Geology: Stories in the Rocks
About 4th grade to Middle School

This hike starts at the NCAR parking lot and continues to the first steep climb of the Mallory Cave trail. An excellent illustrated tour to acquaint you with this route is available at www.bouldercolorado.gov/osmp/elearning. You can print this out and take it with you in the field to practice the rock layers.

Theme: Geologists can read the rocks to decipher the story of a place to see what it looked like long ago. .

Introduction: Here we have geology to thank for our beautiful mountain scenery, as well as the lions, bears and eagles that live here. But this reality is only a brief snapshot in time. Geology is ever changing and as it changes so does the way our land looks. Today we see valleys and mountains, but this place has looked very different in the past. On our hike we will learn how to decipher the story in the rocks, by examining local rocks to read the story the tell us of this place.

Activity: Find your own rock. After they have done the activity, discuss a few examples of how they identified their rock, then bring out examples of river stone, ripple rock, fern fossil and petrified wood. Discuss the story each of those rocks has to tell about the place it was found.

So now that you've seen just how rocks tell stories and precisely how they are made, let's look at the rocks here to determine the history of this place. (Start the hike down off the mesa.)

The history of this place – hike using Ancient Denvers

16,000 ya –mammoths and camels
Imagine that! No McDonald's, this would have been your food supply. Easy pickings?

70 million years ago: Pierre Shale

- A soft shale layer deposited under a shallow sea.
- Pterosaurs, a kind of flying reptile, cruised the skies
- Sharks and toothy fist prowled in the sea **(**show colorful drawing of sea creatures)

Moving on:
Find two new rock layers that indicate changes in the depositional environment:

- Niobrara – find any fossils in this limestone? This layer is made up of mollusk shells and calcium deposits from marine creatures formed in a deep, calm ocean.
- Benton – very soft shale, made from mud in a shallower sea.

Look into the valley between NCAR mesa and Dakota ridge:
Differential Erosion – a variation in the weathering and erosion rates of different rocks.

Best explained using the **"Lasagna" analogy** – if you put a high pressure stream of water on a pan of lasagna, the sauce, ricotta cheese, and other soft layers would wash away leaving the harder, more durable layers, the noodles. In geology, we call this differential erosion. The softer layers wear away or erode, while the harder, more durable layers remain.

Ten thousand years ago huge glacial flows scoured over Boulder Valley, the gravel, sand and silt deposits, remnants of the eroded mountain, can still be see in many places around the county (ex. the gravel layers at Sawhill ponds).

100 million years ago: Dakota Sandstone
CO was the coastline of a huge internal ocean that covered much of North America (picture)

- Imagine long beaches that were dinosaur migration routes.
- Many dinosaur footprints are found in the Dakota Sandstone, as well as "ripple" rock which preserves the wave impressions of waves on the beach.
- Warm humid climate with first flowering plants and insects.
- Like lasagna noodles, very hard layer, resistant to erosion

Mesozoic Era --- Cretaceous Period

Towel exercise at water tank, after looking at ripple rock

150 million years ago: Morrison Formation (softer shale and sandstone)

- Home of the long-necked dinosaurs (show colorful pic of dinos)
- Dinosaur fossils, footprints, before flowering plants!
- Dinos are now extinct but their descendents, the birds, are not and the oldest fossilized bird, *Archaeopteryx*, was alive at the time of the Morrison formation. (pic)
- Soft layer, like spaghetti sauce

Mesozoic Era --- Jurassic Period

250 million years ago: Lykins Formation

- Tropical coastlines with slimy mounds of blue green algae known as *stromatolites*.
- Made softer rock which had eroded away into this valley. Like spaghetti sauce.

Mesozoic Era --- Triassic Period

280 million years ago: **Lyons Sandstone** (show Lyon's rock sample)

- During Pangea (an ancient super-continent) this area was part of a huge desert, the size of the Sahara, the land was high and dry.
- Fossilized sand dunes (pic)
- **Good building material often used in older building around Boulder, CU campus.**

Paleozoic Era --- Permian Period

300 million years ago: Fountain Formation (show a rock sample**)**

- More sedimentary rock, with big chunks and ground-up bits of other rock, very solidly glued together, like lasagna noodles, leaving them sticking out of the mountain
- Dragonflies the size of great-horned owls and cockroaches the size of dinner plates.
- Where do you think our Flatirons came from? What kind of rock are they? Sedimentary! What size chunks of material make up this sedimentary rock? Compared to the Benton shale made from mud? BIG pieces!
- What does this tell you about where the erosion debris, that settled and solidified into the Flatirons came from? Not far away, not worn down into smooth and tiny pieces.
- Where did it come from? The ancestral Rockies, that were here, 300 million years ago!

Paleozoic Era --- Pennsylvanian Period

Final stop - on the west side of NCAR mesa (before they can get distracted by seeing the school bus!)

- Turn around to hike back, asking: "You now know what this place has looked like in the past. What do you think it will look like in 100 million years?"
- "Geology gives us extremely beautiful landscapes to look at. It is a combination of the mountain building processes and erosion that create these beautiful vistas.
- Earlier I asked you what you thought this place would look like in 100 million years. On our hike today we only went back 300 million years ago, to the time when the sedimentary rock of the Flatirons was laid down.
- It has since come and gone and is now replaced by our current Rockies, what will be their fate?
- Would this place look differently if it weren't OSMP? Built up with homes and parking lots and convenience stores. We are lucky to have it set aside. Maybe in a million years it will be beach front once again.

Add-on supplement: Types of Rocks

There are three different types of rocks. But before we can really understand how they are made we need to understand more about how the earth is made.

Has the map of the earth been the same forever? No = plate tectonics
Plate tectonics driven are by:
Core, mantle, curst:
The earth is divided into four main layers: the **inner and outer core, mantle**, and **crust**. The core is composed mostly of iron. The inner core is under so much pressure that it is a solid, the outer core is so hot it is **molten**. 5200 Km thick, or about 3200 miles.

Mantle: is composed of iron, magnesium, aluminum, silicon, and **silicate** compounds. The mantle is solid but can deform slowly in a **plastic** manner. 2900 KM thick, about 1800 miles

Crust: The crust is much thinner than any of the other layers, and is composed of the least dense (calcium and sodium aluminum-silicate minerals). Because it is relatively cold, the crust is made of solid rock that is **brittle**, so it can fracture in **earthquakes**.
About 20 miles thick.

The crust makes up the continental and oceanic plates, which move. The continental crust is less dense than the oceanic crust, hence it "floats" on it. (Analogy: pouring a pool of oil on a dish of water.)

Plate tectonics: Heat released from the earth's core causes movement of the mantel, and heat from both the core and the mantel cause movement of the crust, through convection currents. Convection in the mantle induces plate tectonic motions of the sea floor and continents.

A rock – most are made of several minerals, found in different combinations and amounts. Minerals are made of naturally occurring, inorganic compounds, with the same chemical structure throughout the entire mineral. Some minerals, like gold, are just one element, others are made of more than one element always combined in the same way, like the mineral quartz, made up of one part silicon and two parts oxygen.

Granite is made of several minerals: quartz, mica, feldspar, sometimes hornblende. It's a little like a fruit salad made of different kinds of fruit stuck together.
Igneous – rocks that have solidified from magma, liquid rock. Extrusive and Intrusive. The slower the magma cools the larger the crystals are formed. Therefore intrusive rocks have larger crystals.
Sedimentary – rocks that formed by the accumulation of layers of fragmental material from preexisting rocks, organic materials or precipitated salts.
Metamorphic – rocks that are buried deeply beneath the earth's surface. They experience such great pressure and high temperatures and chemical activity from their surroundings that they re-crystallize into a different type of rock.
When it metamorphoses, granite becomes gneiss; quartz sandstone becomes quartzite. Limestone becomes marble. Clay impurities metamorphose into mica. Carbon, like coal, can become diamond.