Teacher Lesson Plan

LESSON 1.

The present is the key to the past.

The Capitan Formation and Guadalupe Peak.

NPS picture (Buehler).

Overview:

Students are introduced to the Geology of the Guadalupe Mountains National Park by getting to know the Permian reef in the web page, reading brochures and watching a video.

Prerequisites:

Students should have a general understanding of weathering and landscape evolution, topographic maps, map attributes and a basic knowledge of animal groups, especially marine invertebrates.

Grades:

9 - 12

Objectives:

The student will:

- Make field or lab observations of Permian marine fossils.
- Use inquiry and geologic clues to infer paleoenvironment from comparisons with modern analogs.
- Learn about the geology of the Delaware Basin and Guadalupe Mountains during the Permian Period.
- Get to know satellite images and bathymetric maps.
- Use topographic and geologic maps.

Duration:
2 labs (60 min/each) or 1 fieldtrip (about 4 hours)

Vocabulary:
Permian Period, geology, geologist, reef, forereef, backreef, lagoon, paleontology, sponge, algae, brachiopods, cephalopods, crinoids, bryozoans, flora, fauna, fossil, fossilization process, deposits, cement, cemented, evaporites, interpretations, iterative process, bathymetric map, bathymetry, aerial photograph, evaporite, landscape, analog, geomorphology, marine environment, paleoenvironment, stratigraphy, geologic formation, geologic cross-section, topographic map, topography, topographic profile, Delaware Basin, Guadalupe Mountains, Carlsbad Caverns National Park, limestone, bluff, corals

Materials:

- Photographs of the Guadalupe Mountains and Delaware Basin (slides #1-7)
- Photographs of modern reefs (slides #35-37)
- Topographic map of Carlsbad Caverns National Park (slide #80)
- Bathymetric image of a carbonate shelf (slide #30)
- Comparative image of Delaware Basin and Bahamas (slide #31)
- Diagram of Delaware Basin (slide #33)
- Schematic of the local stratigraphy (slide #19)
- Geologic time chart (slide #8 or 9)
- Guide to Permian marine fossils (slides #104 -109)
- Science notebooks
- Major Permian marine fossils (either in the rocks on the fieldtrip or invertebrate fossil hand samples for the lab).
- http://www.nature.nps.gov/views/layouts/main.html#/GUMO/reef/
- Topographic map of Guadalupe mountains
- Listening to the rocks. A young persons guide to the Permian Reef Trail. CCGMA. 2006
- Identification guide to the fossils. Guadalupe Mountains National Park. Mary Carol Coleman & Cameron Coleman. CCGMA, SIPES Foundation and the members of the Society of Independent Professional Earth Scientists. 2010

Background information:
The Delaware Basin and Guadalupe Mountains region of southeastern New Mexico and Western Texas is rich with unique geologic features. Once covered by a sea approximately 250 million years ago during the Permian Period, many of the preserved rocks, fossils, and geologic formations are the best examples of these ancient marine environments in the world.

The Capitan Formation, a resistant limestone bluff that creates the peaks of the Guadalupe Mountains, represents an ancient reef in this sea. Different from modern reefs, which are composed of large branching corals and other flora, the Capitan reef was primarily composed of sponge and algae, containing only a few types of small corals. The Capitan also possessed ample brachiopods, cephalopods, crinoids, and bryozoans. These ancient fauna are preserved in the rocks as fossils resistant to erosion after the fossilization process. Also preserved in the area are the backreef lagoon deposits (the Seven Rivers, Yates, and Tansill Formations), the forereef deposits composed of cemented reef material that slid into the basin, and basin evaporites that were deposited as the sea retreated and evaporated.

Geologists have studied and made interpretations about the area and its ancient deposits since the early 1900s. Further understanding of this ancient landscape, which may be viewed at Carlsbad Caverns National Park, has been accomplished through comparisons of the preserved Permian deposits and fossils to those found in modern reef systems. The comparison and contrast of fossils and ancient deposits with modern analogs is an iterative process that enables geologists to understand the past history of a region. In this lesson students will infer the Permian paleoenvironment of the region through investigations of geomorphology and faunal observations of ancient and modern marine environments.

Preparation:
Read the background information about the park, visit the web site and prepare the video to watch and the slides to show.

Procedure:

Procedure (if in the field)
The teacher will:

- Show students the satellite image of the Guadalupe Mountains at the entry area of McKittrick Canyon and ask what the mountains might have in common with

the photos and bathymetric image of a modern reef (explain satellite images and bathymetric maps if the students haven't seen them before). Give students a chance to respond and think about possible relationships.

- Ask what clues would be necessary to determine a relationship between the two environments (what's missing?). How could the modern geologic configuration be explained?
- Define the term "geology" and explain that geologists put together clues found in the field today to interpret the paleoenvironment of an area.
- Talk about the geologic time chart and explain that life was different in the Permian Period in this region.
- Lead students on the McKittrick Canyon nature trail—have the students look for, describe, and identify several of the fossils using the guide and record their findings in their science notebooks.
- Return to the entry area and discuss findings—show fossil samples.
- Have students brainstorm about the paleoenvironment. Compare Guadalupe Mountains fossils to reconstructed photos and contrast with samples (if possible) of modern reef fauna. Discuss how items became fossils (process of fossilization).
- Define the terms: geologic formation, geologic cross-section, and stratigraphy.
- Look at the stratigraphic diagram and explain where the reef was and which rocks in the Guadalupe Mountains correspond to these sections (The reef of the Capitan formation is the massive limestone bluff; the horizontal layers of the Yates and Tansill behind the bluff are the back reef/lagoon areas; and the sloping layers in front, such as the Lamar Fm. are the forereef deposits, or slump. This was the last unit that was hiked through).
- Back in the lab explain basic information about topographic maps and how to construct a topographic profile.
- Construct a topographic profile of the trail from the pine springs campground to Guadalupe peak.
- For homework, have students produce a topographic profile from A to A' on the Carlsbad Caverns National Park map.

Procedure (if in the lab)

The teacher will:

- Show the satellite image of the Guadalupe Mountains and ask what they might have in common with the bathymetric images of a modern reef (explain satellite

images and bathymetric maps if the students haven't seen them before). Give students a chance to respond and think about possible relationships.

- Ask what clues would be necessary to determine a relationship between the two environments (what's missing?). How could the modern geologic configuration be explained?
- Define the term "geology" and explain that geologists put together clues found in the field today to interpret the paleoenvironment of an area.
- Pass out fossil samples and have students describe and identify several of the fossils using the guide and recording their findings in their science notebooks.
- Discuss how items become fossils. Brainstorm about the environment. Compare to diagrams and contrast with samples (if possible) of modern reef fauna.
- Define the terms: geologic formation, geologic cross-section, and stratigraphy.
- Look at the stratigraphic diagram and explain where the reef was and which rocks in the Guadalupe Mountains correspond to these sections (reef is the massive limestone bluff—Capitan formation; horizontal layers of the Yates and Tansill behind the bluff is the back reef/lagoon area; and the sloping layers, such as the Lamar Fm., in the front are the forereef deposits, or slump).
- Back in the lab explain basic information about topographic maps and how to construct a topographic profile.
- Construct a topographic profile of the trail from the pine springs campground to Guadalupe peak.
- For homework, have students produce a topographic profile from A to A' on the Carlsbad Caverns National Park map.

Assesssments:

- Field notes
- Student worksheet
- Lab or field trip report
- Topographic profile

Alternative assesments or extensions:

- Topographic maps, additional research and class presentations on reefs, the Permian period, Carlsbad Caverns National Park and Guadalupe Mountains National Park, disciplines in geology or the geographical region

- Additional exercises with topographic maps

- Make a poster about the fossils found in Guadalupe Mountains

Bibliography

- Beaubouef, R.T., Rossen, C. Zelt, F.B, Sullivan, M.D., Mohrig D.C. and D.C. Jeanette. 1999. "Deep-Water Sandstones, Brushy Canyon Formation, West Texas." AAPG Field Guide #40.
- Bebout, D.G. and C. Kerans. 1993. *Guide to the Permian Reef Geology Trail, McKittrick Canyon, Guadalupe Mountains National Park, West Texas. Guidebook 26.* Austin, TX: Bureau of Economic Geology.
- Hill, C.A. 1996. "Geology of the Delaware Basin Guadalupe, Apache, and Glass Mountains New Mexico and West Texas." Permian Basin Section – SEPM. Pub. No. 96-39.
- Marshak, S. 2001. *Earth Portrait of a Planet*. New York: W.W. Norton & Co.

Additional reading and other resources

- New Mexico School of Technology virtual fieldtrip of the Guadalupe Mountains: *http://geoinfo.nmt.edu/staff/scholle/guadalupe.html*
- USGS web page on fossils: *http://pubs.usgs.gov/gip/fossils/contents.html*
- Texas A&M Oceanography class' web resource list: *http://oceanworld.tamu.edu/ocean401/ocng401_hotlinks.html*
- Berkeley's Geology homepage (Permian Period): *http://www.ucmp.berkeley.edu/permian/permian.html*
- National Oceanic and Atmospheric Association's (NOAA) web page on coral reefs: *http://www.nmfs.noaa.gov/prot_res/PR/coralhome.html*

Student Worksheet

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Geologists have studied and made interpretations about the area and its ancient deposits since the early 1900s. Further understanding of this ancient landscape, which may be viewed at Carlsbad Caverns National Park, has been accomplished through

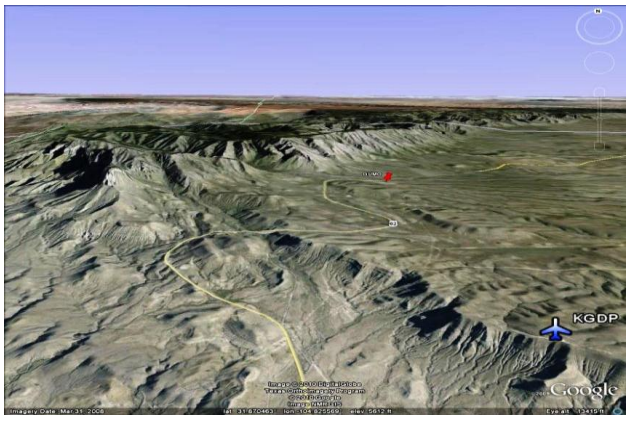
comparisons of the preserved Permian deposits and fossils to those found in modern reef systems. The comparison and contrast of fossils and ancient deposits with modern analogs is an iterative process that enables geologists to understand the past history of a region. In this lesson students will infer the Permian paleoenvironment of the region through investigations of geomorphology and faunal observations of ancient and modern marine environments.

Vocabulary

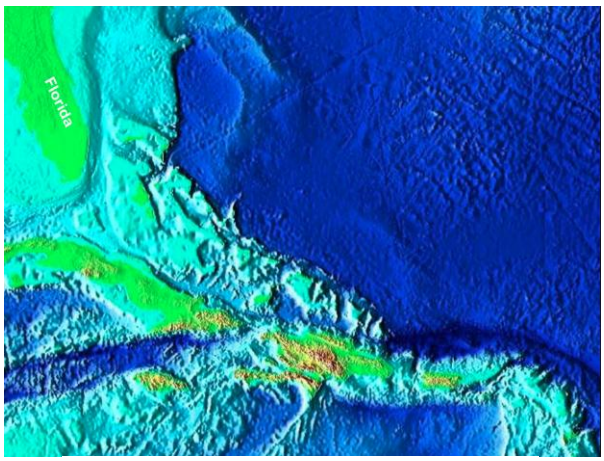
Permian Period, geology, geologist, reef, forereef, backreef, lagoon, paleontology, sponge, algae, brachiopods, cephalopods, crinoids, bryozoans, flora, fauna, fossil, fossilization process, deposits, cement, cemented, evaporites, interpretations, iterative process, bathymetric map, bathymetry, aerial photograph, evaporite, landscape, analog, geomorphology, marine environment, paleoenvironment, stratigraphy, geologic formation, geologic cross-section, topographic map, topography, topographic profile, Delaware Basin, Guadalupe Mountains, Carlsbad Caverns National Park, limestone, bluff, corals

Activity 1.1. Overlapping ovals: Similarities and differences

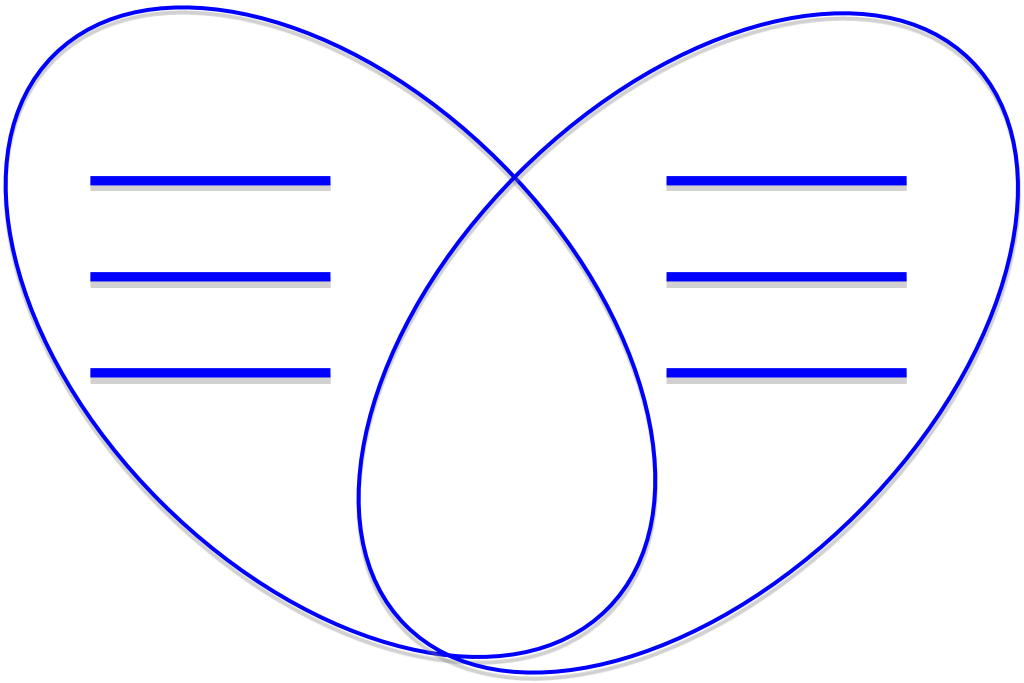
Look at the satellite image of the Guadalupe Mountains and the bathymetric image of a modern reef. Place the boxed words on the correct lines or on the overlapping section, and then answer the questions.



Satellite image of Guadalupe Mountains



Bathymetric image of modern reef



LIVING BEINGS

SEA

REEF

BASIN

ROCKS

MOUNTAIN

ELEVATION

FOSSILS

a. Name two ways that Guadalupe Mountains and the reef in Florida are alike.

b. Name three differences between Guadalupe Mountains and the reef in Florida.

c. What clues are necessary to determine the relationship between the two environments?

d. How can we explain what happened in the Guadalupe Mountains?

Activity 1.2. Identifying fossils !!!

Examine the fossil samples available at the lab (or the Rocks with fossils at the Permian trail at the Guadalupe Mountains National Park) and complete the lab report in your science notebook.

You can use the following information to complete the report:

Types of fossils	Types of organism	Fossil samples
mold, cast, trace, track form, petrified remains	algae or protist, porifera, cnidarian or coelenterate, bryozoan, mollusk (bivalve, gastropod, cephalopod), echinoderm, moneran or bacteria, foraminifera or protozoan, arthropod	algae, ammonoid, brachiopod, bryozoan, clam, coral, fusulinids, nautiloid, gastropod, sponge, crinoid, pelecypod, sea urchin, trilobite

Handout

FOSSIL IDENTIFICATION LAB REPORT

QUESTION: What can we infer about living beings from their fossils?

BACKGROUND RESEARCH: Explain what a fossil is and the process from which a living being becomes a fossil. Name also the types of fossils we can find.

HYPOTHESIS: Form your own hypothesis based on your findings.

EXPERIMENT

- MATERIALS: fossil samples, hand lens, textbook, fossil guides

- PROCEDURE:

1. Examine the fossil sample with naked eye.
2. Examine the fossil sample with a magnifying glass.
3. Determine what type of fossil it is.
4. Determine what type of organism may have formed it.

RESULTS: Complete the data table and describe what you found out after carrying out the experiment.

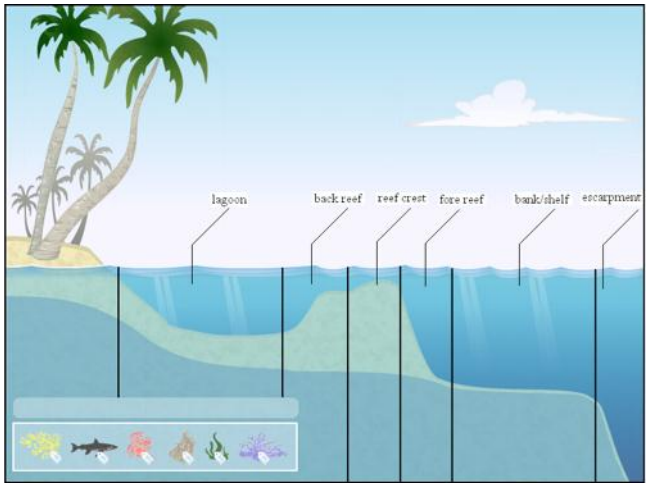
CONCLUSION: Was your hypothesis supported by your results?

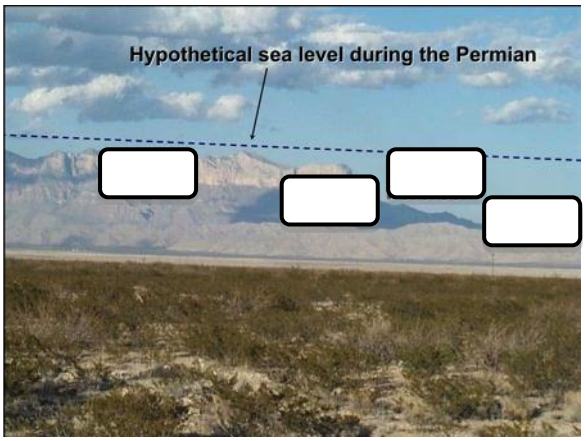
DATA TABLE

FOSSIL #	TYPE OF FOSSIL	TYPE OF LIVING BEING	DESCRIPTION/ DRAWING	NAME
1				
2				
3				
4				
5				
6				
7				

Activity 1.3. Labeling reefs on the mountains

Based on the diagram with the different parts of an actual reef, label the following pictures of the Guadalupe Mountains with the correct tag. This will help you understand what was here millions of years ago.

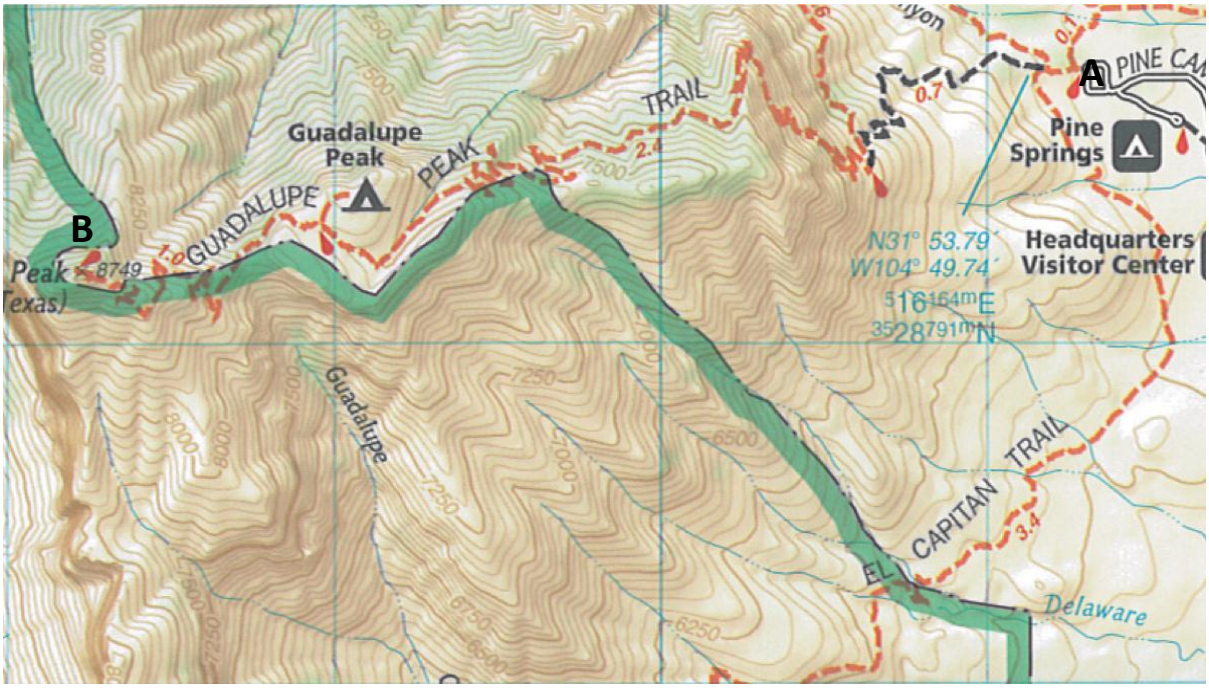




Activity 1.4. Constructing topographic profiles

In the following topographic map of the Guadalupe Mountains, indicate:

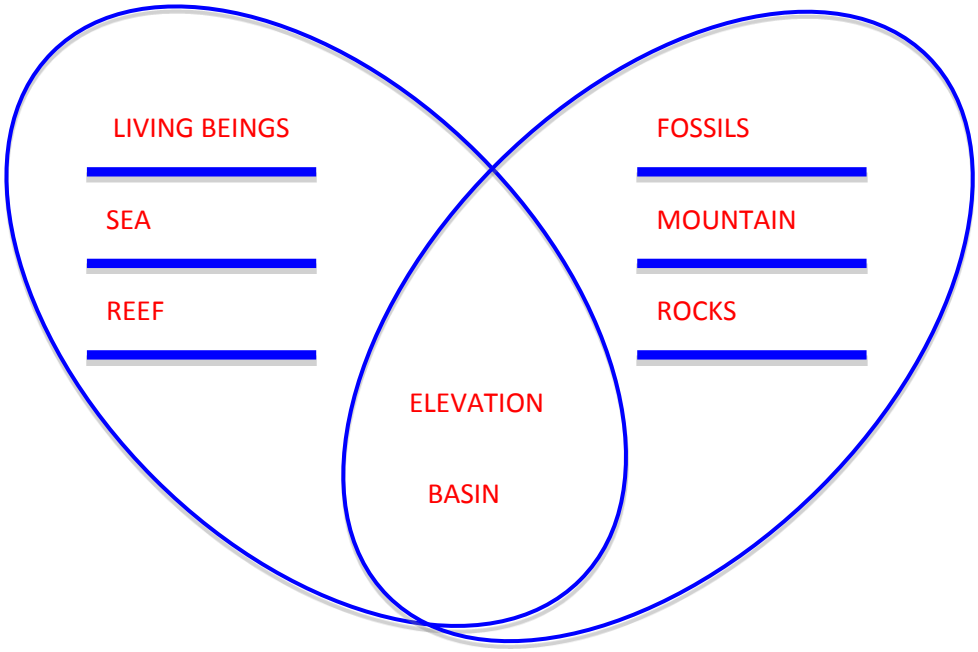
a. What is the average altitude (in feet and meters) of the Pine Springs Campground?
b. What is the altitude of Guadalupe Peak (in feet and meters)?
c. How long is the trail to Guadalupe Peak?
d. If you want to climb this Peak, what is the change in elevation you will experience?
e. Construct the topographic profile between the Pine Springs Campground (point A) and Guadalupe Peak (point B). The scale is 1:35000 and the contour interval is 250 feet (76.2 m).



Answer Key

Activity 1.1. Overlapping ovals: Similarities and differences

Look at the satellite image of the Guadalupe Mountains and the bathymetric image of a modern reef. Place the boxed words on the correct lines or on the overlapping section, and then answer the questions.



a. Name two ways that Guadalupe Mountains and the reef in Florida are alike.

Both have an area elevated and a basin.

b. Name three differences between Guadalupe Mountains and the reef in Florida.

Guadalupe is a mountain whereas Florida reef is in the sea. Guadalupe is made up of Rocks whereas Florida reef is made up of living organisms. Guadalupe has fossils whereas Florida reef has living beings.

c. What clues are necessary to determine the relationship between the two environments?

Fossils and rocks

d. How can we explain what happened in the Guadalupe Mountains?

Try to reconstruct the history of events from the geological features

Activity 1.2. Identifying fossils !!!

Examine the fossil samples available at the lab (or the Rocks with fossils at the Permian trail at the Guadalupe Mountains National Park) and complete the lab report in your science notebook.

FOSSIL IDENTIFICATION LAB REPORT

QUESTION: What can we infer about living beings from their fossils?

BACKGROUND RESEARCH: Explain what a fossil is and the process from which a living being becomes a fossil. Name also the types of fossils we can find.

HYPOTHESIS: Form your own hypothesis based on your findings.

EXPERIMENT

- MATERIALS: fossil samples, hand lens, textbook, fossil guides

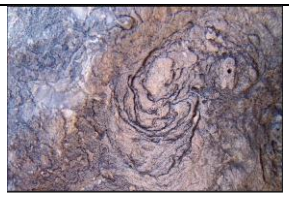
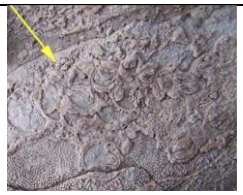
- PROCEDURE:

1. Examine the fossil sample with naked eye
2. Examine the fossil sample with a magnifying glass
3. Determine what type of fossil it is.
4. Determine what type of organism may have formed it.

RESULTS: Complete the chart with a description or drawing of the fossil. And describe what you found out after carrying out the experiment.

CONCLUSION: Was your hypothesis supported by your results?

Answers should vary depending on the students and the fossil samples.

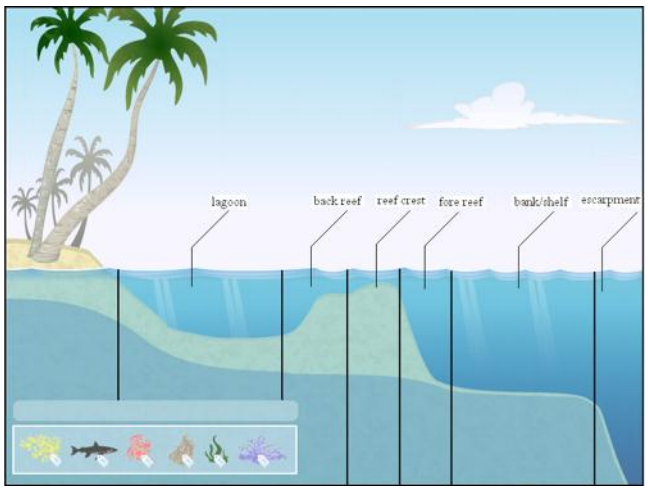
FOSSIL	TYPE OF FOSSIL	TYPE OF LIVING BEING	DESCRIPTION/ DRAWING	NAME
1	MOLD	PROTIST		ALGAE
2	CAST	MOLLUSK CEPHALOPOD		AMMONOID
3	MOLD	MOLLUSK BIVALVE		BRACHIOPOD
4	MOLD	BRYOZOAN MICROORGANISM		BRYOZOAN
5	MOLD	COELENTERATE		CORAL
6	MOLD	PROTOZOAN		FUSULINIDS
7	MOLD	MOLLUSK CEPHALOPOD		NAUTILOID

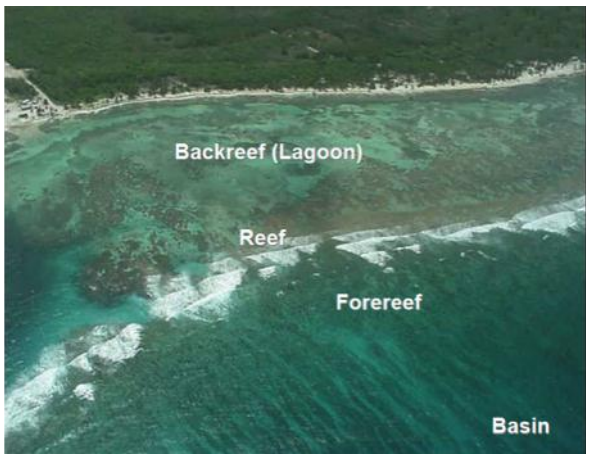
8	MOLD	MOLLUSK GASTROPOD		GASTROPOD
9	CAST	PORIFERA		SPONGE
10	CAST	ECHINODERM		CRINOID
11	MOLD	MOLLUSK BIVALVE		PELECYPOD
12	CAST	ECHINODERM		SEA URCHIN
13	CAST	ARTHROPOD		TRILOBITE

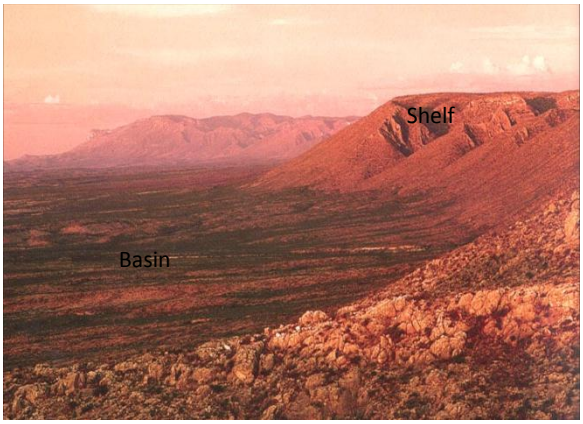
Note: Anwers for “type of fossils” can vary depending on the fossil sample. For descriptions about the fossils, check “Identification guide to the fossils. Guadalupe Mountains National Park. Mary Carol Coleman and Cameron Coleman”

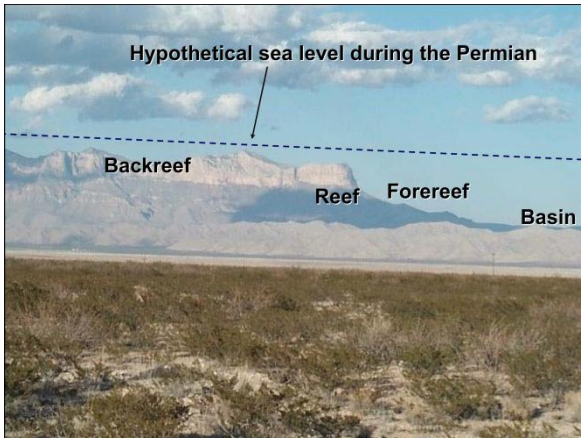
Activity 1.3. Labeling reefs on the mountains

Based on the diagram with the different parts of an actual reef, label the following pictures of the Guadalupe Mountains with the correct tag. This will help you understand what was here millions of years ago.









Activity 1.4. Constructing topographic profiles

In the following topographic map of the Guadalupe Mountains, indicate:

b. What is the average altitude (in feet and meters) of the Pine Springs Campground? 5700 feet = 1737 m

c. What is the altitude of Guadalupe Peak (in feet and meters)? 8749 feet = 2666 m

d. How long is the trail to Guadalupe Peak? 4.2 mi = 6759 m

e. If you want to climb this Peak, what is the change in elevation you will experience? 3049 feet = 929 m

f. Construct the topographic profile of the trail starting at the parking lot close to Pine Springs Campground (point A) and Guadalupe Peak (point B). The scale is 1:35000 and the contour interval is 250 feet (76.2 m).

The contour interval is 250 feet or 76.2 m. This means that the contour interval in the vertical axis will be approximately 2 mm if we do the calculations with the scale.

1 m (map) = 35 000 m (reality)

If we divide 76.2 m (reality) by 35 000 m, we'll have 0.00217 m. Then we convert this to mm and we'll have 2.17 mm (rounded to 2 mm).