Garden of the Gods Park
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Program updates can be found at: https://gardenofgods.com/educational/edu-1/school-field-trips

Land Use Acknowledgement:

We gratefully acknowledge the native peoples on whose ancestral homeland we gather, as well as the diverse and vibrant Native communities of Colorado today.

Geology of the Park Program

Welcome! We look forward to sharing the geological story of Garden of the Gods with your students.

We align with current Colorado Academic Standards for middle and high school Earth and Space Science.

Goals:

- Students become invested in understanding and caring for the exceptional wonder of the Garden of the Gods and the world around them
- Students gain an understanding of the various forces at work that shape and color the natural world
- Students gain an understanding of how humans use and shape natural surroundings
- Students understand the geological timeline of the region plus how ancient events impact today's world and can be used to predict future outcomes

Teacher Reference Guide:

Geology of Garden of the Gods

The Pike's Peak region has been shaped by millions of years of mountain building and erosion. There have been three different mountain building events in the geological history of this area:

1. *The Ancestral Rockies* (300-320 million years ago). The erosion of these first Rocky Mountains formed the sedimentary Fountain Formation and the Lyons Sandstone layers.

2. *The Laramide Orogeny* (70-60 million years ago). This process uplifted the Front Range. The layers seen in the Garden were forced upright as the land broke apart creating the Rampart Range Faulting System. These mountains still exist as the upper half of mountains along the current Front Range.

3. *Late Tertiary Uplift* (5 million years ago). Ongoing erosion and uplift has spread Pike's Peak granite throughout western Colorado Springs. Pikes Peak granite has been dated at over 1 billion years in age using geologic radiometric dating methods. The erosion of this time period exposed the upright fins (hogbacks) seen in the Park today. The bowls on Pikes Peak were scoured out by glaciers during the last Ice Age that ended 11,700 years ago.

The Garden of the Gods Park is composed of sedimentary rock layers. They are geologically remarkable due to their vertical and in some cases beyond vertical positions. This allows study of rock that in other areas has been buried by layers of sediment nearly a mile thick. Students will explore some of these:

Mesa Gravels (2 million- 10,000 years ago): Loose red gravels atop the eastern ridges of the park and the mesa east of 30th street. Remains of regional glaciation from the last ice age. The freezing and thawing of these glaciers deposited layers of gravel that are now sedimentary rocks in the making.

Pierre Shale (73-70 million years old): Formed when Colorado was beneath the Western Interior Seaway. Composed primarily of shale with layering of sandstone and clay in certain regions. Natural and artificial fracturing (fracking) has produced hydrocarbons in Fremont and Boulder Counties and the Raton Basin, Colorado. Pierre Shale exists in our Park between the Visitor and Nature Center and Rattlesnake Ridge.

Niobrara Formation (88-70 million years old): Also formed beneath the Western Interior Seaway of the late Cretaceous at a time of deepening seas. Composed primarily of limestone and chalk sometimes separated by layers of shale. Holds excellent examples of marine fossils. Exposed in our Park along Niobrara Ridge and Rattlesnake Ridge.

The Benton Group (100-88 million years ago): The small valley between the rise of the Niobrara Formation and the towering red hogbacks of the Central Garden was formed by the easily eroded Benton Group. Consisting mostly of black shales and limestones, this formation also contains thin lenses of volcanic ash clays. These layers were created as the Cretaceous Seaway began.

Dakota Sandstone (112-100 million years old): Shallow marine formation from river deltas, beaches, etc. as the Cretaceous Seaway was forming. Composed primarily of sandstone with layers of shale and limestone in areas. Differs in composition from Dakota Group found in the Midwest (eastern side of Cretaceous Seaway). Exposed in the Park between Rattlesnake Ridge and Juniper Way Loop.

Morrison Formation (155-148 million years ago): Between White Rock and Juniper Loop Road are the purple to gray shales and pale gypsum of the Morrison Formation. A swampy lowland created this environment and the resulting sediments. This rock layer formed during the late Jurassic period.

Lykins Formation (260-250 million years ago): A pale, Triassic period formation visible east of the red South Gateway Rock from the sidewalk connecting the Gateway Trail to the Perkins Central Garden Trail. This thin, light-colored outcrop was formed in a tidal environment that produced a mixture of shale, dolomite, and limestone. Lykins contains fossilized algae and cyanobacteria called stromatolites. Geologists have found evidence of a mass extinction event in the Lykins Formation. Called The Great Dying (or the Permian-Triassic Extinction), this event wiped out over 90% of all life on earth and paved the way for the emergence of dinosaurs.

Lyons Formations (300-250 million years old): The local climate changed and this part of Colorado became a windswept desert filled with sand dunes. The formation is composed of three layers, two of which are visible in the Park (upper member and lower member). The red color is from iron becoming iron oxide (rust), which helps cement the grains together. The Lyons formations are the tallest rocks in the Park and include: North Gateway Rock, South Gateway Rock, White Rock and Gray Rock.

The Fountain Formation (320-300 million years old): Composed of sand, gravel, and mud that washed down from the Ancestral Rockies in alluvial fans. These sediments compacted and cemented into the conglomerates, sandstone, and mudstone (shale) of the Fountain Formation. This layer is over 4,500 feet thick. Formations in the western part of the Garden are made up of Fountain Formation: Balanced Rock, Three Graces and Sentinel Spires.

All the various sedimentary layers were gradually compacted and cemented into rock. Beginning about 70 million years ago these layers were broken and tilted upright. Erosion has exposed the ridges and carved out the valleys to what we see today.

A fault is essentially a crack in the earth's surface where movement occurs.

There is a fault system, or zone, at Garden of the Gods that has helped build our mountains and shaped our Park. The largest fault in Garden of the Gods is the Rampart Range Fault, which trends north, parallel to the foothills (the fault extends north and south beyond the 2 square mile area of the park). The Rampart Range Fault was caused by mountain building and indirectly by tectonic movements. Of the three main types of faults, the Rampart Range Fault is a high-angle reverse fault. Reverse faults are also called thrust faults. Igneous rocks, mostly Pikes Peak granite, are on the upthrown west side, while the Park's spectacular sedimentary rocks are on the downthrown or east side. Smaller faults connect or radiate east from this main fault throughout the park and have offset the exposed rock layers. The best example of our misaligned rocks is Gray Rock and White Rock. These rocks are part of the same rock layer (the upper member of the Lyons Formation) but have shifted so they are now offset. The best place to view these shifted layers are along the Perkins Central Garden Trail, either from JC Plaza, or from the Upper Loop section. Also, while driving through the Park, Juniper Way Loop road is extremely near or directly above the Rampart Range Fault on the west side of the Central Garden

Fossil evidence of dinosaurs and ancient marine animals has been found in the Park. The skull of a dinosaur named *Theiophytalia kerri*, a type of iguanodon, was found in the Garden of the Gods in 1878 by Colorado College Professor, James Kerr. The fossil dates to the early Cretaceous period and is the only evidence this species found anywhere in the world.

Supplemental Activities:

- Replicate ice wedging by conducting an "ice power" experiment: Have students fill plastic bottles with water. Seal the bottles and freeze them. What happens? The freezing water may crack the bottles. This shows what the freezing and thawing of water can do to the rocks in our Garden.
- Collect pictures to identify geological specimens from the Garden of the Gods.
- Create a geological timeline of the Pike's Peak region.
- Complete artwork or creative writing projects based on your experience in the Garden of the Gods.

Additional Resources:

Chronic, Malika and Felicia Williams. *Roadside Geology of Colorado.* Mountain Press Publishing, Missoula, MT; 2014

Johnson, Kirk R. and Robert G. Reynolds. *Ancient Denvers*. Denver Museum of Nature and Science, Denver, CO; 2006.

Johnson, Kirk R. and Richard K. Stucky. *Prehistoric Journey*. Denver Museum of Nature and Science, Denver, CO; 1995.

Noblett, Jeffrey B. *A Guide to the Geological History of the Pikes Peak Region.* Colorado College Department of Geology, Colorado Springs, CO; 2011.

Official Guide to Garden of the Gods and Rock Ledge Ranch Historic Site. 2012.

www.usgs.gov