Interpretive Outline of Boulder County Geology

4.6 BYA (billion years ago): Earth was formed.

1.7 BYA: The **Colorado Basement Province** adhered itself to the much older core of North America during **Precambrian** times, in repeated collisions of **continental accretion**, about where Wyoming is today. Major mountain building associated with the continental collisions buried and deformed existing rock into metamorphic basement rocks (gneiss and schist). As accretion continued, igneous plutons (intrusive bodies of magma that cool and form rock deep underground) intruded the basement rocks several times during the Precambrian. **Boulder Creek Granodiorite** (1.7 BYA), the **Silver Plume Granite** of Long's Peak (1.4 BYA), and **Pike's Peak Granite** (1 BYA) were intruded during this period. Today, more than 85% of Colorado's basement rocks are buried beneath younger rocks. They are exposed only where erosion has uncovered them, such as along the crest of mountain ranges (e.g. Front Range) and in some deep canyons (e.g. Boulder Canyon).

Boulder Creek Granodiorite, one of the oldest rocks in the Boulder area, formed 10-15 miles below the earth's surface. Named for its exposures along Boulder Creek, Boulder Creek Granodiorite is also exposed on Flagstaff Mountain, and on the Walker Ranch and Bald Mountain Boulder County Parks and Open Space properties.

1.4 Billion Year Unconformity (missing geologic time) between **Boulder Creek Granodiorite** (1.7 BYA) and **Fountain Formation** (300 MYA).

- Unconformity due to nondeposition and/or erosion between Precambrian and Pennsylvanian time.
- From sandstones, shales, and limestones preserved in other areas of Colorado (e.g. near Colorado Springs), we know that periods of uplift and erosion occurred, and that shallow seas and low-lying landscapes covered much of Colorado during the time interval that is missing in the Boulder area.
- "Contact Corner", a switchback-turn on Flagstaff Mountain road, is a good place to observe the unconformity and see the Fountain Formation overlying the Boulder Creek Granodiorite.

300 MYA: The shallow seas ebbed in Colorado, as the **North American Plate** collided and bonded with other crustal plates to begin the formation of one giant continent called **Pangea**. These collisions impacted the Colorado area by causing the **Ancestral Rockies** to uplift **(Colorado Orogeny)**. Although the Ancestral Rockies had nothing to do with the "modern" Rocky Mountains, the **Ancestral Front Range** was almost parallel to, and only about 20-30 miles further west of today's Front Range. As the Ancestral Rockies eroded, sediments were deposited in alluvial fans; the sediments were compacted and cemented together to form the **Fountain Formation**. The Fountain Formation was named for exposures along Fountain Creek near Manitou Springs, and is also exposed in the **Flatirons** in Boulder, the Red Rocks Amphitheater west of Denver, and the Garden of the Gods near Colorado Springs. Tracks of small amphibians and early reptiles are fossilized in the rocks of the Fountain Formation.

300 MYA - 225 MYA: Erosion of the Ancestral Rockies continued, as a shallow sea advanced westward toward the mountains. Fields of coastal sand dunes developed along the eastern flank of the Ancestral Front Range. Some of these dune areas are preserved in the **Lyons Sandstone**, which is named for exposures near the town of Lyons. This buff to salmon-colored sandstone has been extensively quarried for building stone (e.g. CU-Boulder Campus).

Between the Ancestral Rockies (300 MYA) and the Laramide Orogeny (65 MYA):

- The Ancestral Rockies were eroded down nearly to sea level and buried in their own debris.

190-135 MYA: During the **Jurassic Period**, the shallow sea retreated to the east. The lowland climate became more humid, lush vegetation developed, and dinosaurs flourished. Sediments deposited in swamps, lakes, and floodplains formed the colorful sandstones, siltstones, and shales of the **Morrison Formation**. Named for exposures near Morrison, Colorado, the Morrison Formation is known for dinosaur fossils at many sites around Colorado, including **Dinosaur Ridge** near the town of Morrison.

135-65 MYA: The **Cretaceous Period** was dominated by the **Western Interior Cretaceous Seaway**, a widespread but relatively shallow sea that covered the interior of the western U.S. and Canada, including Colorado. At its maximum extent, it connected cold ocean waters from northern arctic areas with warm ocean waters from today's Gulf of Mexico. The seaway was as much as 1,000 miles across (west-central Utah to eastern Iowa), and deposited nearly 9,000 feet of sediment that hardened into shale, sandstone and limestone. In Boulder, the oldest Cretaceous rocks are part of the **Dakota Formation**. The erosion-resistant Dakota Formation sandstones form the **Dakota Hogback** that frames the skyline in north Boulder. The entire Boulder Valley is underlain by over a mile of sedimentary rock known as **Pierre Shale,** a soft, easily eroded rock that typically forms valleys. Fossils of animals that lived in the ancient sea can still be found today.

- Dinosaurs, and 75% of all plant and animal species, became extinct by the end of the Cretaceous Period, about **65 MYA**. A massive asteroid or comet impact crater dating to 65 MYA was discovered in the early 1990s, offshore of and beneath the Yucatan Peninsula near Chicxulub, Mexico. Enormous amounts of dust, ash, and other materials were ejected into the atmosphere from the impact, significantly reducing photosynthesis and plant growth and causing a prolonged "impact winter" on Earth, leading to the extinctions. The Morrison Formation contains dinosaur fossils at many sites around Colorado, including **Dinosaur Ridge**, west of Denver near the town of Morrison.

65 MYA: When the shallow seas made their final retreat about 70 million years ago, sediments as thick as 2 miles deep covered the eroded basement core of the Ancestral Rocky Mountains. The **Laramide Orogeny**, which began about 65 MYA, uplifted the **Laramide Rockies** in about the same position as today's Rockies. This uplift was **probably** triggered by **continental accretion** and **subduction** on the west coast of North America, although this is not known for certain.

The uplift of the Rockies so far inland from the **North American-Pacific plate boundary** is a geologic anomaly. Today, many scientists believe that a shallower than normal subduction angle of the Pacific oceanic plate beneath the North American continental plate caused the uplift of the Rockies so far inland from the plate boundary.

The Laramide uplifting tilted and fractured the sedimentary **Fountain Formation,** and subsequent erosion exposed the **Flatirons** in Boulder that we see today. As the sedimentary rocks were uplifted and eroded away, the resistant basement rocks (e.g. **Boulder Creek Granodiorite**) emerged at the summits. The corresponding western-tilting portion of the Fountain Formation is exposed near Aspen and is known as the **Maroon Formation**.

The **Colorado Mineral Belt** was also created during the Laramide mountain-building period, as mineral-rich solutions were injected into fractures of older rock, including the Boulder Creek Granodiorite. These solutions hardened to form veins of precious metals, which have been mined extensively in Boulder County and throughout the mountains of Colorado. **Gold, silver, lead, zinc, and tungsten** have all been part of Colorado's colorful mining history. The Colorado Mineral Belt extends in a Southwest-Northeast belt from the **San Juan Mountains to Boulder County**.

40 MYA: The **Laramide Rockies** eroded away to low rolling hills and plains, and the basins filled with eroded debris.

9 MYA: The most recent episode of mountain-building formed the **present-day Rocky Mountains**, when the western U.S. from the Sierra Nevada Range in California to the Colorado Front Range was uplifted by 6,000 feet or more. The **Great Plains** and the **Colorado Plateau** were also uplifted to modern-day elevations during this period. It was during this time that Colorado's fourteeners were born. Deep valleys and canyons were cut as erosion was accelerated by the regional uplift (e.g. Black Canyon of the Gunnison River).

1.5 MYA: In the **Pleistocene**, as the climate cooled and precipitation increased, **valley glaciers** formed in the mountains west of Boulder **above 8,000 feet**. (North American ice sheets did not extend into Colorado) The glaciers moved downslope, carving out glacial cirques, jagged peaks, and U-shaped valleys. The last major glaciation in Colorado began to recede about **10,000 years ago**. As the valley glaciers began to melt, the swollen streams transported large amounts of sand and gravel to the plains. The streams cut wide swaths in the soft sediment and erosional surfaces were leveled, creating the flattened mesa tops that flank the foothills. Table Mountain and Haystack Mountain, located between Boulder and Lyons, are examples of isolated mesa remnants that have resisted further erosion due to deposits of erosion-resistant cobbles and gravels.

Erosion continues to be the dominant geologic force altering the Boulder-area landscape today. Present-day sedimentary deposits could potentially be buried under future deposits and become lithified to form new rock units.

Anthropocene (present time): To the west of the Boulder County and the Colorado Front Range, **isolated lava flows** continued until quite recently. The most recent lava flow, near Dotsero, Colorado, occurred about **4,000 years ago,** and is visible from Interstate Highway 70.

Sources:

A Brief Summary of Boulder Geology, Volunteer Naturalist & Geologist Barb EchoHawk (2006)

Ancient Denvers: Scenes from the Past 300 Million Years of the Colorado Front Range, Denver Museum of Nature & Science (2002)

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