GEOLOGIC TIME

Geologic Era	Geologic Period	Million Years Ago
Cenozoic	Quaternary	0 - 1.8
	Tertiary	1.8 - 65.5
Mesozoic	Cretaceous	65.5 - 145.5
	Jurassic	145.5 - 200
	Triassic	200 - 251
Paleozoic	Permian	251 - 299
	Carboniferous - Pennsylvanian	299 - 318
	Carboniferous - Mississippian	318 - 359
	Devonian	359 - 416
	Silurian	416 - 444
	Ordovician	444 - 488
	Cambrian	488 - 542
Precambrian back to Earth's Formation		542 – 4,650

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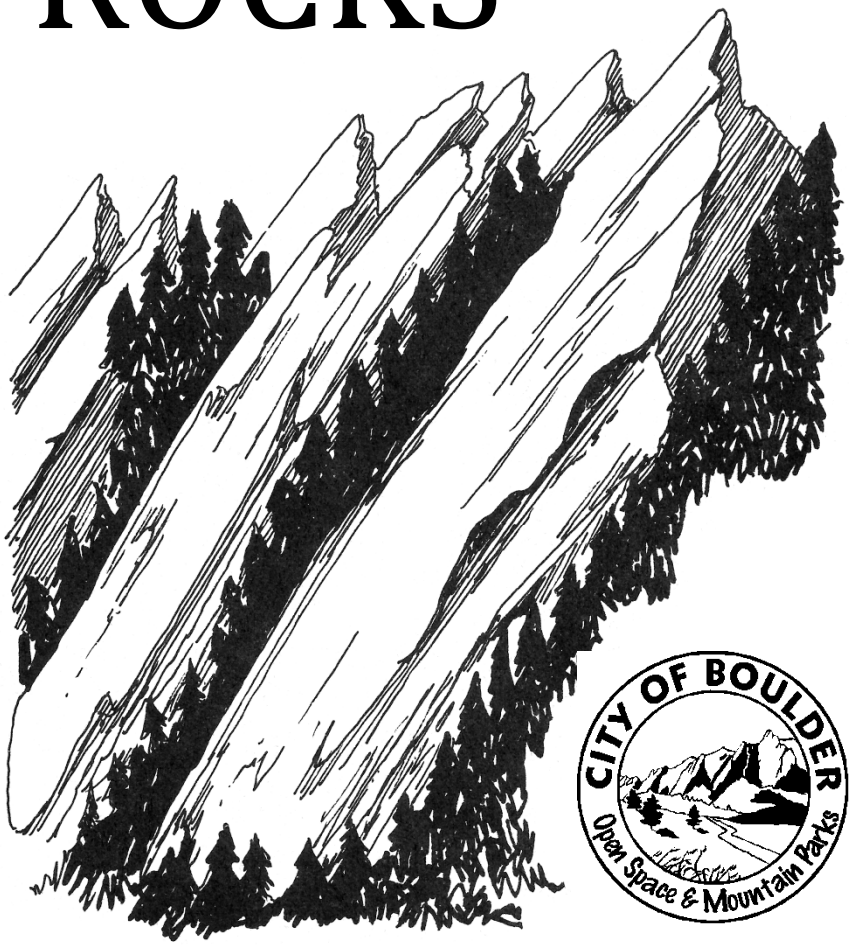
STORY IN THE ROCKS



Story In The Rocks

It would be difficult to visit Boulder and not be struck by the rock formations that shoot up to the west of town, forming a majestic backdrop that is unmistakable, even from a distance. These impressive rock slabs were nicknamed “the Flatirons” by early settlers, because their shape resembles an old-fashioned iron. Whether you are a technical climber or simply enjoying the view, the area provides an array of spectacular rock formations. It is hard to imagine Boulder without its iconic backdrop, but the rocks you see have had a long and varied history. How do we know this? The answers lie in the rocks themselves. Once you take the time to examine them, you can discover the clues that they reveal.

Boulder Creek Granodiorite And Pegmatites

On the summit of Flagstaff Mountain examine a piece of the salt-and-pepper colored rock. This Boulder Creek Granodiorite (similar to granite, but with more dark minerals) is an igneous rock - it was once in molten form. About 1.7 billion years ago it formed from magma buried miles beneath the earth’s surface. This liquid rock cooled very slowly, giving the white and black crystals plenty of time to grow large enough to be visible to the naked eye. Also look for the beautiful pegmatites (similar to granite, but coarse-grained) that cut across the granodiorite in bands and contain large pink, gray, and black crystals.

The Ancestral Rockies

Around 300 million years ago an ancient episode of mountain building uplifted the granodiorite and pegmatites, and created the Ancestral Rocky Mountain range just west of Boulder. The Ancestral Rocky Mountains are long gone, but might have been as high, or perhaps higher, than the current Rocky Mountains. In the uplift process, the miles of overlying rock were eroded away, exposing the granodiorite and pegmatites. It took more than a billion years for the processes of uplift and erosion to occur before the next rock unit that we see today, the Fountain Formation, was deposited.

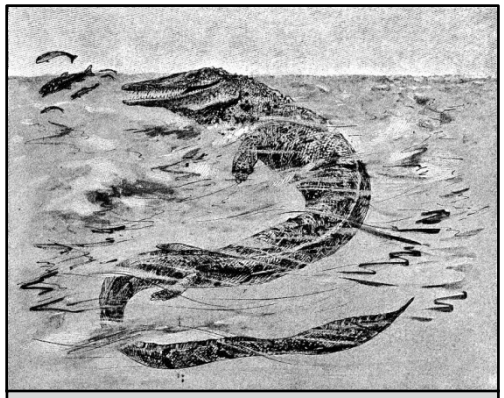
Also at this time, gold, silver, and other ore deposits formed when mineral-rich solutions intruded into fractures in the overlying rock. These intrusions created the Colorado Mineral Belt which extends from Boulder County to the La Plata Mountains in Southwestern Colorado. Much of Boulder’s pioneer history was shaped by the mining industry which harvested these minerals.

Glaciation And Erosion

Around 2.5 million years ago, global temperatures cooled, and the most recent ice age began to shape the rugged mountain landscape that is evident today. Although the great North American continental ice sheets did not extend into Colorado, valley glaciers developed in the mountains above 8,000 feet. As the glaciers advanced and retreated, they scoured the rock, carving U-shaped valleys in the high country. As the glaciers melted, running water carried large deposits of sand and gravel out onto the plains. Although most of the glaciers have melted, a few can still be seen in the Indian Peaks. The well-known Arapaho Glacier is owned by the city of Boulder and supplies water to the area.

As streams carried rock debris out of the mountains, coarse gravel and huge boulders covered the gently sloping surfaces along the mountain front. Over time, streams eroded and cut through these gravel- and boulder-covered surfaces, leaving a patchwork of higher, gravel-capped areas separated by lower erosion channels where streams cut through the soft older rock layers beneath. NCAR Mesa is one of the gravel-capped areas created by this erosion process, with Skunk Creek to the north and Bear Canyon Creek to the south. From the Boulder Valley Trail in north Boulder you can see the pyramid shape of Haystack Mountain. This is another example of an isolated mesa remnant. Thousands of years ago, Haystack Mountain was actually the southeastern tip of Table Mountain. A former channel of Lefthand Creek cut through this mesa, creating a valley that separated Haystack Mountain from Table Mountain. Haystack Mountain now stands on its own, an isolated hilltop that has resisted erosion.

Rocks are indeed good storytellers, and the Boulder geologic story is still in the making. We live on a restless, dynamic planet, and we can be certain that geologic processes and landscapes will continue to change.



A Ram-Nosed Mosasaur
from the Cretaceous Seaway

Finally, as the current Rocky Mountains (known as the Laramide Rockies) were uplifted, sediment eroding from the mountains began to fill the sea and push it eastward. Once again, Boulder became a beach-front locality. The beach sands from the retreating seaway can be seen in the Foxhills Sandstone, which forms White Rocks east of Boulder and is also exposed at Marshall Mesa. As the sea continued to retreat, sandstone and shale of the Laramie Formation accumulated in coastal swamps and in lakes and rivers. Plants in these swamps were compressed to form the coal deposits that were extensively mined in the town of Marshall during the last century. Southeast of Boulder along the Marshall Mesa trails, you can still see the abandoned tailings from past coal mining.

The Mighty Rockies

Between about 68 and 40 million years ago the present Laramide Rocky Mountains were uplifted. The 1.7 billion year old Boulder Creek Granodiorite and pegmatites that had been covered by younger rocks were uplifted once again, and the 10,000 feet of overlying sedimentary rock layers were tilted and eroded exposing the ancient igneous rocks. During this uplift the Fountain Formation of the Flatirons, the Dakota Ridge sandstone, and the other rock layers were tilted to their present position. Much like a drawbridge that is tilted upward to allow ships to pass, the sedimentary rock layers were tilted upward as the granodiorite rose beneath them. The western side of the drawbridge can be seen on the Rockies' Western Slope near Aspen in the Maroon Bells. The Maroon Formation is the western counterpart of Boulder's Fountain Formation.

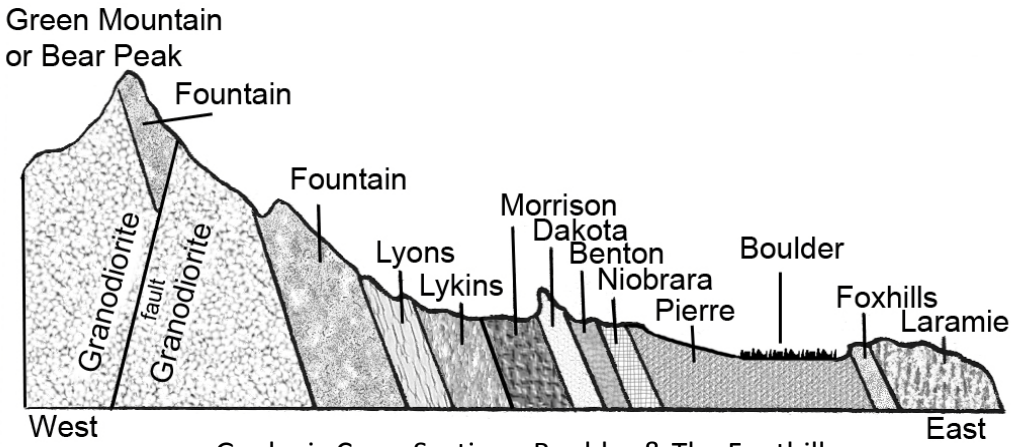
During the Laramide uplift molten magma from deep beneath the earth's surface forced its way into cracks in the overlying rock. An example of this is the prominent Valmont Dike, a nearly vertical igneous intrusion into the overlying Pierre Shale. Because igneous rock is harder than the surrounding sedimentary rock, it has resisted erosion and forms a visible landmark east of Boulder.

Here in Boulder there is no rock or sediment preserved from the **billion** years between the formation of the Boulder Creek Granodiorite and the deposition of the Fountain Formation. If Boulder were the only place that we could look, we would have no idea what the earth was like during that time. This gap in the geologic record, like a book with a group of chapters torn out, is called an unconformity.

The Fountain Formation

Sedimentary rock is formed from the broken fragments of older rock that accumulate on the earth's surface in rivers, lakes, and oceans. Once the granodiorite and pegmatites were exposed in the Ancestral Rockies, they too were eroded into smaller pieces, and rivers deposited this gravel, coarse sand, and mud along the mountain front. This sand and gravel became a sedimentary rock unit called the Fountain Formation, the rock of Boulder's Flatirons.

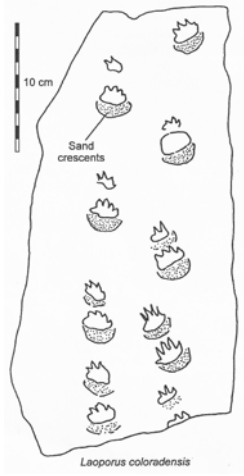
A hike to Royal Arch will let you stand beneath the Fountain Formation, as the Arch is formed from this ancient stone. The 1st/2nd and 2nd/3rd Flatiron Trails will take you up to the Flatirons to see the Fountain Formation sandstone and conglomerate – look for pebbles and crystals from the ancient granodiorite embedded in the rock. Farther south, the Fountain Formation can be seen at Eldorado Springs State Park and Red Rocks Amphitheater.



Geologic Cross Section - Boulder & The Foothills

Lyons Sandstone

Over time the Ancestral Rocky Mountains were more deeply eroded and supplied quartz sand to the rivers. Approximately 270 million years ago a wide, shallow sea covered areas to the east, and Boulder's environment was desert-like with large wind-blown sand dunes. Mammal-like reptiles, ancestors to modern mammals, scuttled across these ancient sand dunes leaving their footprints. When the dunes cemented with quartz to form the Lyons Sandstone (named for the city of Lyons, Colorado), some of these tracks were frozen in time. You can see a fossil of these ancient tracks in the Chautauqua Ranger Cottage.



Lyons Sandstone is valued for its salmon color, hardness, and tendency to break into smooth, flat slabs. It has been extensively quarried to construct numerous buildings in Boulder, including many at the University of Colorado. Scars from old sandstone quarries can be seen on Mount Sanitas, on the Woods Quarry Trail, and in Skunk Canyon.

The Lykins And Sundance Formations

Around 250 million years ago erosion reduced the Ancestral Rockies to lowlands along the margin of the shallow sea. Extensive deposits of mud covered the ancient dunes of the Lyons Sandstone. This mud hardened to form the bright red shale of the Lykins Formation. Stromatolites, limestone fossils of slimy layered mounds of photosynthetic cyanobacteria (blue-green algae), formed in the salty waters. On the Mallory Cave Trail, just west of the Mesa Trail, there is a large grey rock by the side of the trail. Close inspection will reveal the thin, onion-like layers of a stromatolite.

Later, the sea retreated and wind-sculpted sand dunes formed the sandstone of the Sundance Formation. This white, cross-bedded sandstone was not widely deposited, but it can be seen along the Kiln Trail in north Boulder. Cross-beds appear as crisscross patterns in the sandstone layers. They are deposited by moving currents of wind or water.

The Morrison Formation

The deposition of the Morrison Formation marks the complete erosion and burial of the Ancestral Rocky Mountains. About 150 million years ago, during the Jurassic period, rivers draining highlands in what is now Utah flowed across Colorado, depositing sand and mud that accumulated along rivers and lakes. The soft rocks of the Morrison Formation often have a characteristic green, purple, or chocolate color, and are famous for dinosaur fossils. Although not commonly seen in the Boulder area, dinosaur bones are abundant elsewhere in the Morrison Formation, particularly near the town of Morrison, at Dinosaur Ridge in Golden, and in Dinosaur National Monument.

The Western Interior Seaway And Dakota Sandstone

Around 100 million years ago, a large shallow sea spread from the Gulf of Mexico to the Arctic Ocean. The Dakota Sandstone records the shoreline and beach deposits along the edge of this spreading sea. Iguanodons, large herbivorous dinosaurs, walked along this shoreline. Look in the Chautauqua Ranger Cottage for their fossilized footprints.

Dakota Sandstone forms the first ridge west of Boulder, often called the Hogback. It can be traced all the way from Colorado Springs to the Wyoming border. Besides being a major source of groundwater, Dakota Sandstone has been extensively mined for fire clay and contains a third of the state's oil and gas deposits in the Denver Basin. You can hike over Dakota Ridge on the NCAR Trail, west of the National Center for Atmospheric Research (NCAR), the Red Rocks trails north of Canyon Blvd., and the Dakota Ridge Trail in north Boulder.

The Western Interior Seaway, or the Cretaceous Seaway, rose and submerged the Boulder area for millions of years, depositing an additional 9,000 feet of sediment that became the Benton, Niobrara, and Pierre Formations. These soft sedimentary rocks contain fossils from the marine organisms that lived in this area when Boulder was under water.