsewhere enters a limestone area the stream may infiltrate or sink through a swallow hole and disappears from the surface leaving a trace of dry channels. The stream now flows downwards as an underground river. When the stream reemerge on the ground from the limestone underground it is called a resurgence.

- It is only during periods of heavy rainfall when the sink or swallow holes and the connecting underground passages are unable to accommodate all the water, that the streams may temporarily flow for a short period in their dry beds, otherwise they remain dry for most of the year.



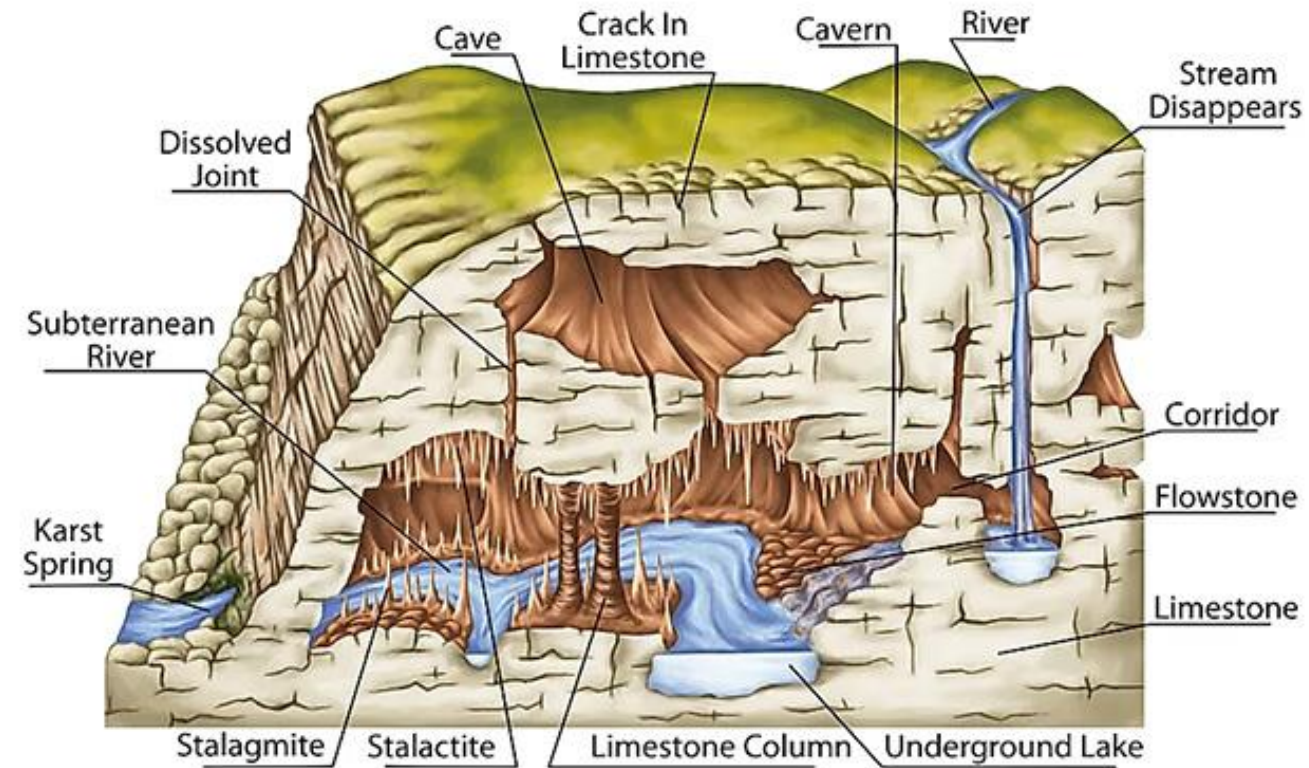
11. **BLIND VALLEY:** Where the stream terminates in a sinkhole and this situation continues for a long time, the stream curves out a fairly deep valley below the level of the caste plain. Under such conditions, the river valley ends at the sink or swallow hole is called a *blind valley*.

- The dry bed, if any, beyond the sinkhole, gradually becomes obliterated through disuse and losses the character of a surface valley or dry valley.
- During the rainy season, when the increased volume of water is not able to enter the sinkholes, the blind valleys are converted into temporary lakes due to large accumulation of water



12. **Underground streams and Caverns:** Underground streams and caverns are distinctive features of limestone regions.

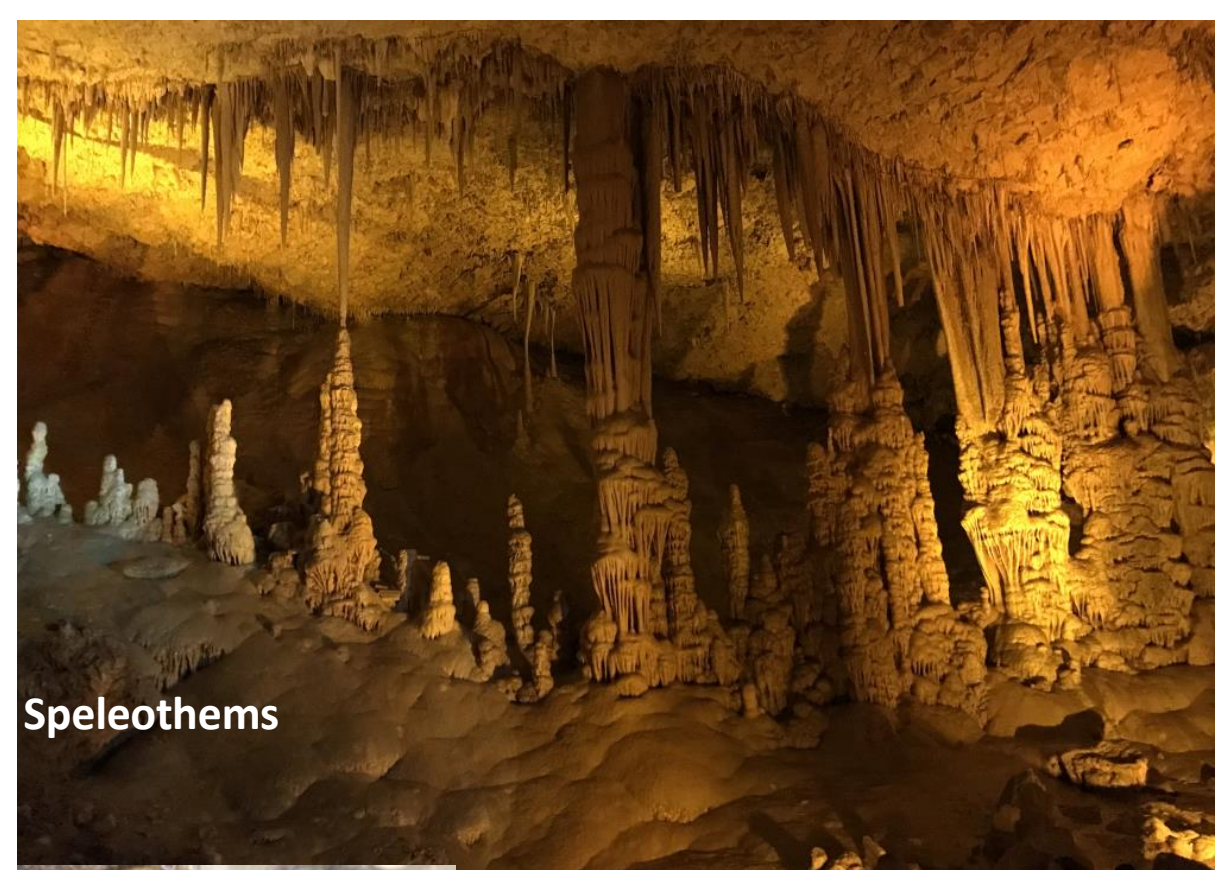
- Caves are originated predominantly due to solution, but mechanical abrasion can also be important, especially where sediment and pebbles are carried through the limestone by streams.
- **Tectonic influences such as faults or stress release, may be of local significance. Roof collapse and rockfalls into caves are often important in cave extension and modification.**
- As the sinking creeks go underground, they flow horizontally along the joints and bedding planes or sometimes fall vertically down as waterfalls.
- **By prolonged solution their underground course becomes so wide that a series of underground caverns are formed which are interconnected by narrow pathways and extended for several miles.**
- At places water may collect and form underground ponds. Thus in course of time below the surface there comes to develop an extensive labyrinth of caverns, interconnecting galleries, reverse waterfalls and lakes.



13. CAVE DEPOSIT: Cave deposits are important to geomorphologists and archaeologists because they preserve evidence of cave history, climatic change and human occupation.

A **speleothem** is a geological formation by mineral deposits that accumulate over time in natural caves. Speleothems most commonly form in calcareous caves due to carbonate dissolution reactions. They can take a **variety of forms**, depending on their depositional history and environment. **Cave travertine** is a term which is collectively used for these diverse depositional forms.

- I. **Stalactite**
- II. **Stalagmite**
- III. **Column and Pillars**
- IV. **Curtains or Draps**
- V. **Helictes** : Helictite, cave deposit that has a **branching, curved, or spiraled shape** and may grow in any direction in seeming defiance of gravity. They are most likely the result of **capillary forces** acting on tiny water droplets, a force often strong enough at this scale to defy gravity. But another hypothesis based on **wind formation** is also viable

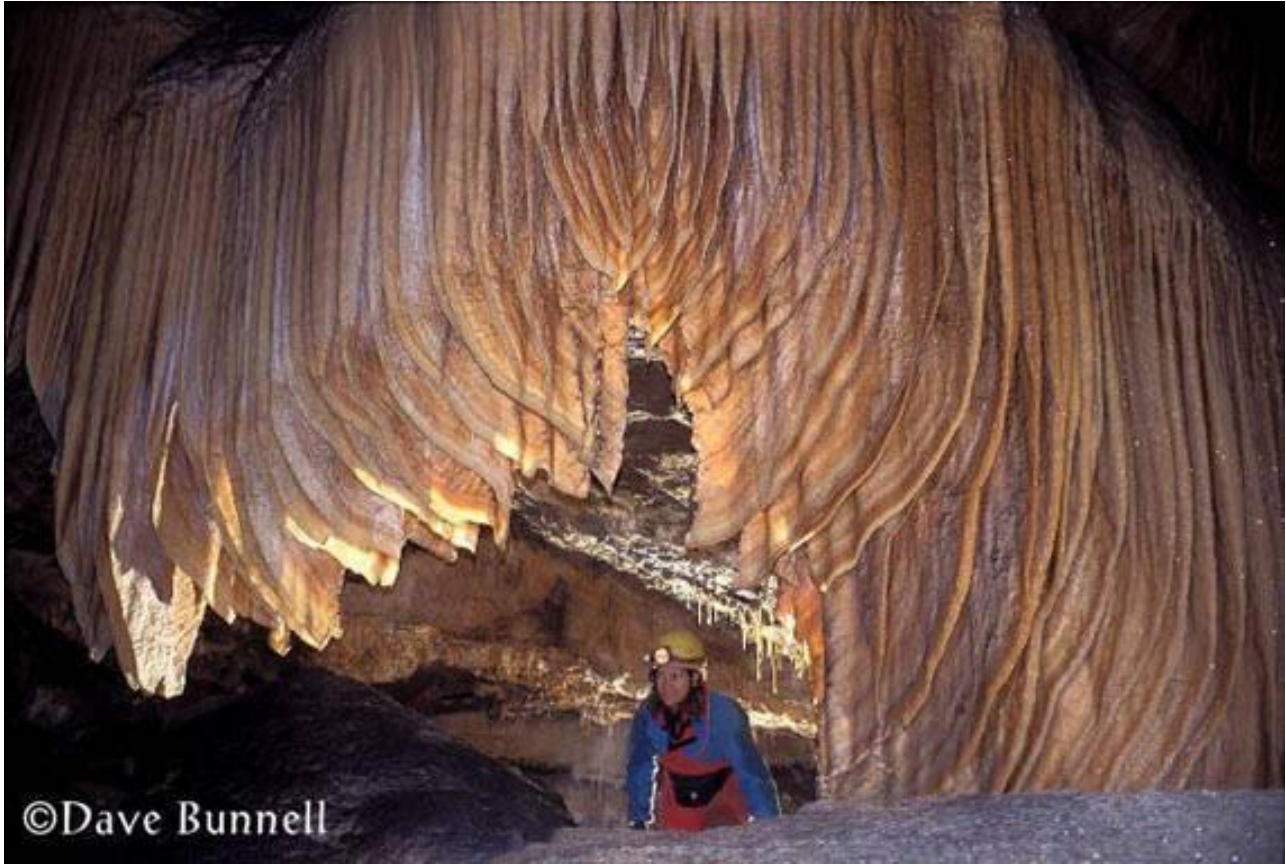


Speleothems





VI. Flowstone occurs when water rich in calcium carbonate flows along the walls or floor of a cave, depositing layers of calcite. Formations can look smooth and glossy, or create hanging 'curtains' and draperies.



IMPORTANCE OF KARST TOPOGRAPHY:

- Karst landscapes are important for the climate because of their carbon dioxide binding capacity.
- Through their complex underwater systems they provide drinking water to people all over the world. With more than eight million sq. km of karst, Asia has the largest share worldwide.
- Because of their underground and aboveground bizarre rock formations, karst mountains have been fixed points for mystical stories and places of spiritual ceremonies of the local inhabitants for thousands of years.
- At the same time, they are a magnet for tourists.
- Karst landscapes are not only a mirror of the cultural history of mankind they are also useful paleoclimatic proxies.



THANK YOU