Canon Paleontology Curriculum
Unit Two: Paleontology
Background Material

FLORISSANT FOSSIL BEDS

NATIONAL MONUMENT

INTRODUCTION

A mountain valley just west of Pikes Peak holds volumes of information about prehistoric life on Earth. Almost 35 million years ago, during the Eocene epoch, volcanic eruptions buried the then lush valley and petrified the redwood trees that grew here. A lake formed in the valley and the fine-grained sediments at its bottom became the final resting-place for thousands of insects and plants. These sediments compacted into layers of shale and preserved the delicate details of these organisms as fossils. The Florissant Fossil Beds are world-renowned, and in1969 were set aside as a National Monument.

STATEMENT OF PURPOSE

The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education and inspiration of this and future generations. The National Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

FLORISSANT FOSSIL BEDS MISSION

The fossils of Florissant represent an important chapter in the study of evolution. The insects, plants and other life forms preserved by the volcanic events of the Eocene epoch allow us to compare the ecosystems of that age with those of today. Because the fossils found at Florissant are not found in such quantity or quality at any other place in the United States, their preservation and scientific study is critical. The goal of the National Park Service at Florissant Fossil Beds National Monument is three fold; provide facilities and programs for visitor understanding of the fossil story; encourage visitor appreciation of the role fossils play in understanding geologic history; promote the protection and preservation of fossil resources through visitor contacts.

GEOLOGICAL HISTORY

Teacher's note:
Use Orientation to Florissant Fossil Beds National Monument as an introduction to the Unit.

Pike's Peak Granite is the oldest rock at Florissant. More than a billion years ago, magma cooled deep beneath the Earth's surface. This pink granite was then uplifted to form the hills in the Monument as well as the 14,110 foot Pike's Peak 15 miles to the east. The granite uplift occurred 65-70 million years ago (mya). Rocks deposited on top of the granite were exposed and eroded away, leaving the granite exposed on the surface.

About 35 million years ago, a large volcano, about 18 miles to the southwest, dominated the region. Early eruptions produced mudflows, which inundated a forest of giant redwoods and other trees that grew in the valley. The mud hardened into tuffaceous mudstones, burying the trees up to a depth of 15 feet. Groundwater penetrated the tuff, dissolving silica. This mineral-rich solution saturated the wood and hardened as it filled between the cell walls, causing the wood to become petrified. These petrified redwood stumps--the bases of once-towering trees--are one of the more impressive attractions for the visitor.

Later, another volcanic mudflow impounded the stream drainage and a lake formed, much as reservoirs now form behind manmade dams. Mud and silt, along with volcanic ash from nearby eruptions, settled as sediments on the lake bottom. Insects, plant parts, leaves and seeds fell into the lake. These settled to the bottom and were quickly buried by sediment. The sediment compacted to form shale and the enclosed insects and plants were compressed to become fossils. The fossils are revealed when the shale is split along its natural bedding planes.

CULTURAL HISTORY

James Castello founded the community of Florissant in 1872 naming it after his hometown of Florissant, Missouri. The name means "flowering" or "blooming" in French. The name is appropriate because of the abundant wildflowers that bloom during the summer months and because of the abundantly preserved plant fossils. Ute Indians inhabited the area during their annual migrations, but left little impact.

A.C. Peale of the Hayden Survey published the first official report of the fossil beds in 1874. However, Theodore Mead completed the first collection of fossils in 1871. His collection ended up in the hands of Dr. Samuel Scudder, a paleoentomologist, who later visited the site and collected more than five thousand fossils during a five day period.

Over the latter part of the nineteenth and early part of the twentieth centuries numerous expeditions collected tens of thousands of fossils. These specimens are found in museums around the world.

The giant redwood stumps were something everyone could get excited about. Earliest accounts from homesteader reports the ground littered with petrified wood, so much so, that in some places passage was difficult. The discovery of a petrified stump 12 feet tall and 38 feet in circumference solidified the fame of the area as a tourist destination. Excursions on the Colorado Midland Railroad featured fossil digs. Several families owned and operated guest ranches featuring the stumps and fossils and allowed collecting for a fee.

The popularity of the valley explains its long history of exploitation and collection. Areas once littered with petrified wood are now bare and priceless information about the past has vanished. Some of the families that owned property on what is now the National Monument tried to limit the removal of specimens. As early as 1920, proposals were made to protect the park under the National Park Service. But, because the lands were in private ownership, no legislative actions were taken.

During the 1960's, development threatened the Florissant fossil beds. Real estate promoters planned a sub-division over the fossil beds. Concerned citizens formed the Defenders of Florissant and stood ready to defy the blades of bulldozers. At the last minute a court injunction halted the housing development. President Richard Nixon signed legislation creating the Florissant Fossil Beds National Monument on August 20, 1969.

DIRECTIONS

Florissant Fossil Beds National Monument is 35 miles west of Colorado Springs. From Interstate 25 take US 24 west to the small town of Florissant. Turn south on Teller County Road #1 for two and one half miles to the Visitor Center. The route is well marked by signs.

AGENCY ORGANIZATION AND CONTACTS

Superintendent
Florissant Fossil Beds National Monument
National Park Service
PO Box 185
Florissant, CO 80816
719-748-3253 or FAX 719-748-3164
Internet: www.nps.gov/flfo
For education: press “in-depth”

RULES

Please stay on the marked trails. Pets are allowed in the parking lot and small exercise area near the visitor center and *must* be on a leash at all times.

The mission of the National Park Service is to preserve and protect the natural and cultural features of the Florissant Fossil Beds for this and future generations. Accordingly, no collecting of any kind is allowed. This includes, but is not limited to; the collection of fossils and petrified wood; picking of flowers; collecting of pinecones or other plant material.

Please make sure that all trash is packed out, or use the trash receptacles near the visitor center.

Hunting is not allowed at any time on the Florissant Fossil Beds National Monument.

Do not feed the animals. Wild animals should stay wild and get their own food. When you feed animals they become dependent on humans as a source of food. Animals can and do die from food given to them by visitors.

Bicycles are not allowed on the trails in the monument.

FACILITIES

The visitor center has fossil displays, other exhibits and a bookstore. The space is adequate for visitor services, but will not accommodate large groups or indoor programs. Water is available. Restroom facilities are available in the visitor center and in the nearby picnic area.

In addition to the visitor center, we have two "yurts" which shelter some of the petrified stumps. The "yurts" will accommodate small groups of 15 or 20 people for brief programs. They are not heated.

The Monument has14 miles of hiking trails in segments of varying length. The trails allow flexibility in scheduling time and level of fitness. Two short loop trails are self-guided and are well suited for "on your own" activities.

A picnic area is located next to the visitor center and is convenient for a brown bag lunch after a busy morning or before an afternoon program. Another picnic area is about 1 1/2 miles away. Restrooms are located at both picnic areas.

THINGS TO CONSIDER

Traffic delays on US 24 are possible. In general, plan on travel time of one hour from Colorado Springs. No food service is available at the Monument. Small convenience stores are located in the village of Florissant. Two restaurants are able to accommodate moderately sized groups. Gasoline and limited automotive products are also available in Florissant.

Entrance fees are $2.00 per person or $4.00 per family. Those under 17 are free. Reservations are required for ranger assisted activities. Entrance fees are waived for school groups that have reservations. A donation of 50 cents per student is suggested for ranger assisted programs.

One chaperone per every 7 or 8 students is requested so that the ranger may be a guide, not a guard.

The Monument elevation is 8400 feet. Mountain weather is highly variable. Daytime highs in the summer rarely exceed the upper 80's; wintertime highs are in the 20's. Overnight summertime lows in the 40's are common and overnight lows in winter are below zero. Come prepared for changing weather summer and winter. Dress warmly in layers and bring rain gear for sudden summer showers. Sturdy shoes should be worn; sandals, cowboy boots and dress shoes are discouraged. Solar radiation can be intense at this altitude. Be prepared with sunscreen. Food and water are always a good addition to a daypack.

The Florissant Fossil Beds are part of the montane ecosystem, with forests of ponderosa pine, douglas fir, blue spruce, aspen and interspersed with mountain meadows.

POTENTIAL HAZARDS

Hazards are few, but can be severe. They include but are not limited to the following:

- Lightning during summer thunderstorms can strike from a storm many miles away. Seek shelter in case of nearby thunderstorms.
- Contact with small animals such as squirrels, chipmunks, rabbits and ground squirrels should be avoided. Small mammals may carry fleas or disease. Check for ticks in early spring and summer.
- Groups should stay together on trails to prevent lost hikers.

MISCELLANEOUS INFORMATION

The primary interpretive focus of the Florissant Fossil Beds National Monument is the world class fossils that are found in the shale formations of ancient Lake Florissant. Giant petrified sequoia stumps from that warmer and wetter climate are found on the trails and near the visitor center.

Another interpretive focus is that of the Hornbek Homestead a short drive from the visitor center. This 1878 Homestead represents the hard work, spirit and dedication of Adeline Hornbek. Interpretive programs can be arranged that explain the life of homesteaders and how the Homestead Act of 1862 provided economic opportunity to women.

Winter at the Monument brings snow and winter fun on cross-country skis and snowshoes.

Canon Paleo Curriculum
Intoduction
Unit: 2

1. **Dendrochronology**
2. **Dendrochronology Background**
3. **Florissant tree rings**
4. **Orientation Florissant Fossil Beds National Monument Slide Show**
5. **(Background Materials for Geology of the Front Range and Florissant**
6. **Stratigraphic Mapping**
7. **Paleontology** - Fossil Identification
8. **Paleontology** - Leaf Identification
9. **Paleontology** - Climate Activity/ Powerpoint for Climate Activity
   Overheads for Climate Activity
10. **Exam**

Inserts:
- Leaf Manual

Canon Paleo Curriculum
Lesson Plan 1
Unit: 2

The lesson is from educational material provided by Dendrochronology Tree Ring Dating Kit, Lab Aids, inc.,17 Colt Court, Ron Kon Koma, NY 11779, Lab-Aids inc., 1996

LAB-AIDS #52 DENDROCHRONOLOGY-TREE RING DATING KIT

Student Worksheet and Guide
Dendrochronology or tree ring dating is an absolute dating technique using the growth rings of trees to deter- mine the average age of a stand of trees. It is used to determine the age of wooden objects and wooden components of buildings at archaeological sites. A specific date for each growth ring can be assigned based on a characteristic pattern produced by alternating wet and dry years.

Forestry workers use an instrument called an increment borer to obtain core samples from trees in a particular area. The increment borer is twisted 1/2 the diameter through the tree and then removed. This produces a core sample approximately 1/8 inch in diameter. The hole produced is then plugged in order to prevent infection in the tree. By counting the number of xylem rings in this tree and other trees in a given area, the average age of a stand of trees is determined. Wet and dry years can be identified by examining the individual rings (the spaces between the dark lines). Thicker rings indicate wetter years and thinner rings indicate dryer years.

Archaeologists often use tree rings to help determine the age of a particular ruin. A piece of a wooden structure is obtained and the xylem pattern is compared with a master chart dating back several hundred and even several thousands of years. The age of the dwelling can be accurately dated by comparing it to this chart. In some cases tree ring dating is more accurate than carbon-dating.

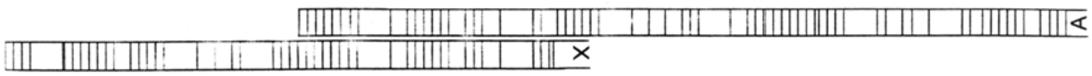
This lab activity will give you a basic knowledge of the principle of tree ring dating by using simulated core samples-one from tree (A) and one from a Forest Ranger's cabin (X).

MATERIALS:
I simulated tree core sample from a tree marked A
I simulated tree core sample from a forest ranger's cabin marked X

PROCEDURE:
PART I

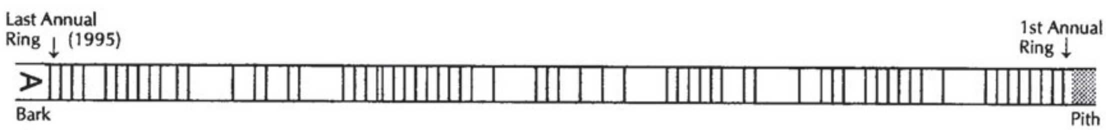
Using core sample **A,** compare to the following diagram.

1. Core A is a copy of a core sample taken from a tree in 1995. Find the age of the tree by counting all the annual rings. Remember, each space between two grooves is one annual ring and represents one year of growth. *Don't count the pith or the bark as these are not annual rings.* How old was the tree when it was cut down?



2. If the last annual ring represents the growth of the tree during 1995, what year is represented by the first annual ring?

3. In what year were you born?   How old was the tree in this year?
Remembering that wide rings represent wet years and narrow rings dry years, was your birth year a wet or dry year?



4. Was 1950 a wet or dry year?

1. Core sample X was taken from a log from the roof of a forest ranger's cabin. Count the number of annual rings on this sample to determine the age of this tree when it was cut down. How old was the tree?

2. What year did the tree, from which core sample X was taken, start its growth?

3. The forest ranger's cabin was built the same year that the tree was cut down. What year was that?

4. Was the cabin built during a wet **year or** a **dry year? How do you** know?

5. The forest ranger's who lived in this cabin died in 1960. How many years did he live in the cabin before he died?

Optional Activities

Obtain a cross-section form a tree which has been recently cut down, such as a Christmas tree. By counting the rings you should be able to answer the following questions:

1. How old was the tree when it was cut down?

2. What year did the tree begin growing?

If the cross-section is large enough and old enough, use colored straight pins to mark the annual rings that correspond to important dates in your past such as:

1. The year you were born.

2. The birth years of your parents and or brothers and sisters.

3. The year you started school.

4. The year your school was built.

Teacher Key

1. How old was the tree when it was cut down? *64 years*

2. If the last annual ring represents the growth of the tree during 1995, what year is represented by the first annual ring? *1931*

3. In what year were you born? *Answers will vary* How old was the tree in this year? *Answers will vary* Remembering that wide rings represent wet years and narrow rings dry years, was your birth year a wet or dry year? *Answers will vary*

4. Was 1950 a wet or dry year? *wet*

1. Core sample X was taken from a log from the roof of a forest ranger's cabin. Count the number of annual rings on this sample to determine the age of this tree when it was cut down. How old was the tree? *66*

2. What year did the tree, from which core sample X was taken, start its growth? *1888*

3. The forest ranger's cabin was built the same year that the tree was cut down. What year was that? *1954*

4. Was the cabin built during a wet **year or** a **dry year?** *dry* **How do you** know?*I shows a narrow annual ring*

5. The forest ranger's who lived in this cabin died in 1960. How many years did he live in the cabin before he died? *6 years*

Canon Paleo Curriculum
Background 2
Unit: 2

Background Information on Dendroclimatology Studies Conducted at Florissant by Kathryn M. Gregory

The thirty-five million-year-old petrified stumps found on the National Monument are exceptionally preserved extinct redwoods (*Seguoia affinis*) closely related to the modern coast redwoods (*Sequoia sempervirens*) found in California today. During the late Eocene these giant trees lined a small stream in a paleovalley of low relief. About 35 million years ago a volcaniclastic mudflow originating in the Guffey Volcanic Center 18 miles to the west-southwest flooded the paleovalley and surrounded the trees with up to 4 meters of silica-rich mud. While modern redwoods can survive burial by sprouting new roots higher up the stump, the lack of these features on any of the fossil stumps at Florissant suggests that the speed and depth of burial killed these trees. (Gregory 1992) Later, another volcanic debris flow dammed the stream running over the earlier mudflow, causing a large lake to develop in the valley. Most of the upper portions of *Seguoia affinis* would have rotted away but the lower 4 meters were protected by the mudflow, and the slow process of petrification preserved the remnants of these ancient organisms.

The petrified stumps found at Florissant today are valuable scientific artifacts for several reasons. First, the process of petrification that these stumps underwent, called *permineralization*, preserves much more detail than the process of *replacement*, seen in logs from the Petrified Forest in Arizona. (Kiver and Harris 1999) Permineralization preserves individual cellular structures and internal features of the tree, will in replacement most cellular information is lost and only the outer features of the tree can be distinguished. (Kiver and Harris 1999) Secondly, it is believed that as many as 28 of the unearthed stumps are *in situ* — they have not moved relative to each other in 35 million years. (Gregory 1992) In the Petrified Forest of Arizona only the northern Black Forest portion contains *in situ* stumps. (Kiver and Harris 1999) Unfortunately, it is uncertain how many of

Florissant's petrified trees were *in situ,* since nearly a century of collection and vandalizing took place before the National Monument was established in 1969. Lastly, there is evidence that suggests that these trees co-existed. Two of the trees have ring width series that overlap, or *crossdate*, for 180 years. These two trees contain the best crossdating relationship yet found in the fossil record. (Gregory 1994) Crossdating emphasizes the climatic events observable in tree rings, while selecting against anomalies found in a single tree's growth pattern.

Among the numerous scientific papers published about Florissant, paleoelevation and paleoclimate have captured the most attention. While most research in the past relied on the plant fossils from the shales for information, Kate Gregory furthered her study of paleoelevation and paleoclimate by examining the finest details of the petrified stumps. The *Sequoia affinis* specimens from Florissant contain remarkably well preserved tree rings, which record the annual growth, and by extension the growing conditions, of individual trees. Wide, light-colored bands of earlywood are added underneath the bark during the early part of the growing season. The thin, dark band is called latewood, and marks the end of the growing season. Wetter, warmer, more favorable growing conditions are marked by a thicker earlywood band, while dry years show up as thin bands of earlywood. Furthermore, climate anomalies may show up as missing rings, rings that pinch out, or false rings (two rings during the same year). Trees that grow in tropical regions often lack true annual growth rings, since conditions may be suitable for growth year round. In these instances, rings record growth interruptions that may have no temporal significance. Some trees from Petrified Forest National Park contain interruption rings, as they record a much earlier (220mya) and warmer period in Earth history than those trees found at Florissant. (Kiver and Harris 1999)

When trees can be crossdated the limiting climatic factors influencing plant growth in a region can be distinguished from a poor growth year for one individual tree. As Gregory states

"Crossdating is the hallmark of dendrochronology; it is the fundamental principle that establishes that a common year-to-year variable signal exists in tree ring series." -Gregory, 1994

For her dissertation Gregory collected ring width data from 28 stumps where she could find series of more than 50 rings exposed. Ring width was measured to a tenth of a millimeter using a hand lands, and in the field she also noted the potential for missing or false rings. (Gregory 1992) Once her data was collected, standard dendrochronology statistics were conducted using the information she gathered. These calculations include "mean ring width, percentage of missing and false rings, mean sensitivity, standard deviation, and first order autocorrelation." (Gregory 1994) Mean sensitivity is a statistic used to describe the "year to year variability of a series." (Gregory 1992) First order autocorrelation describes the width difference between one ring and immediately adjacent rings. Gregory also noted the importance of comparing her results with ring width series from modern sequoias to better understand the limiting factors of climate as opposed to "site and genotype" variability. (Gregory 1994)

Gregory noted several interesting results from her study. Like the modern *Sequoia sempervirens*, *Sequoia affinis* stumps from Florissant have a distinct earlywood/latewood boundary, which Gregory inferred to be evidence of annual rings. (Gregory 1994) The two species of redwood also shared an affinity for missing rings and rings that pinch out, though no false rings were found in the Florissant stumps. (Gregory 1994) Many of the trees she sampled internally crossdate, and as previously mentioned, two stumps more than 50 meters apart crossdated for 180 years. (Gregory 1994) One of the most striking differences that Gregory noted between the two species was mean ring width. Giant sequoias were found to have a mean ring width between .84 and .96mm, coast redwoods had a mean ring width between .98 and 1.04mm, and *Sequoia affinis* had a mean ring width of 1.4mm. (Gregory 1992) Gregory found these numbers to be "significantly different at the 95% confidence level."

The significant difference in mean ring width between modern sequoias and *Sequoia affinis* led Gregory to infer that the fossil trees were growing under more favorable conditions then their modern counterparts. Gregory proposed two potential explanations for this difference. First, while mean annual temperature (MAT) along the modern California coast is similar to the MAT at Florissant in the late Eocene[1], the growing season precipitation (GSP) may have been quite different. Modern sequoias see only 3.8cm of rain during their growing season, while it is believed that Florissant received up to 57cm of rain in the summer months. (Gregory, 1994) The hypothesized summer precipitation is further supported by the sharp differentiation between earlywood and latewood in the fossil stumps, marking a “rapid end to the growing season” that may have been coincident with the end of the rainy season. (Gregory 1994)

Another, less established theory explains the difference in mean ring width between the species of sequoia with change in atmospheric carbon dioxide levels. Several scientific studies have shown that there is a direct relationship between increases in carbon dioxide levels and plant growth. Furthermore, it is believed that carbon dioxide levels were significantly higher during the Eocene. However, the long-term impact of increased carbon dioxide levels is not known. (Gregory 1994) For this reason, Gregory favored the hypothesis that growing season precipitation was the primary factor influencing the increase of mean ring width of *Sequoia affinis* found at Florissant.

To sum up:

- Unlike petrified trees that have undergone replacement, the permineralized sequoias at Florissant contain a remarkable amount of detail, including annual growth rings and cellular structure.
- Many of the petrified stumps are vertical, in situ, and at least two have been proven co-eval, providing even more information about their growing conditions and environment.

[1] Gregory calculated the MAT at Florissant in the late Eocene to be 12.8 +/-1.5 degrees celsius using plant physiognomy. The coast of California today has a MAT of 11.8 degrees C. (Gregory, 1992)

- Fossilized *sequoia affinis* stumps at Florissant have many features in common with their closest living relatives in California, including a high number of missing rings or rings that pinch out.
- The larger average mean ring width (1.4mm) in *sequoia affinis* fossils, when compared to rings of *sequoia sempervirens* or Giant sequoias (.95mm), is most likely a result of a wetter growing season, or less likely an increase in carbon dioxide levels.

References Cited

Gregory, K.M., 1992, Late Eocene paleoelevation, paleoclimate, and paleogeography of the Front Range region, Colorado [Ph.D. thesis]: Tucson, University of Arizona.

Gregory, K.M., 1994, *Florissant Petrified Forest: Discussion of* Sequoia affinis *Ring-Width Series*: Guidebook for the Field Trip: Late Paleogene Geology and Paleoenvironments of Central Colorado with emphasis on the Geology and Paleontology of Florissant Fossil Beds National Monument, p. 45-53.

Kiver, E.P., and Harris, D.V., 1999, Geology of U. S. Parklands: New York, John Wiley & Sons, Inc.

Canon Paleo Curriculum
Lesson Plan 3
Unit: 2

Florissant Tree Rings

Students will have a chance to see pre- and misconceptions evolve through personal experience.

Supplies:
Per group of four students:
- one worksheet
- one modern ring
- one petrified tree ring

Preparation:
Read the Background material by Kate Gregory and go over that material along with the basic tree information below.

Terms and Info about Tree Rings

A. Terms
   1. Bark
      a. Protects the tree from disease and pests
   2. Phloem
      a. Transports food to the roots
   3. Cambium
      a. Only part of tree that produces new cells.
   4. Xylem (Sapwood)
      a. Transports water to the leaves
   5. Heartwood
      a. Dead, inner portion of tree.
   6. Pith
      a. Center of tree.

B. Tree Ring Info
   1. All tree rings are found in the xylem and heartwood.
   2. Tree rings are produced by the cambium.
   3. Light, wide rings are called “earlywood”
      a. Produced during early part of growing season
   4. Dark, thin rings are called “latewood”
      a. Produced at the end of the growing season

C. Climate
   1. In most cases, wetter, more favorable years produce thicker earlywood rings.
   2. More info on climate to follow during our trip to the park!

Concept:

Students will:

- observe how similar species in different climates grow differently.
- begin to understand how climate is reflected in tree ring size.
- review observation and inference.

Activity:

Have students mark significant areas of climate change.

Observation and Inference Review

- Hand out “tree cookie sheets” to groups of 4 students.
- After a few minutes, write each group’s observations on the board.
- Inquire about inferences that might follow from their observations.
- Have back up inferences if the students don’t come up with any.

Tree Ring Worksheet

- Working in groups of four, answer the question in the worksheet.
- Groups will count and mark the tree rings from the right side towards the center on both sets.
- On the modern tree rings have the groups come up with events that happened during some of the years they have marked.

IV. How old is old?

- Discuss the concepts of Deep Time, as it relates to the difference between historical time (written history) and geologic time (the geologic time scale).

Tree Rings Studies

The modern and petrified tree rings before you holds keys to the past. Locked in their cells is information about growing conditions, age, wet and dry seasons, and maybe more, but we need to ask the right questions if we are to learn from them.

1. What do we want to know?

2. What do we observe?

Qualitative:

Quantitative (remember to label your measurements with units):

3. How might we go about answering our questions? What else do we need to know?

4. What observations and inference can we make about how the modern tree rings compare to the petrified tree rings?

Tree Rings Studies - Key

The stump before you holds keys to the past. Locked in its petrified cells is information about growing conditions, age, wet and dry seasons, and maybe more, but we need to ask the right questions if we are to learn from them.

1. What do we want to know?

- **How old was the tree when it died? How long ago did it die? How did it die?**
- **How tall was the tree? What species is it? Why is the stump as big as it is?**
- **Why are there different colors?**
- **What is this tree's story, what happened to it?**
- **Has this tree moved since it fossilized, and where are the rest of the trees in the forest?**
- **What was the weather like?**
- **What was the climate like? "Was it happy?"**

Observations

2. What do we observe?

Qualitative:

- **Living things on the tree. Multi-colored. Hard or petrified. There are tree rings visible. The tree has flaked along the rings. The rings are different sizes.**
- **The tree feels cool, and is rough in some places and smooth in**
- **others.**
- **The tree is large.**

Quantitative (remember to label your measurements with units):

Have student average a set of ten random tree ring for each sample

3. How might we go about answering our questions? What else do we need to know?
Missing Information

Make more measurements. Compare it to other trees. Compare it to the closest living relative. Compare rings to information from living species about weather.

4. What observations and inference can we make about how the modern tree rings compare to the petrified tree rings?

Observations:

- **The petrified tree has wider tree rings.**
- **There seems to be fewer in the same rings in the same amount of area.**
- **The color is different.**

Inferences:

- **The petrified tree seems to be in a wetter climate.**
- **The petrified tree seems to have had better growing conditions**
- **The air that the petrified tree was exposed to could have had more carbon dioxide.**

Petrified Tree Rings

Modern Tree Rings

Canon Paleo Curriculum
Lesson Plan 4
Unit: 2

Orientation to Florissant Fossil Beds National Monument Slide Show

Important Information:
To use this slide show either the teacher or the students must have access to a PowerPoint program. Download the slide show from the button on the main page labeled "Orientation to Florissant Fossil Beds National Monument Slide Show."

Supplies:
- PowerPoint presentation
- LCD Projector

Concept:
- Students will gain an understanding of the National Park Service
- Student will gain and understanding of the geology of Florissant Fossil Beds National Monument

Activity:
Be familiar with the slide show before the presentation. Possibly have students take turns reading the captions. Have them answer the multiple choice questions below.

Time:
1 hour

Questions for labeled "Orientation to Florissant Fossil Beds National Monument Slide Show"

1. Which of the following are not part of the National Park System?

    a) Yellowstone National Park
    b) Mueller State Park
    c) Great Smoke Mountains National Park
    d) Mississippi National River and Recreational Area

2. Florissant is located in
    a) Colorado
    b) Utah
    c) New Mexico
    d) Arizona

3. The most common fossils found in the Florissant lakeshales:
    a) dinosaurs
    b) oreodants
    c) leaves and insects
    d) shells

4. The most common fossilized tree in the Monument is:
    a) Ponderosa Pine
    b) Oak
    c) Sequoia
    d) Fur

5. The pertrification process of the trees is facilitated by:
    a) the trees being submerged in a muddy bog
    b) the trees being surround by volcanic mud beneath a lake
    c) the trees being submerged in sand at the bottom of an ocean

6. The three rock types found at Florissant are:
    a) basalt, conglomerate mudstone, and granite
    b) granite, sandstone, and marble
    c) volcanic tuff, lakebed shale, and conglomerate mudstone
    d) marble, lakebed shale, and conglomerate mudstone

7. Scientist who study the fossils at Florissant are called:
    a) Ornothologists
    b) Paleontologists
    c) Petrologists
    d) Geologists

8. One of the early homesteaders to the Florissant valley was:
   a) Lewis and Clark
   b) Adeline Hornbek
   c) James Johnson
   d) Reva Stough

9. The Early American Indians who some areas of Teller County, Colorado are named for are the:
   a) Cheyenne
   b) Souix
   c) Ute
   d) Piute

10. In the 1860 there was so much petrified wood in the Florissant Valley that a wagon could not drive through by 1969 most of it was gone do to:
   a) a huge forest fire that burned it off.
   b) people taking it for souvenirs.
   c) people taking it for firewood.

Key

Questions for labeled "Orientation to Florissant Fossil Beds National Monument Slide Show"

1. Which of the following are not part of the National Park System?
   a) Yellowstone National Park
   b) Mueller State Park
   c) Great Smoke Mountains National Park
   d) Mississippi National River and Recreational Area

2. Florissant is located in
   a) Colorado
   b) Utah
   c) New Mexico
   d) Arizona

3. The most common fossils found in the Florissant lakeshales:
   a) dinosaurs
   b) oreodants
   c) leaves and insects
   d) shells

4. The most common fossilized tree in the Monument is:
   a) Ponderosa Pine
   b) Oak
   c) Sequoia
   d) Fur

5. The pertrification process of the trees is facilitated by:
   a) the trees being submerged in a muddy bog
   b) the trees being surround by volcanic mud beneath a lake
   c) the trees being submerged in sand at the bottom of an ocean

6. The three rock types found at Florissant are:
   a) basalt, conglomerate mudstone, and granite
   b) granite, sandstone, and marble
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Canon Paleo Curriculum
Background 5
Unit: 2

BACKGROUND MATERIAL

Excerpts from: National Science Foundation

Nature of Science

Teaching about evolution has another important function. Because some people see evolution as conflicting with widely held beliefs, the teaching of evolution offers educators a superb opportunity to illuminate the nature of science and to differentiate science from other forms of human endeavor or and understanding. However, it is important from the outset to understand how the meanings of certain key words in science differ from the way that those words are used in everyday life.

Think for example, of how people usually use the word “theory.” Someone might refer to an idea and then add, “But that’s only a theory.” Or someone might preface a remark by saying, “My theory is . . ..” In common usage, theory often means “guess” or “hunch.” In science, the word “theory’ means something quite different. It refers to an overarching explanation that has been well substantiated. Science has many other powerful theories besides evolution. Cell theory says that all living things are composed of cells. The heliocentric theory says that the earth revolves around the sun rather than vice versa. Such concepts are supported by abundant observational and experimental evidence that they are no longer questioned in science.

Sometimes scientists themselves use the word “theory” loosely and apply it to tentative explanations that lack well-established evidence. But it is important to distinguish these casual uses of the word “theory” with its use to describe concepts such as evolution that are supported by overwhelming evidence. Scientists might wish that they had a word other than “theory” to apply to such enduring explanations of the natural world, but the term is too deeply engrained in science to be discarded.

Glossary of Terms Used in Teaching About the Nature of Science

Fact: In science, an observation that has been repeatedly confirmed.
Law: A descriptive generalization about how some aspect of the natural world behaves under stated circumstances.
Hypothesis: A testable statement about the natural world that can be used to build more complex inferences and explanations.
Theory: In science, a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses.

As with all scientific knowledge, a theory can be refined or even replaced by an alternative theory in light of new and compelling evidence.

The geocentric theory that the sun revolves around the earth was replaced by the heliocentric theory of the earth’s rotation on its axis and revolution around the sun.

However, ideas are not referred to as “theories” in science unless they are supported by bodies of evidence that make their subsequent abandonment very unlikely. When a theory is supported by as much evidence as evolution, it is held with a very high degree of confidence.

In science, the word “hypothesis” conveys the tentativeness inherent in the common use of the word “theory.’ A hypothesis is a testable statement about the natural world. Through experiment and observation, hypotheses can be supported or rejected. At the earliest level of understanding, hypotheses can be used to construct more complex inferences and explanations.

Like “theory,” the word “fact” has a different meaning in science than it does in common usage. A scientific fact is an observation that has been confirmed over and over. However, observations are gathered by our senses, which can never be trusted entirely. Observations also can change with better technologies or with better ways of looking at data. For example, it was held as a scientific fact for many years that human cells have 24 pairs of chromosomes, until improved techniques of microscopy revealed that they actually have 23. Ironically, facts in science often are more susceptible to change than theories, which is one reason why the word “fact” is not much used in science.

Finally, “laws” in science are typically descriptions of how the physical world behaves under certain circumstances. For example, the laws of motion describe how objects move when subjected to certain forces. These laws can be very useful in supporting hypotheses and theories, but like all elements of science they can be altered with new information and observations.

Those who oppose the teaching of evolution often say that evolution should be taught as a “theory, not as a fact.” This statement confuses the common use of these words with the scientific use. In science, theories do not turn into facts through the accumulation of evidence. Rather, theories are the end points of science. They are understandings that develop from extensive observation, experimentation, and creative reflection. They incorporate a large body of scientific facts, laws, tested hypotheses, and logical inferences. In this sense, evolution is one of the strongest and most useful **scientific** theories we have.

Excerpts from:
National Science Foundation, Teaching About Evolution and the Nature of Science, National Academy Press, 1998,
ISBN 0-309-06364-7
Geologic Resource Division, National Park Service Website

GEOLOGIC BACKGROUND FOR PIKES PEAK AREA

Plate Tectonics
The action is at the edges!

If you are lucky enough, or sometimes, unfortunate enough to live where two plates meet, you've probably had first-hand experience with moving plates! That's because many potentially catastrophic geologic phenomena, such as earthquakes, volcanic eruptions, and tsunamis originate at the narrow boundary zones between plates.

There are three basic things that can happen where the edge of one plate meets another. The plates can push against each other, producing a convergent plate boundary, the plates can move apart, forming a divergent plate boundary, or the plates can slip past each other side to side, which geologists call transform plate boundaries. Wherever plates grind against each other, you can expect earthquakes.

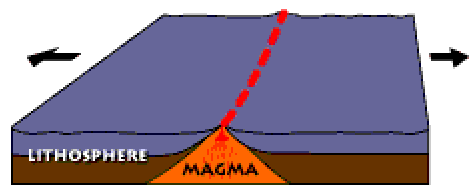
Divergent plate boundaries

One young divergent plate boundary that you'll recognize is actively forming the Red Sea. Although the Arabian Peninsula and Africa were once linked to form a single continent, they are now being ripped apart. The white arrows show the directions the two plates are moving. You can see that a new ocean, the Red Sea is being formed as they separate.

What's going on inside?

Geologists still have a lot to discover about the Earth's deep interior. Evidence we have today suggests that divergent boundaries form above temperature instabilities near the boundary between the core and mantle. Just above the core hot blobs of mantle begin to move slowly upward, eventually forming conveyor belt-like convection currents within the semi-fluid asthenosphere.

Convection currents diverge where they approach the surface. The diverging currents exert a weak tension or "pull" on the plate above it. Tension and high heat weakens the floating plate and it begins to break apart. The two sides move away in opposite directions, creating a divergent plate boundary.

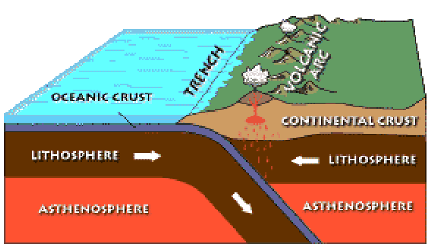


The weaknesses between the diverging plates fill with molten rock from below. Seawater cools the molten rock, which quickly solidifies, forming new oceanic lithosphere. This continuous process builds a chain of volcanoes and rift valleys called a **mid-ocean ridge** or **spreading ridge**.

Little by little, as each batch of molten rock erupts at the mid-ocean ridge, the newly created oceanic plate moves away from the ridge where it was created.

Convergent plate boundaries

Convergent plate boundaries come in several flavors, but they share one thing in common - plate collisions! Take a look at the differences between the three examples on this page.



Continental vs. oceanic plate convergence

In a contest between a dense oceanic plate and a less dense, buoyant continental plate, guess which one will sink? The dense, leading edge of the oceanic plate actually *pulls* the rest of the plate into the flowing asthenosphere and a **subduction zone** is born! Where the two plates intersect, a deep **trench** forms.

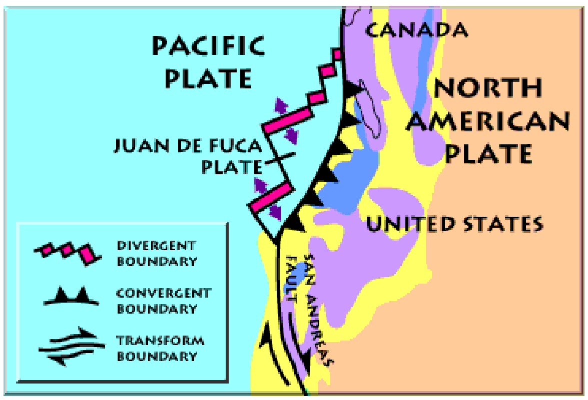
Geologists aren't sure how deep the oceanic plate sinks before it completely melts, but we ***do*** know that it remains solid far beyond depths of 100 km beneath the Earth's surface.

When the subducting oceanic plate sinks deeper than 100 kilometers, huge temperature and pressure increases make the plate 'sweat'. Well, not exactly, but the uncomfortable conditions force minerals in the subducting plate to release trapped water and other gasses. The gaseous sweat works its way upward, causing a chain of chemical reactions that MELT THE MANTLE above the subducting plate.

This hot, freshly melted liquid rock (magma) makes its way toward the surface. Most of the molten rock cools and solidifies in huge sponge-like magma chambers far below the Earth's surface. Large intrusive rock bodies that form the backbones of great mountain ranges such as the Sierra Nevada form by this process.

Some molten rock may break through the Earth's surface, instantly releasing the huge pressure built up in the gas-rich magma chambers below. Gasses, lava and ash explode out from the breached surface. Over time, layer upon layer of erupting lava and ash build volcanic mountain ranges above the simmering cauldrons below.

An example of this kind of convergence produces the spectacular volcanic landscape of the Northwest. Off the coast of Oregon, Washington, Alaska and Canada a small plate, the Juan de Fuci, dives beneath North America. This type of convergent plate boundary, called a **subduction zone**, is known for producing historic earthquakes of great magnitudes.

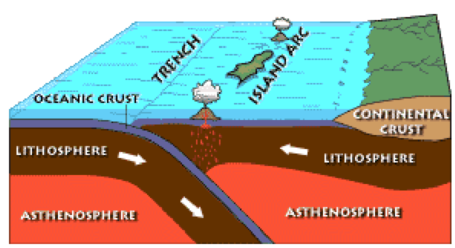


<u>Oceanic vs. oceanic plate convergence</u>

In a contest between a dense oceanic plate and a less dense, buoyant continental plate, you know that it's the dense oceanic plate that sinks.

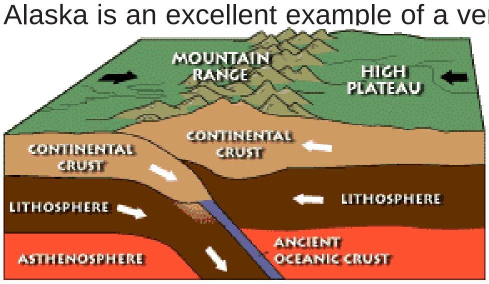
What happens when two dense oceanic plates collide? Once again, density is the key!

Remember that oceanic plates are born at midocean ridges where molten rock rises from the mantle, cools and solidifies. Little by little, as new molten rock erupts at the mid-ocean ridge, the newly created oceanic plate moves away from the ridge where it was created. The farther the plate gets from the ridge that created it, the colder and denser ('heavier') it gets.



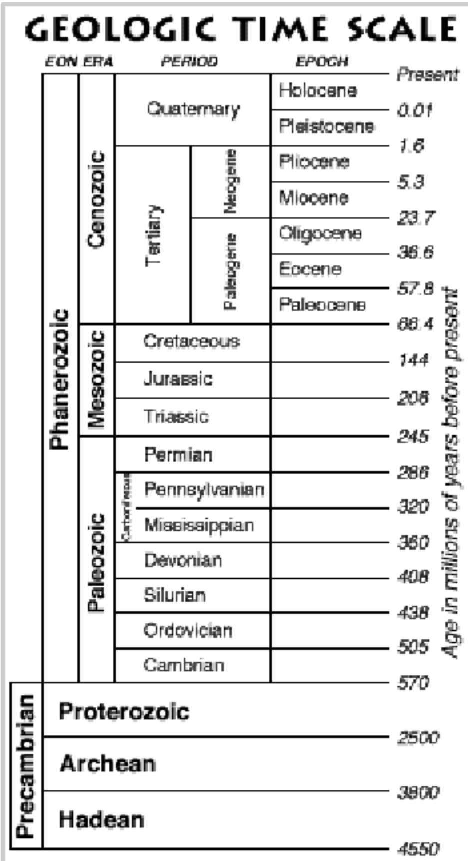
When two oceanic plates collide, the plate that is older, therefore colder and denser is the one that will sink.

The rest of the story is a lot like the continental vs. oceanic plate collision we described above. Once again, a subduction zone forms and a curved volcanic mountain chain forms above the subducting plate. Of course, this time the volcanoes rise out of the ocean, so we call these volcanic mountain chains **island arcs**. The Aleutian Peninsula of Alaska is an excellent example of a very volcanically active island arc



<u>Continental vs. continental plate convergence</u>

By this time, you understand enough about plates to guess that when the massive bulk of two buoyant continental plates collide there is bound to be trouble!

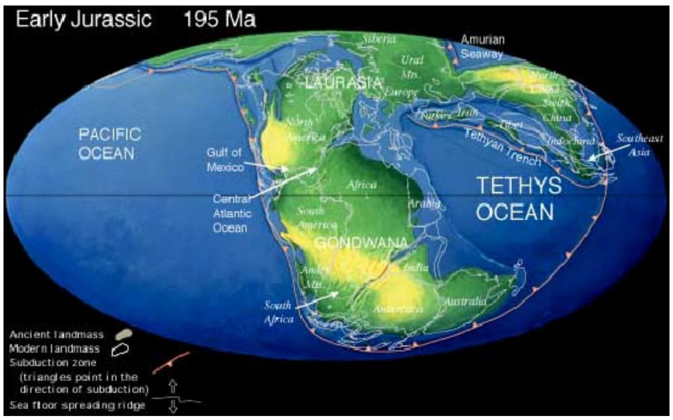


The Himalayan mountain range provides a spectacular example of continent vs. continent collision. When two huge masses of continental lithosphere meet head-on, neither one can sink because both plates are too buoyant.

It is here that the highest mountains in the world grow. At these boundaries solid rock is crumpled and faulted. Huge slivers of rock, many kilometers wide are thrust on top of one another, forming a towering mountain range. The pressure here is so great that an enormous piece of Asia is being wedged sideways, slipping out of the way like a watermelon seed squeezed between your fingers.

Northern Rocky Mountains

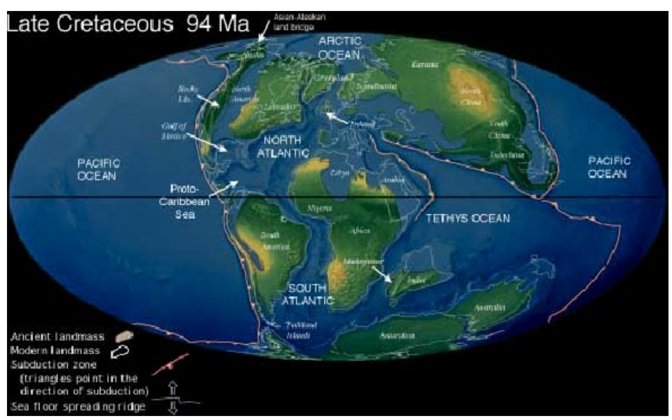
The Rockies form a majestic mountain barrier that stretches from Canada through central New Mexico. Although formidable, a look at the topography reveals a discontinuous series of mountain ranges with distinct geological origins.



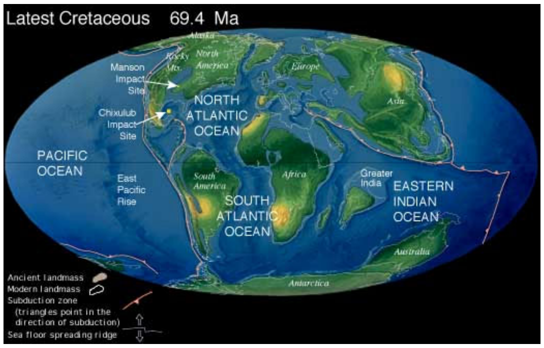
The Rocky Mountains took shape during a period of intense plate tectonic activity that formed much of the rugged landscape of the western United States. Three major mountain-building episodes reshaped the west from about 170 to 40 million years ago (Jurassic to Cenozoic Periods). The last mountain building event, the Laramide orogeny, (about 70-40 million years ago) the last of the three episodes, is responsible for raising the Rocky Mountains.

Setting the stage

During the last half of the Mesozoic Era, the Age of the Dinosaurs, much of today's California, Oregon, and Washington were added to North America. Western North America suffered the effects of repeated collision as slabs of ocean crust sank beneath the continental edge. Slivers of continental crust, carried along by subducting ocean plates, were swept into the subduction zone and scraped onto North America's edge.



About 200-300 miles inland, magma generated above the subducting slab rose into the North American continental crust. Great arc-shaped volcanic mountain ranges grew as lava and ash spewed out of dozens of individual volcanoes. Beneath the surface, great masses of molten rock were injected and hardened in place.

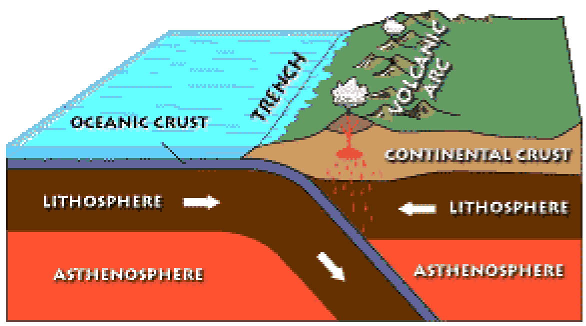


For 100 million years the effects of plate collisions were focused very near the edge of the North American plate boundary, far to the west of the Rocky Mountain region. It was not until 70 million years ago that these effects began to reach the Rockies.

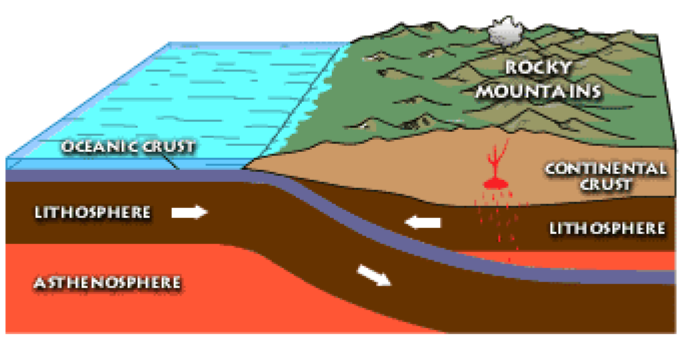
Raising the Rockies

The growth of the Rocky Mountains has been one of the most perplexing of geologic puzzles. Normally, mountain building is focused between 200 to 400 miles inland from a subduction zone boundary, yet the Rockies are hundreds of miles farther inland. What geologic processes raise mountains at this scale? Although geologists continue to gather evidence to explain the rise of the Rockies, the answer most likely lies with an unusual subducting slab.

Sketch of an oceanic plate subducting beneath a continental plate at a collisional plate boundary. The oceanic plate typically sinks at a fairly high angle (somewhat exaggerated here). A volcanic arc grows above the subducting plate.



This sketch shows the plate tectonic setting during the growth of the Rocky Mountains (Laramide orogeny). The angle of the subducting plate is significantly flatter, moving the focus of melting and mountain building much farther inland than is normally expected.



Pikes Peak

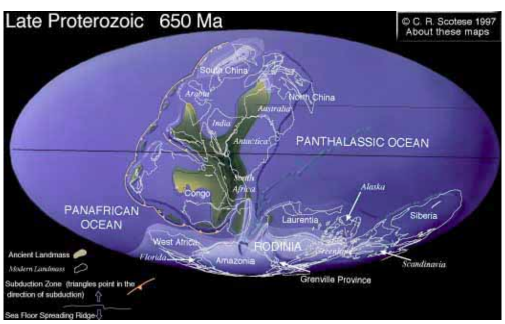
The grandeur of Pikes Peak is the culmination of many geologic events:

- the formation of the rocks through hundreds of millions of years,
- the repeated uplift of the mountains by gigantic tectonic forces, and
- millions of years of erosion by water and ice that sculpted the mountains into their present forms.

Brief geologic history

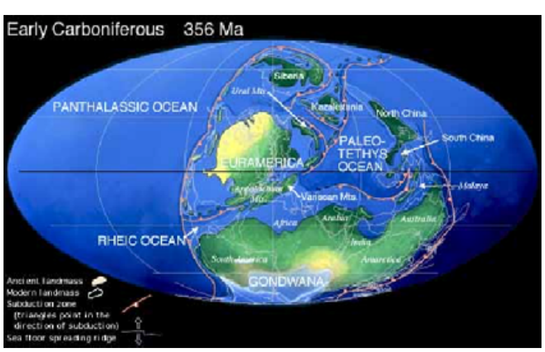
Most of the rock in Pikes Peak is granite. The newer rocks of the **Garden of the Gods** are —originally were **shale, siltstone**, and **sandstone**, along with some **volcanic rocks** deposited about *1.8 to 2 billion years ago* in an ancient sea. Between *1.7 and 1.6 billion years ago*, these **sedimentary rocks** were caught in a collision zone between sections of the Earth's crust called **tectonic plates**.

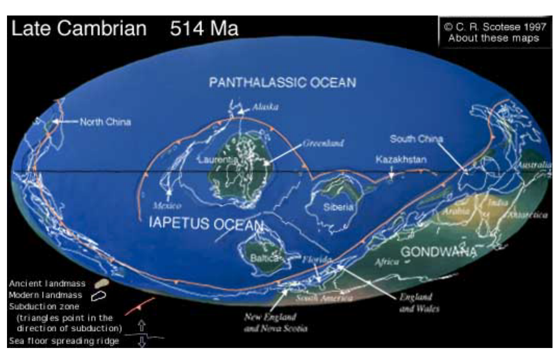
The Pikes Peak granite is a batholith, which extends from near Castle Rock, 40 miles to the north, and southward through the Rampart Range to the southern end of the Cheyenne Mountains. It extends from Colorado Springs westward for more than 40 miles. The **Pike Peak granite** uplifted into the metamorphic rocks about *300 million years* after the formation of the Proterozoic mountains. We do not know what caused this igneous episode.

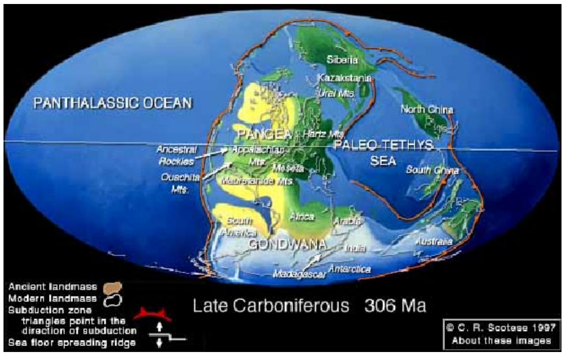


The "ancestral Rocky Mountains" that formed here during Proterozoic time were slowly eroded and reduced to a fairly flat surface, exposing the core of metamorphic rocks and granite. This erosion occurred over a long period, from approximately *1,300 million to 500 million years ago*. Little else is known about the geologic events in this area during this time span because the rocks of that age have eroded away in the region. This lack of stratigraphic information is called an unconformity.

About *500 million years ago*, this relatively flat area became covered with shallow seas. Over the next *200 million years*, several hundreds of thousands of feet of **Paleozoic** sedimentary rocks were deposited on the old Proterozoic surface. During the **middle Pennsylvanian Period**, yet another mountain range was uplifted in this area. From it the Paleozoic Period sediments were eroded.





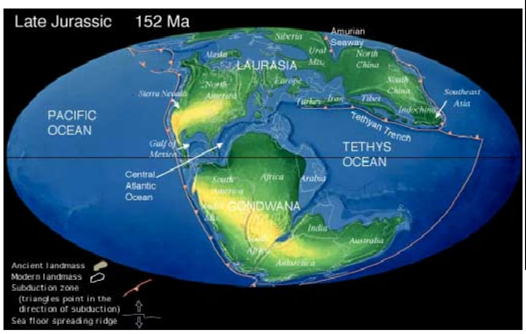


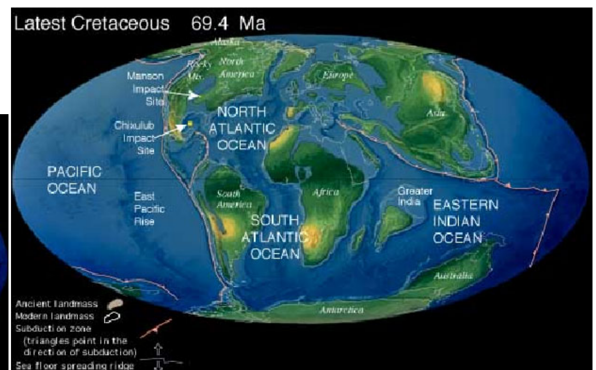
• Sediments shed from these **"ancestral Rocky Mountains"** were deposited along the mountain flanks. Today, these make up the sedimentary formations at the bottom of Pikes Peak.

• the red rocks in the **Garden of the Gods** near Colorado Springs.

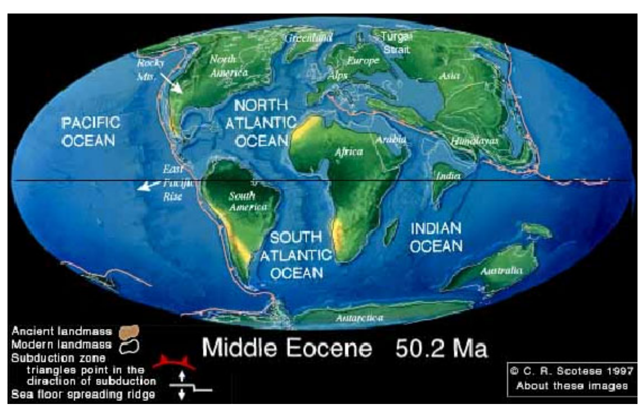
The area that is now Pikes Peak was eroded again and intermittently covered by seas from the middle of the **Permian Period** to the end of the **Cretaceous Period** about *65 million years ago*. Abundant bones and tracks found in sedimentary rocks, like the Morrison formation. They date back to **Jurassic and Cretaceous** times, indicating that **dinosaurs** lived here during those periods.

Major tectonic plates of the Earth's crust began to collide along what was then the western edge of North America about *130 million years ago*. Uplift caused by this collision began to affect the area of the present Colorado Rockies about *70 million years ago*. As the region began to rise, the Cretaceous sea withdrew and the thick layer of sedimentary rocks that had accumulated began to erode. Within a few million years, the sedimentary rocks of the Front Range had eroded away, and the Proterozoic igneous and metamorphic rocks again were exposed to erosion.





As uplift proceeded, deep **fault zones** formed, enormous stresses pulled the Earth's crust apart at what is now the west side of the peak. Between *34-35 million years* ago, the magmas reached the surface and erupted as volcanoes. The tops of the volcanoes stood several thousand feet above the present granitic masses, which since have been eroded to their present size. Extensive **ash beds** from the volcanoes are preserved at Florissant Fossil Beds National Monument.



From the plate collision to the present, rivers and streams have eroded the mountains and transported enormous amounts of sediment to the oceans. By the end of the **Tertiary Period**, the mountains were still fairly high but rounded. The area also was characterized by wide, V-shaped stream valleys.

Then, the Rocky Mountain area saw more drama. About *2 million years ago*, Earth's climate cooled and the **Ice Age** began. Large ice sheets ebbed and flowed across much of the Northern Hemisphere. During several major periods of glaciation—as well as several minor episodes—ice covered much of North America and Europe. The high mountain valleys filled with glaciers.

Pikes Peak felt the effects of the Ice Age. Glaciation in the park probably started about *1.6 million years ago*. Specific evidence of the earliest glaciations doesn't exist because **moraines** formed by the early glaciers were destroyed by glaciers that followed later. Each time glaciers flowed down the mountain valleys they eroded the valley sides and bottoms, helping to straighten and deepen them, removing evidence of earlier glaciations.

There is evidence of the last two major periods of ice accumulation, about *300,000 years ago* and ended about *130,000 years ago*. After the *130,000 years ago* event, came a warmer period that lasted about 100,000 years. The last major glacial episode, called the **Pinedale Glaciation**, began about 30,000 years ago when Earth's climate once again cooled. The Pinedale glaciers reached their maximum extent between 23,500 and 21,000 years ago. Most of the major valleys were filled with glaciers during this time. Between 15,000 and 12,000 years ago, the climate warmed and the glaciers rapidly disappeared. Though glaciers remain in the front range of the Rockies, none of these Alpine glaciers are remnant of Ice Age glaciers.

Some scientists believe that we are living today in a **warming interglacial period**. But they speculate that we could be heading into a period of cooler climate during which glaciers would return.

These explanation are taken from the NPS/USGS website. For lots more on Geology and Paleontology go to:

http://wrgis.wr.usgs.gov/docs/usgsnps/project/home.html
http://www2.nature.nps.gov/grd/
http://www.nps.gov/flfo/mained.htm

Eocene Oligocene Boundary Climate Change

Florissant Fossil Beds National Monument was established in 1969 to protect two types of fossils dating from 34-35 million years ago, lake shale fossils, and permineralized tree stumps. These fossils tell a story about ecosystems quite different from today's enviroment. Many of the plants found in the fossil record reflect a subtropical to warm temperate climate. Florissant presently has a cool temperate climate. Sequoia trees and palms were present at Florissant 34-35 million years, along with insects like the Tsetse fly; all indicators of a warmer enviroment. The follow activities are designed to help students learn to interpret data and propose a hypothesis about the climate change at the Eocene-Oligocene boundary.

There are many reasons why the climate changes: orbital relationship to the sun, tilt of the earth, plate tectonics, oceanic currents, etc. Some are the proposed hypotheses that may have affected the changes in climate the 34-35 million years ago.

First, what are some of the indicators that tell scientists the climate may have been warmer 34-35 million years ago. A paleobontanist in th 1950s suggested that the plants we find in Florissant's fossil record might have existed at a lower altitude contributing to the types of plant genera that are found. He used the floristic method to determine the paleoelevation. His estimates place Florissant at about 3,000 ft. to 4,000 ft. The floristic method though not totally discounted, does have some weaknesses. It compares these mostly extinct fossil leaf species to modern counterparts. This method relies on accurate identification of fossils, which is sometimes only possible to the genus level, even in the most well preserved specimens. At this level, the widespread distribution of plant genera and families severely limits the ability to accurately assign one particular habitat to plants found in the fossil record. Many of their modern counterparts may have evolved and adapted to new climate conditions. Thus the information about what climate these ancient plants may have lived in may not be entirely accurate.

In the 1970s and 1980s, scientists began to emphasize methods that considered plant characteristics (the physiognomic method), rather comparing genera and species. By studying the modern leaf morphology and anatomy in the context of specific climates, scientists are able to identify climate indicators that did not depend upon identification of taxa, on distribution of modern families, and accounted for some evolutionary adaptation. Some of identifying characteristics of plants that correlated with a climate, such as subtropical are drip tips (pointed apex of a leaf which allows water to drip off), entire margins (smooth margins with no serration), and cordate bases (the base of the leaf has a heart shape). This morphology seems to be consistent with different species in similar climates throughout the world. Several paleobotanists have used this method and published estimates of an elevation very close to Florissant's elevation today (8,400 ft.).

These hypotheses developed by paleobotanists indicate a warmer climate than the one we see today at Florissant. Their research indicates the climate 34-35 million years ago was sub tropical to warm temperate. Today, the climate is cool temperate. But why was the climate warmer? Was it locally warmer? Was it globally warmer? Was Florissant at a lower elevation? Was Florissant closer to the equator? Or are there other events that influenced the change in climate.

MacGinitie in the 1950s suggested that the southern Rocky Mountains uplifted after Florissant, which like the Himalayan uplift, may have contributed to global cooling after 34 million years ago. This also suggests that Florissant may have been at a lower elevation. Some geomorphologists (geologists who study structure movements of the plates and stratigraphic information) support this idea and propose that the tectonic activity continued well past the Eocene/Oligocene boundary. These scientists look at field evidence, which shows a shift in the paleostream drainage and erosion that has taken place since 34-35 million years ago. Some think that structural events could have taken place as little as 5 million years ago.

Much the evidence points to plate tectonics being a major influence in the cooling of the planet at the Eocene/Oligocene boundary. During the Eocene epoch time period Antarctica, the tip of South America, and the Australian Continent were connected. Central America was mostly submerged allowing the warm ocean currents at the equator to flow freely flow from the Pacific into the Atlantic Ocean. Also, the polar ice caps were smaller and more land in general was submerged allowing the oceans of the earth to absorb the heat from the sun. At the beginning of the Oligocene both South America and the Australian Continent broke away from Antarctica. This tectonic movement increased cooling due to convection currents encircling the southern pole and furthered the development of a larger and deeper polar ice cap in Antarctica. The deep ocean currents surrounding Antarctica began to cool and Central America also began to rise out of the water blocking the equatorial currents from the Pacific to the Atlantic. The Pacific current then dropped south and picked up the cooler Antarctica water. The current then brought the cooler water north into the Atlantic Ocean. Scientists think this shift in direction and temperature of deep ocean currents contributed greatly to the cooling of the planet. Other factors could have contributed to this cooling, such as the tilt of the earth toward the sun, or eccentricity (our proximity to the sun). The hypotheses mentioned above are just a few of the put forth by scientist concerning the Eocene Oligocene Boundary Climate Change.

We hope this helps student and teachers begin to understand the processes affecting climate change and science itself. These various studies (at Florissant Fossil Beds National Monument) serve to provide a good applied illustration of the scientific process, wherein hypotheses and results are retested in view of alternative methodologies.[1] Florissant Fossil Beds National Monument was set aside as an important site containing significant fossil resources, though these resources are important, just as important are the questions being raised by the scientists who study them.

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[1] Evanoff, E., Gregory_Wodzicki, K., and Johnson, K., *Proceedings of the Denver Museum of Nature and Science:* Fossil Flora and Statigraphy of the Florissant Formation, Colorado, Series 4, Number 1, 2001

Canon Paleo Curriculum
Lesson Plan 6
Unit: 2

Activity Name: Stratigraphic Mapping

Supplies:

- One **Florissant Formation Wall Section** per group
- **Stratigraphic Mapping Worksheet** for each group
- **Stratigraphic Mapping Definitions** for each group
- Rulers
- One color chart for each group
- One grain chart
- Use a geologic reference book for description of rock types

Preparation:
- Print:
    - one **Florissant Formation Wall Sections**
    - one color chart
    - one **Stratigraphic Mapping Definitions**
    - one grain chart for each group.
- Print several copies of the fossil page and cut out each pair. You will hand out the fossil or non-fossil for the layers each group has picked. Se the list below.
- Go over **Stratigraphic Mapping Definitions with the class and the abbreviations they can use on the exercise.**

Concept:
Students will gain an understanding of:
- superpositioning
- how scientists describe layers of earth
- how scientists note the fossil that are found or not found in each layers
- how scientists label or map section of a stratigraphic column

Activity:
Read background materials for Unit 2 to gain an understanding of how the earth has changed and the layers have built up over time.

The teacher will need to divide the students into group.
- divide class into groups of four, they can work together
- have students pick out three layers of the section they would like to describe and start by comparing each layer to the color chart. They do not have match

exactly, we are only using a small portion of the chart geologist use.

- then have students compare each of the three layers to the grain chart.
- have them decide the lithology of each layer
- then measure the width of the each layer

The fossiliferous layer is determined by the teachers(you are the paleontologist who is examining the layer for fossils and will tell the students if they have fossils or not.) After each group has chosen the three layers go around the room and ask them which layers they are working on. Then using the list below to determine which sets of fossils or non-fossils they will receive to describe if the layers is fossiliferous or not.

For the purposed of this exercise, the clay shale have fossils and the sand mudstones and mudstones do not. This not always true though sometimes fossils are not found in the clay shale and sometimes fossils are found in the mudstone. They are hardly ever found in the sandy mudstone.

As students complete the **Stratigraphic Mapping Worksheet** pass out one set (part and counterpart) of either one **fossil** or **no fossil** set to each groups to help the fill out the "Fossiliferous" portion of the Worksheet.

Layer	Fossil (F) or non-fossil (N)
1	F
2	N
3	F
4	N
5	F
6	N
7	F
8	N
9	F
10	N
11	N
12	N
13	F
14	N

Time:
1 hour

Stratigraphic Mapping Worksheet - KEY

Students Name ____________________Date______________________

Have the students attach **the Florissant Formation Wall Section** they used to the sheet along with the fossil for your evaluation. Use the key images for the correct answers.

Wall Section

Number of Layer __14.

Pick any three layer, indicate on your Florissant Formation Wall Section what three layers you are measuring. *Note: Give students some leeway on their answers, but they should arrive at answers close to the range in the table.*

Descriptor	thickness	lithlogy	color	bedding	grain
1	8-9mm	CS	GB3	uk -SMS	<.1
2	11mm	SMS	GB3-RB3	CS-CS	.5-1.0
3	16mm-2cm	CS	GB3	SMS-SMS	<.1
4	8-13-mm	SMS	GB3-RB3B1	CS-CS	.5-1.0
5	1mm	CS	GB3	SMS-SMS	<.1
6	1-2mm	SMS	GB3-RB3B1	CS-CS	<.5
7	6-7mm	CS	GB3	SMS-SMS	<.1
8	3-4mm	SMS	GB3-RB3B1	CS-CS	.5-1.0
9	2.5-3 cm	CS	GB3	SMS-SMS	<.5
10	4-4.5cm	SMS	GB2,3,4	CS-MS or CS	I.0
11	3.5-7mm	MS or CS	GB3	SMS-SMS	<.5
12	2.5-3cm	SMS	GB2,3,4	CS or MS -CS	1.0
13	1.3-1.5cm	CS	GB3	SMS-SMS	<.5
14	1.4 -1.7cm	SMS	GB2,3,4B1	CS-UK	1.0

Stratigraphic Mapping Defintions

Characteristics to be described:

Number of Layer - What layer from the bottom of the Column

Thickness – take measurement in millimeters

Lithology – the science of describing the mineral characteristics of rock specimens.
– such as mudstone(MS — thick without layering or sand), sandy mudstone(SMS — sandy mudstone), and clay shales(CS- multiple thin layers of clay), unkown (UK)

Color – use color chart to describe specimen, usually this is done with a Munsell Color chart. For color abbreviations — use red brown(rb), gray brown(gb), etc. and add the number, example rb-4

Weathering – how the rock breaks

- uniform pattern, no uniformity, etc.
- since these are not real samples the aspect cannot be tested in this exercise

Bedding - lamination

- how the unit is layered, above, and below

Grain size - use stratigraphic grain chart to determine size of rock grain

Fossiliferous – does layer contain fossils and describe the type of fossils

- plant, plant and insect, plant debri, etc. (F) No fossil content (NF)

Cement – calcareous or non calcareous

- does it react to hydrochloric acid; does it contain calcium
- if it does react, it reveals the fact that there is limestone in the rock specimen (Note: none of your rock specimens react to the acid)
- since these are not real samples the aspect cannot be tested in this exercise

Symbols for descriptors

- thickness — the measurement in millimeters
- lithology — the type of rock will be one of the three mentions in the Stratigraphic Mapping Defintions
- color — use red brown(rb), gray brown(gb), etc. and add the number, example rb-4
- Bedding — the lithology of the layers above and below the current layer
- Grain size — use the grain chart to determine the grain particles

Fossiliferous — when you passed out the pairs if the student had a fossil in their split rock or not.

Stratigraphic Mapping Worksheet

Students Name ____________________Date______________________

Wall Section
Total Number of Layer

____

Pick any three layers and indicate on your Florissant Formation Wall Section what three layers you are measuring.

Thickness__________________________mm
Thickness__________________________mm
Thickness__________________________mm

Lithology

1. ____
2. ____
3. ____

Color - name ___________________number________________
Color - name ___________________number________________
Color - name ___________________number________________

Bedding ____
Bedding ____
Bedding ____

Grain size ____
Grain size ____
Grain size ____

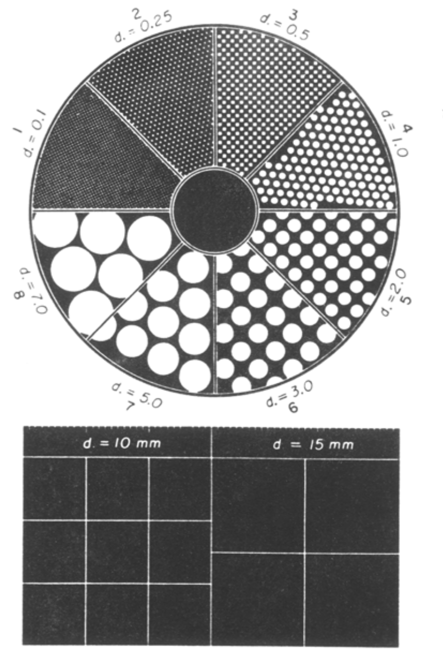
Fossiliferous ____
Fossiliferous ____
Fossiliferous ____

Symbols for descriptors

- thickness — the measurement in millimeters
- lithology — the type of rock will be one of the three mentions in the Stratigraphic Mapping Defintions
- color — use red brown(rb), gray brown(gb), etc. and add the number, example rb-4
- bedding — the lithology of the layers above and below the current layer
- grain size — use the grain chart to determine the grain particles
- fossiliferous — when you passed out the pairs if the student had a fossil in their split rock or not.

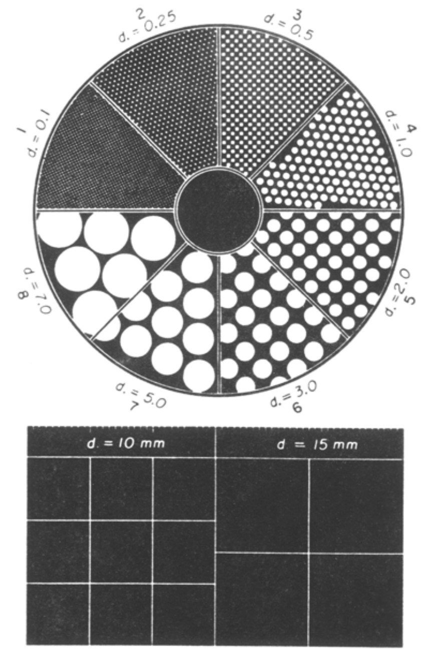
Color Chart

Red Brown
1
2
3
4
Gray Brown
1
2
3
4
Brown
1
2
3
4
Gray
1
2
3
4
Yellow Brown
1
2
3
4
Gray Blue
1
2
3
4



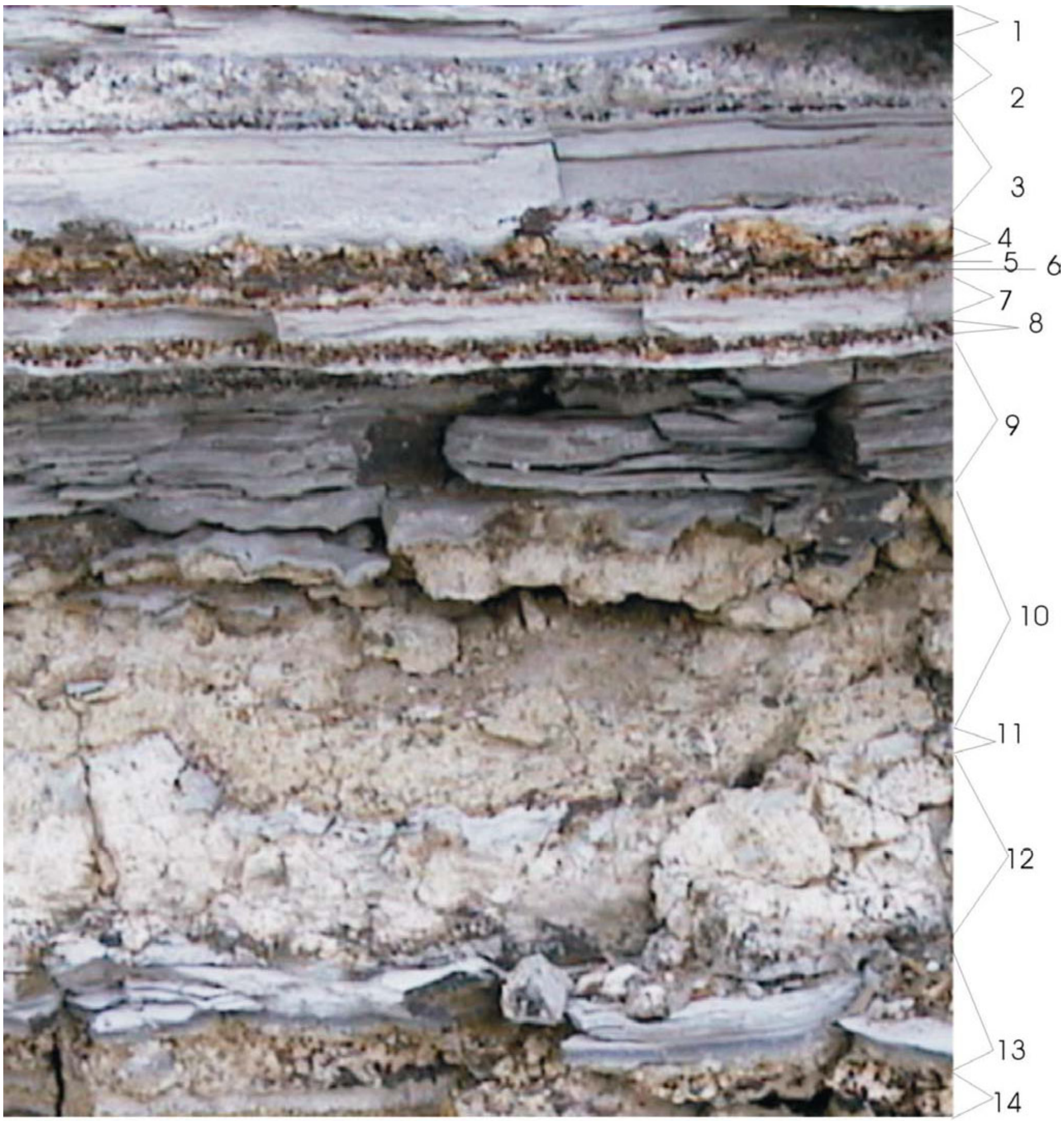
References: (1) George V. Chilingar, 1956, Soviet classification of sedimentary particles and Vasil'evskiy graph: AAPG Bull., v. 40, no. 7, p. 1714. (2) M.S. Shvetsov, 1948, *Petrography of sedimentary rocks*, 2nd ed., 387 p. Gosgeolizdat, Moscow-Leningrad

Grain chart

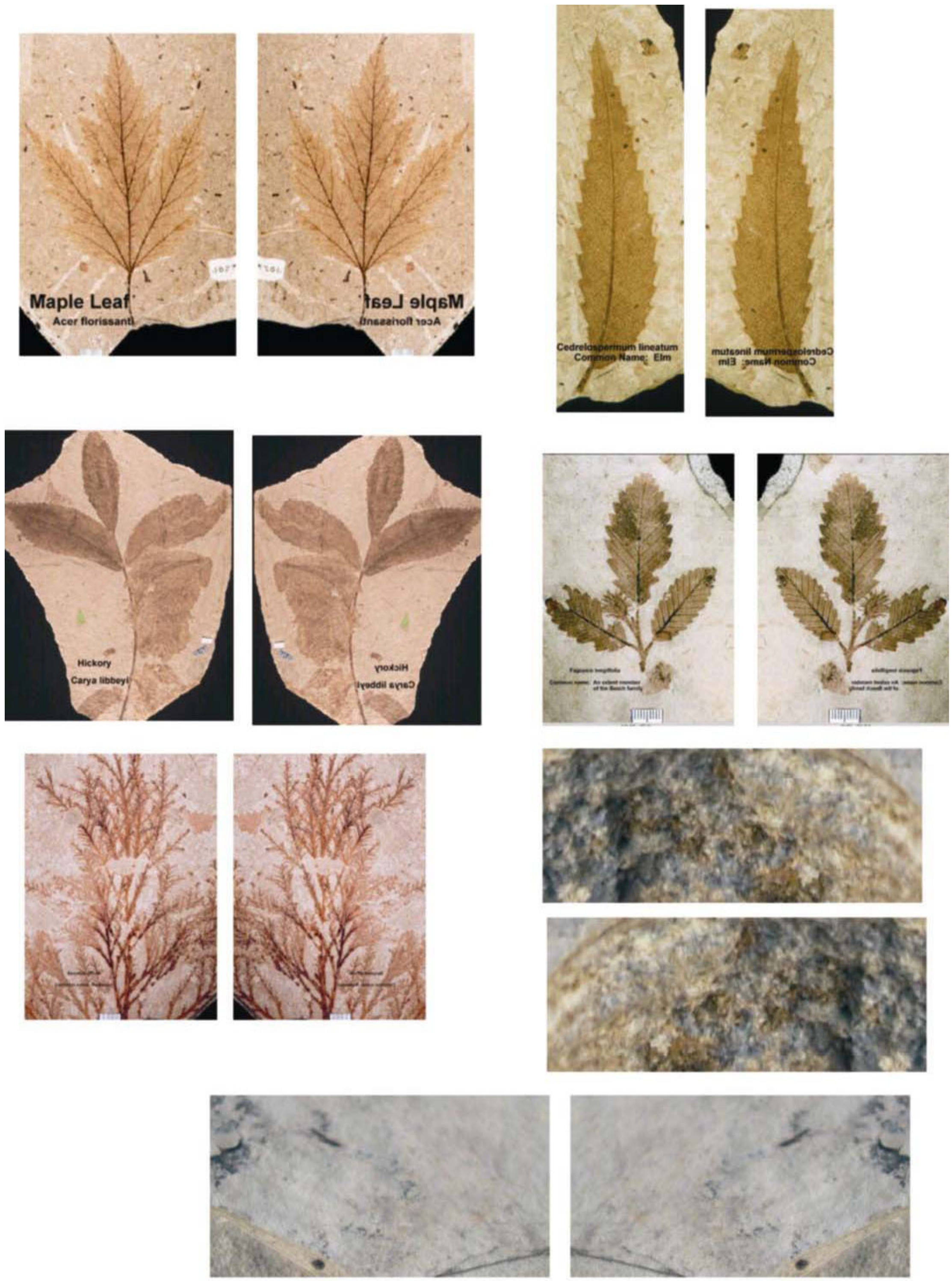


References: (1) George V. Chilingar, 1956, Soviet classification of sedimentary particles and Vasil'evskiy graph: AAPG Bull., v. 40, no. 7, p. 1714. (2) M.S. Shvetsov, 1948, *Petrography of sedimentary rocks*, 2nd ed., 387 p. Gosgeolizdat, Moscow-Leningrad

Grain chart



Florissant Formation Wall Sections



Part and counterpart for fossiliferous test

Canon Paleo Curriculum
Lesson Plan 7
Unit: 2

PALEONTOLOGY
FOSSIL IDENTIFICATION

Materials Needed:

- Fossil ID Packets (share packet between a group of 4-5 students), it is suggest that these are printed and laminated for other classes to use.
- Paper Fossils
- Catalog Sheets (two fossils for each student)
- Rulers and pencils

Grades: 7-12

Colorado State Standards Met: Science 1, 3.4, 4.1, 6

Skills:

- This activity is designed to sharpen the visual skills needed to classify fossil plants.
- Students learn to research materials and use available information.

Lesson Plan:

- Copy **Paper Fossils** and cut up, give each student two **Paper Fossils** and two **Catalog Sheets**.
- Have students assign their **Paper Fossil** a number and write number on both the **Paper Fossil** and on the **Catalog Sheets** provided.
- Have students work in groups of 4-5 sharing the **Fossil ID Packets**, helping each other identify their fossils.
- Have students draw a picture of their fossil to scale.
- Each student identifies their plant fossils from the **Fossil ID Packets**.

CATALOG SHEET

Cataloger (Name of Student)___________________________________

Name of fossil________________________________ Date_______________

Number of Fossil (student assigns a number)_______________________

Place Fossil was found_____________________________(school name)

Measure the fossil and draw a picture of your fossil (include shape of rock) in the grid. Boxes are1 cm square.

Canon Paleo Curriculum
Lesson Plan 8
Unit: 2

LEAF IDENTIFICATION

Important information:
For this activity you will need to download the “Leaf Manual” PDF file (Adobe Acrobat) on the main page.

Materials:
- Leaf Manual Sheets (a PDF file) for every 4-5 students
- Fossil Id Packet
- Paper Fossils used in Fossil Identification Activity
- Descriptions and Some Common Vegetational Correlations for every 4-5 students

Skills:
- Observation
- Learning to key plants for identification
- Names of plant parts.

Have students in groups of 4-5 use paper fossils from **Fossil Identification Activity** and use the **Leaf Maunal Sheets** as a guide to draw three identifiable parts of the fossil leaf, one of the three parts must be margin type.

Margin types, tips, and bases are climate type indicators. This is called the “Physiognomic Method”. It is currently the most predictable method of identifying what climate a plant may be found.

Have the students label the parts of their fossil according to the **Leaf Manual Sheets**.

Now have student use **Descriptions and Some Common Vegetational Correlations** to place their fossil with a climate.

Key
- Smooth or entire margin are found in tropical to subtropic climate
- Acuminate apex or drip tip is usually found in tropical to subtropical climate.
- **Acuminate apex with a non entire margin is usually associated with a temperate climate.**
- **Look at the chart to determine other correct answers.**

Descriptions and Some Common Vegetational Correlations

Tropical: Within five degrees of the equator there is little seasonal variation, it being hot and wet year round. Between five and fifteen degrees from the equator wet and dry seasons are common. • The coolest month is above 18 degrees C. • The annual mean temperature approaches 27 degrees C. • Average rainfall between 100 and 200 cm per year. *Examples:* • Brazilian Lowlands· • Philippine Islands	Leaf Margins between 57 and 89% entire. Large leaves, with drip tips common on understorey evergreens. Lianes (vines) are common in understorey.
Subtropical: More noticeable seasonal variation in temperature, as well as distinct wet and dry seasons. • Coldest month above 6 degrees C but below 18 degrees C. • Annual mean temperature approximately 20 degrees C. • Average annual rainfall between 50 and 100 cm.*Examples*: • Hawaiian Islands	Leaf Margins 39-55% entire. Broad-leaved evergreens often with conifers and broad-leaved deciduous plants.
Warm Temperate: Thoroughly differentiated seasons. Warm Temperate is further divided based on the wet season. Many interior continental regions have warm wet summers and mild winters. Those regions that have mild wet winters and hot dry summers are termed *Mediterranean*. • Coldest month above 0 degrees C. • Annual mean of 12 degrees C. • Average annual rainfall is between 25 and 75 cm. *Examples*: • Milan, Italy • San Francisco, CA	Leaf Margins 30-38% entire. Broad-leaved deciduous plants with conifers. Evergreens may be present but not dominant.
Cool Temperate: Thoroughly differentiated seasons. Cool Temperate is also divided into two categories: *Oceanic* and *Continental*. *Oceanic Cool Temperate* is mild and rainy year round, while *Continental* regions experience cold winters and warm summers. • Coldest month below 0 degrees C. • Annual mean of 6 degrees C. • Average annual rainfall is 25 to 75 cm. Examples: • Woodland Park, CO • Nova Scotia, Canada	Evergreens may be present and dominant. Some broad-leaved deciduous plants, low growing.
Cold: Cold climates are defined as those regions that spend 6 to 9 months below 6 degrees C.· Coldest month well below 0 degrees C.· Average rainfall is often below 25 cm per year.*Examples*:· Fairbanks, AK	Some evergreen, small. Low growing, short season, tundra plants.

Climate Information:

http://www.fs.fed.us/colorimagemap/images/230.html

Espenshade, E. B. and Morrison, J. L., 1974, *Goode's World Atlas*. Chicago, Rand McNally and Co. pp. 10-15.

Pearce, E.A. and Smith, C.G., 1998, *Fodor's World Weather Guide*. New York, Random House. p. 11.

NA, 1987, *Encyclopedia of Climatology, Volume XI*, New York.

Canon Paleo Curriculum
Lesson Plan 9
Unit: 2

CLIMATE ACTIVITY

Important Information:
If you can have access to PowerPoint equipment then download the "Exploring Ecosystems for Paleontology" presentation on the Main page. If you do not have access to PowerPoint, download the "Exploring Ecosystems for Paleontology" PDF (for Adobe Acrobat) for your overhead machine. The information in both of these files is critical for the activities and forming hypotheses.

Materials:
- Investigating Paleoclimates
- Climate Descriptions
- Climate Work Sheet
- Paleoclimate and Paleoelevation

Skills:
- Using observation to make an inference
- Categorizing

Directions: Have students complete **Leaf Idendification** and **Fossil Identification** activity first. Then show them **Part 1** of the Powerpoint or overheads – **Explore Ecosystems for Paleontology.**

After completing **Part 1**, take the fossils identified in the **Fossil Identification Activity,** project the **Investigation Paleoclimates** list on an overhead and put a score mark for each student's fossil (genus) on the overhead into all the climates that applies to that fossil.

After scoring all of the fossils from the students. Tell them that they have just completed what scientists call the "Floristic Method", identifying climate through plant species.

Show the class **Part 2** of the powerpoint program on plate tectonics, life zones, and climate indicators or show overheads from the PDF file.

Again have the class break out into group of 4-5, hand out the **Climate Descriptions,** have them look at the fossil list in terms of climate, and then have them answer the questions on the **Climate Work Sheet**.

After they finish the **Climate Work Sheet** and the answers have been discussed, have them break out into groups again to speculate and form some hypotheses. List the hypotheses on the board and then show **Part 3** of the powerpoint presentation or overheads explaining all of the current hypotheses.

Key to Investigation Paleoclimates Activity:

Most of the student's plants will fall in Subtropical and Warm Temperate

Hint: List the percentage of plants that are found in each climate; 100% being the total plants listed

Key to Climate Descriptions Activity:

Question 1:

- Floristic and Physiognomic

Question 2:

- That most of the genre falls into Subtropical and Warm Temperate, only a small percent fall into aCool Temperate climate.

Question 3:

- List the 3 characteristics for the three climates from the **Climate Descriptions** page. Such annual mean temperature, annual mean rainfall, and coldest and warmest temperatures.

Question 4:

- That it was wetter 34-35 million years ago.
- That it was warmer 34-35 million years ago.

Question 5:

- That it was wetter 34-35 million years ago.
- That it was warmer 34-35 million years ago.
- That most of the plants may have been in a subtropical to warm temperate climate.

Hypotheses

- That Florissant Fossil Beds National Monument site was at a lower elevation 34-35 million years ago.
- That Florissant Fossil Beds National Monument site was closer to the equator.

• That the planet was just warmer 34-35 million years ago.

Name___________________________

Investigating Paleoclimate

On the list below circle each of the plant genera that you identified in Activity One. If the name appears more than once, circle it everywhere that it occurs.

Climatic environments of extant plant genera.

Subtropical	Warm Temperate	Cool Temperate
Dryopteris fern	*Pinus* pine	*Pinus* pine
Sequoia redwood	*Sequoia* redwood	*Cercocarpus* mountain mahogany
Vanquelinia Rose	*Bursea* aromatic	*Populus* poplar
Zizyphus lotus	*Crataegus* hawthorn	*Chamaecyparis* white cedar
Cardiospermum soapberry	*Carya* hickory	*Acer* maple
Rhus anacard	*Fagopsis* beech	Salix willow
Salix Willow	*Acer* maple	*Quercus* oak
	Cercocarpus mountain mahogany	*Rosa* Rose
	Chamaecyparis white cedar	*Ulmus* elm
	Cedrelospermum elm	
	Paracarpinus beech	
	Typha cattail	
	Quercus oak	
	Ulmus elm	
	Rosa Rose	

The plants you circled are the closest living relatives of genera typically found in the Florissant Fossil Beds.

Climate Work Sheet

1. List two methods that help scientists determine paleoelevation.

2. What are some observation about the plant list and their genre?

3. What are the characteristics of a Subtropical Climate? Warm Temperate? Cool Temperate?

4. What would you infer about the past climate at Florissant based on the plants genre you circled?

5. What would you infer about the past climate at Florissant based on the plant characteristics you describe in the “Pieces-Parts of Leaves” exercise?

Climate Descriptions

Tropical: Within five degrees of the equator there is little seasonal variation, it being hot and wet year round. Between five and fifteen degrees from the equator wet and dry seasons are common.

- The coolest month is above 18 degrees C.
- The annual mean temperature approaches 27 degrees C.
- Average rainfall between 100 and 200 cm per year.

Examples: **Brazilian Lowlands, Philippine Islands**

Subtropical: More noticeable seasonal variation in temperature, as well as distinct wet and dry seasons.

- Coldest month above 6 degrees C but below 18 degrees C.
- Annual mean temperature approximately 20 degrees C.
- Average annual rainfall between 50 and 100 cm.

Examples**:** **Hawaiian Islands**

Warm Temperate: Thoroughly differentiated seasons. Warm Temperate is further divided based on the wet season. Many interior continental regions have warm wet summers and mild winters. Those regions that have mild wet winters and hot dry summers are termed *Mediterranean*.

- Coldest month above 0 degrees C.
- Annual mean of 12 degrees C.
- Average annual rainfall is between 25 and 75 cm.

Examples: **Milan, Italy; San Francisco, CA**

Cool Temperate: Thoroughly differentiated seasons. Cool Temperate is also divided into two categories: *Oceanic* and *Continental*. *Oceanic Cool Temperate* is mild and rainy year round, while *Continental* regions experience cold winters and warm summers.

- Coldest month below 0 degrees C.
- Annual mean of 6 degrees C.
- Average annual rainfall is 25 to 75 cm.

Examples: **Woodland Park, CO; Nova Scotia, Canada**

Cold: Cold climates are defined as regions that spend 6 to 9 months below 6 degrees C.

- Coldest month well below 0 degrees C.
- Average rainfall is often below 25 cm per year.

Examples**:** **Fairbanks, AK**

Climate Information:

http://www.fs.fed.us/colorimagemap/images/230.html

Espenshade, E. B. and Morrison, J. L., 1974, *Goode's World Atlas*. Chicago, Rand McNally and Co. pp. 10-15.

Pearce, E.A. and Smith, C.G., 1998, *Fodor's World Weather Guide*. New York, Random House. p. 11.

NA, 1987, *Encyclopedia of Climatology, Volume XI*, New York.

[1] MacGinite, H.D., 1953, *Fossil Plants of the Florissant Beds, Colorado*: Baltimore, Lord Baltimore

PALEOCLIMATE AND PALEOELEVATION

(Past climate and Past Elevation)

Comparing Research Methods

You have now completed activities on fossil identification and have made observations and inferences about the climates in which the may have exisited. Do you have any questions?

We purposely left many questions unanswered, because as you me have discovered, science is a process, and not a list of facts.

Take your own hypothesis for example. As a class you decided that the most likely reason that Florissant has cooled off considerably in the last 35 million years was due to regional uplift.

In the chart below you will find information about other hypotheses and methodoligies that have fueled debate on this very issue for almost 50 years.

began only 5 million years ago. Studied sediment deposition in stream beds to calculate relative age of tilting and canyon cutting.

Woodland High School Classes (2000)*Hypothesized that the decrease in average temperature at Florissant since the Eocene could be caused by uplift. "Warm Temperate"About 12 degrees C.* ***Floristic****Comparing fossil plants to closest living relative's habitat. Lower than present elevation.Present elevation is 2600 meters. Propose to study landscape for evidence of Uplift. This would be* geomorphic *evidence.*

	Paleo-Temperature (Currently 4 C)	**Technique for Temp.**	**Elevation** (Currently 2600m)	**Technique for Elev.**
Harry MacGinitie (1953) By comparing fossil plants to the habitat of their closest living relatives, MacGinitie predicted a low paleo-elevation.	>18 degrees C	**Floristic**Closest living relative	305-915 meters	Qualitative analysis using closest living relatives and current habitat.
Dr. Herb Meyer (1986) Studied fossil leaf structures to predict past climate and elevation.	About 14 degrees C	**Physiognomic**First to apply plant features to the problem of paleo-elevation at Florissant.	2450 meters	Compared Florissant flora with co-eval sea level flora and calculated elevation using an inferred
Dr. Jack Wolfe (1992) Studied fossil leaves to calculate past temperature and elevation.	12 degrees C	**Physiognomic** Compared leaf structures at Florissant with current leaf structures to est. temp.	2700-2900 meters	lapse rate. Compared fossils from Florissant with sea level fossils and calculated elevation using lapse rate.
Dr. Kate Gregory (1994) Studied fossil leaves and sequoia stumps to calculate past temp, and believes Florissant has not been uplifted since Eocene	10.7 degrees C	**Physiognomic** Plant features and *sequoia affinis* tree ring comparison.	2300-3300 meters	Compared paleo temps at Florissant with *co-eval* (same age) temps from sea level and calculated using a lapse rate.
Dr. Emmett Evanoff (1997) Hypothesized that the Florissant region has been uplifted since the Eocene.		*Uplift* – due to plate tectonics	Lower than present elevation. Proposes that uplift began only 5 million years ago.	Studied sediment deposition in stream beds to calculate relative age of tilting and canyon cutting.
Woodland High School Classes (2000) Hypothesized that the decrease in average temperature at Florissant since the Eocene could be caused by uplift.	“Warm Temperate”About 12 degrees C.	**Floristic** Comparing fossil plants to closest living relative’s habitat.	Lower than present elevation.Present elevation is 2600 meters.	Propose to study landscape for evidence of Uplift. This would be *geomorphic* evidence.

UNIT TWO EXAM

Multiple Choice. Put the letter on the line that best completes the sentence.

_____1. Evidence that life existed in the past is called a:
a. mutation b. fossil c. variation d. selection

_____2. The fossils at Florissant Fossil beds show that:
a. a lake existed in the valley b. and ocean was once here
c. granite peaks in Colorado were once volcanoes
d. life was much the same as it is today

_____3. Scientists at Florissant use this fossil as a primary indicator of climate:
a. insect fossils b. plant fossils c. mammal fossils d. dinosaur fossils

_____4. The fossilization process at Florissant was due to:
a: volcanic material b: being encase in swamp material c: sedimentary deposition d. deposition at the bottom of the ocean

_____5. The layers of rocks that make up the shale layers where fossils are found in Florissant come from:
a. mud b. gravel c. ash d. sand

_____6. the petrified trees at Florissant Fossil Beds are thought to be:
a. sequoias b. firs c. beech d. ponderosa pines

_____7. The petrified trees are thought to have become petrified as a result of:
a. hot lava flows from volcanoes b. old river deposits
c. granite sediments d. volcanic mudflows

_____8. Dinosaur fossils are not found at Florissant Fossil Beds Because:
a. the climate was too cold b. dinosaurs were not in the area
c. they were already extinct d. they were not preserved

_____9. Only the bases of the trees are petrified because:
a. the tops had already rooted away b. fire burned the tops off
c. that was the part that was surrounded by mudflows
d. the bases were stronger than the rest of the tree

_____10. By studying the petrified trees, scientists have determined that:
a. the climate was much different at one time than it is today
b. the rainfall was much greater than today
c. . the trees were up to 500 years old based on tree ring studies
d. all of the above

_____11. The Florissant Formation is thought to be:
a. 10,000-20,00 years old   b. 34-35 million years old
c. 4-4.5 billion years old d. 2.5Million years old

_____12. a mineral found in the rock surrounding the petrified trees is responsible for their petrification. The name of this mineral is:
a. obsidian   b. silica   c. tuff   d. conglomerate

_____13. The fossils of Florissant have been protected over the years by:
a. a slower mudflow called "caprock" b. granite   c. lava flows
c. volcanic eruptions of ash

Identify each of the following statements as either an Inference or Observation by putting the letters "I" or "O".

_____14. Plant Species found in the fossils of Florissant suggest a warmer, moister, climate.

_____15. The petrified stumps of Florissant have a circumference of up to12 meters.

_____16. Living sequoia trees today live at lower elevations and receive more rainfall.

_____17. Volcanic tuff surrounds the bases of the petrified trees at Florissant.

_____18. There are fossils of plants and insects, some fish birds at Florissant.

_____19. There was a lake at Florissant that supported many types of organisms.

_____20. Florissant was probably at the same elevation 34-35 million years ago.

UNIT TWO EXAM – TEACHERS KEY

Multiple Choice. Put the letter on the line that best completes the sentence.
If there are two answers, either or both is correct.

__B__1. Evidence that life existed in the past is called a:
a. mutation b. fossil c. variation d. selection

__A_2. The fossils at Florissant Fossil beds show that:
a. a lake existed in the valley b. and ocean was once here
e. granite peaks in Colorado were once volcanoes
f. life was much the same as it is today

__A,B_ 3. Scientists at Florissant use this fossil as a primary indicator of climate:
a. insect fossils b. plant fossils c. mammal fossils d. dinosaur fossils

__A,C_4. The fossilization process at Florissant was due to:
a: being encase in volcanic material b: being encase in swamp material c: sedimentary deposition d. deposition at the bottom of the ocean

__C__5. The layers of rocks that make up the shale layers where fossils are found in Florissant come from:
a. mud b. gravel c. ash d. sand

__A__6. The petrified trees at Florissant Fossil Beds are thought to be:
a. sequoias b. firs c. beech d. ponderosa pines

__D__7. The petrified trees are thought to have become petrified as a result of:
a. hot lava flows from volcanoes b. old river deposits
c. granite sediments d. volcanic mudflows

__C__8. Dinosaur fossils are not found at Florissant Fossil Beds Because:
a. the climate was too cold b. dinosaurs were not in the area
c. they were already extinct d. they were not preserved

__C__9. Only the bases of the trees are petrified because:
a. the tops had already rooted away b. fire burned the tops off
c. that was the part that was surrounded by mudflows
d. the bases were stronger than the rest of the tree

__D__10. By studying the petrified trees, scientists have determined that:
a. the climate was much different at one time than it is today
b. the rainfall was much greater than today
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