

Virtual Field Trip
of the
Geological History of Summit
County

a discussion with
Joe Newhart

Virtual Field Trip with Nine Stops in the Summit County Area

First Stop will be at Officers Gulch.

Second Stop will be at the Eagle River Canyon.

Third Stop will be at I-70 Near Vail Pass.

Fourth Stop will be at Elliot Ridge in the Gore Range

Fifth Stop will be at Dillon Dam Road.

Sixth Stop will be at Green Mountain Reservoir.

Seventh Stop will be at Lower Cataract Lake.

Eighth Stop will be at Sapphire Point.

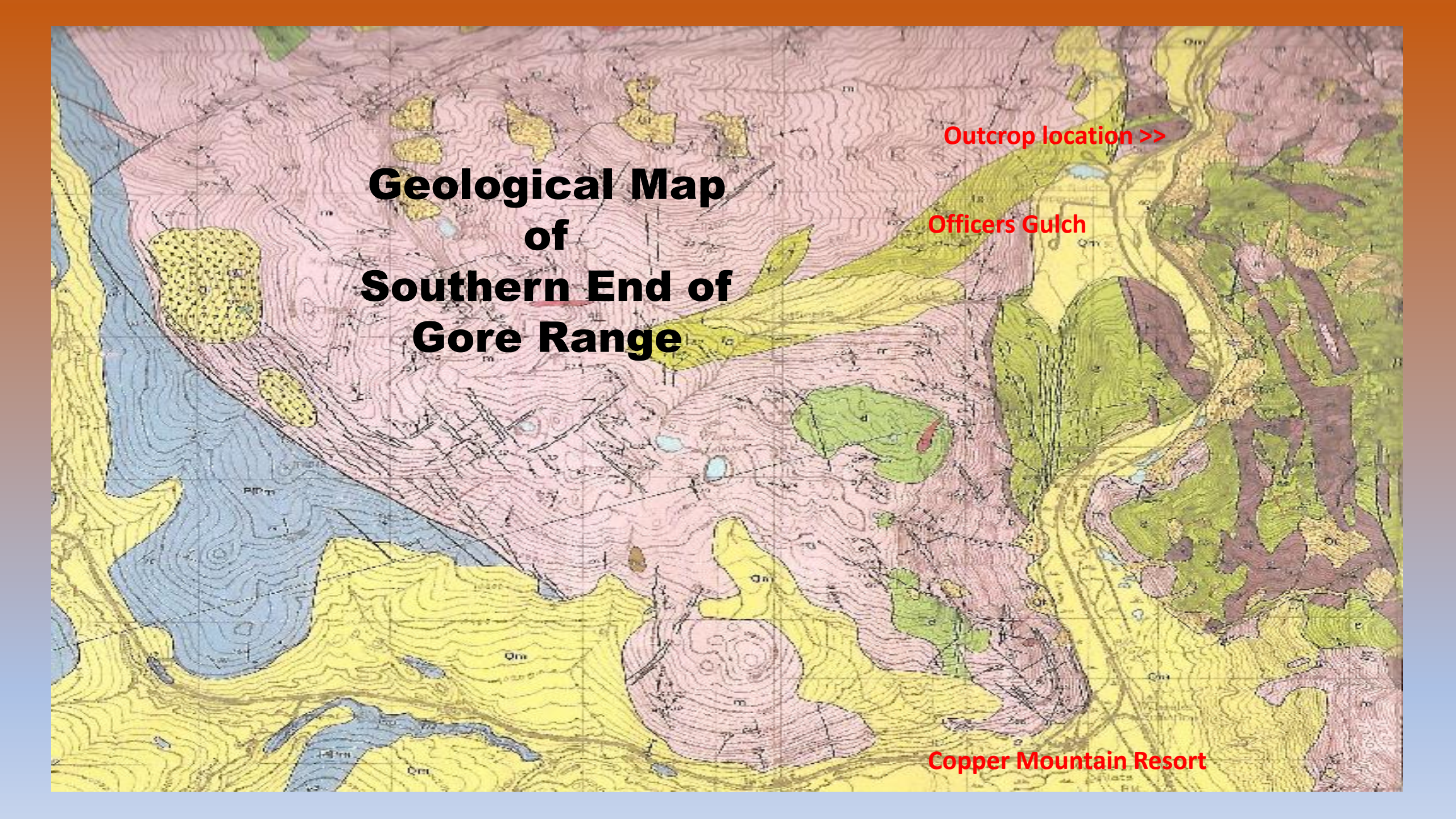
Ninth Stop will be at Dillon Overlook.

Stop One

Proterozoic Metamorphic Rocks form the Core of Ten-Mile and Gore Ranges and top of Williams Fork Range



- **Photo taken in Officer Gulch along old highway 6 of gneisses, coarsely-banded metamorphic rocks.**
- **These rocks were originally deposited as sedimentary rocks along the margin of the proto North American continent.**
- **How did the sedimentary rocks become metamorphic rocks and how did they get here?**



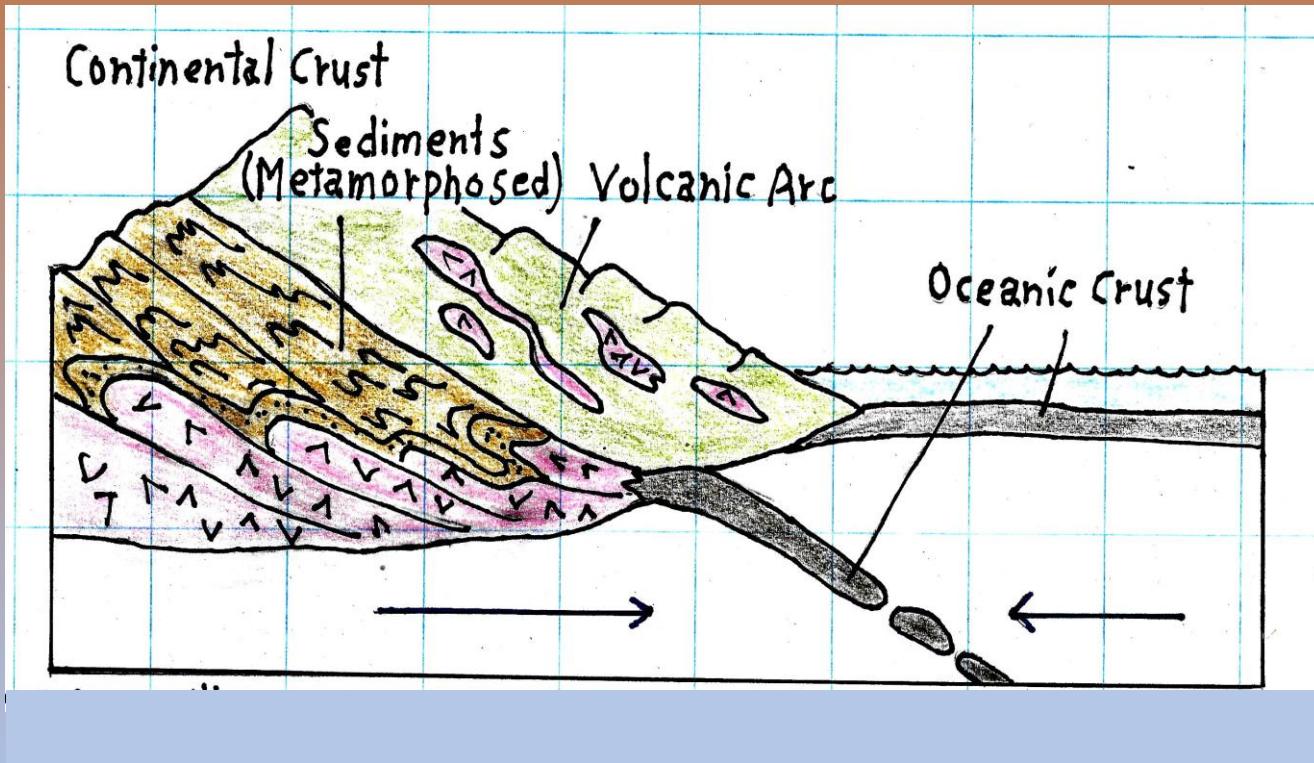
**Geological Map
of
Southern End of
Gore Range**

Outcrop location >>

Officers Gulch

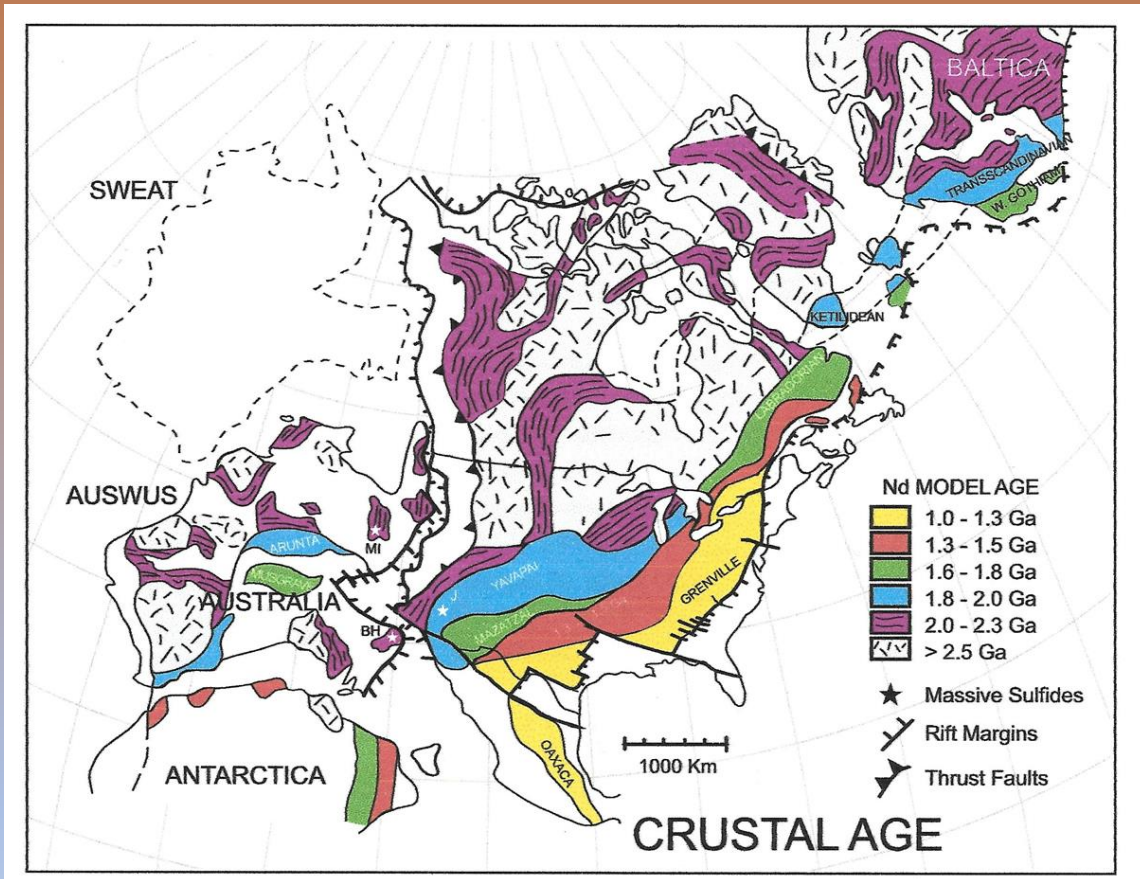
Copper Mountain Resort

Collision



- **1800-1700 million years ago, collision between volcanic arc and Wyoming continental block (Yavapai Orogeny) formed tall mountain range. Deep burial and heat metamorphosed the sediments. Subsequent erosion has exposed the roots of this range in The Rocky Mt. uplifts.**
- **The gneisses in the Gore Range have been radiometrically age dated at 1758-1693 mya.**
- **The granite in the Gore range has been dated at 1700 mya.**

Growth of North America and Formation of Supercontinent Called Rodinia



- The Vavapai- age terranes are indicated in blue in the illustration.
- Younger terranes accreted to North America between 1.8 and 1.0 billion years ago are indicated in green, brown and yellow.
- The other continental masses had combined into the Rodinia supercontinent by around 1.0 billion years ago.

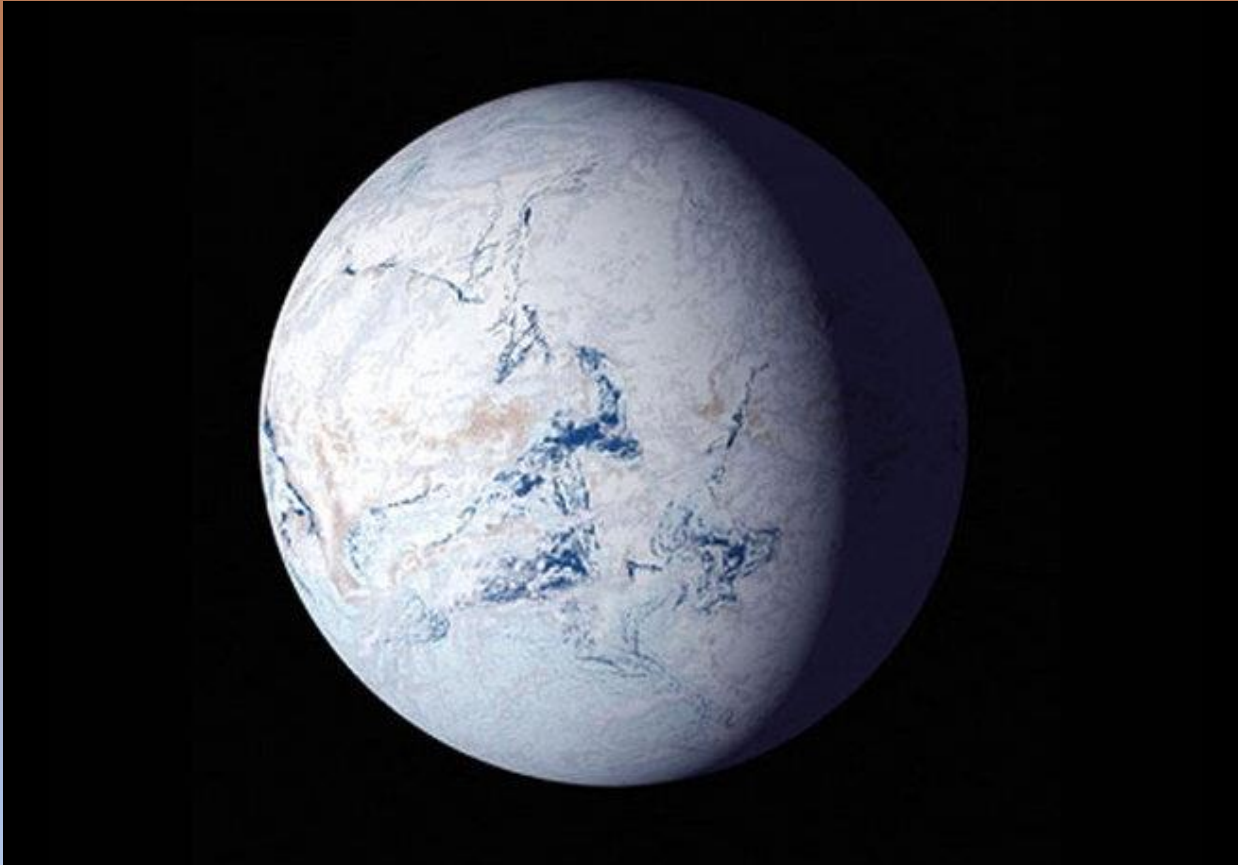
Missing 900 Million Years in the Rock Record in Most of Colorado and the World



- **With the accretion of mountain ranges to the margin of North America between 1.8 and 1.0 billion years ago, it would be expected that sedimentary rocks from the erosion of the those ranges would be preserved on the continental mass.**
- **However there are very few places in the world where this time frame is preserved in the rock record. What happened?**

Snowball Earth

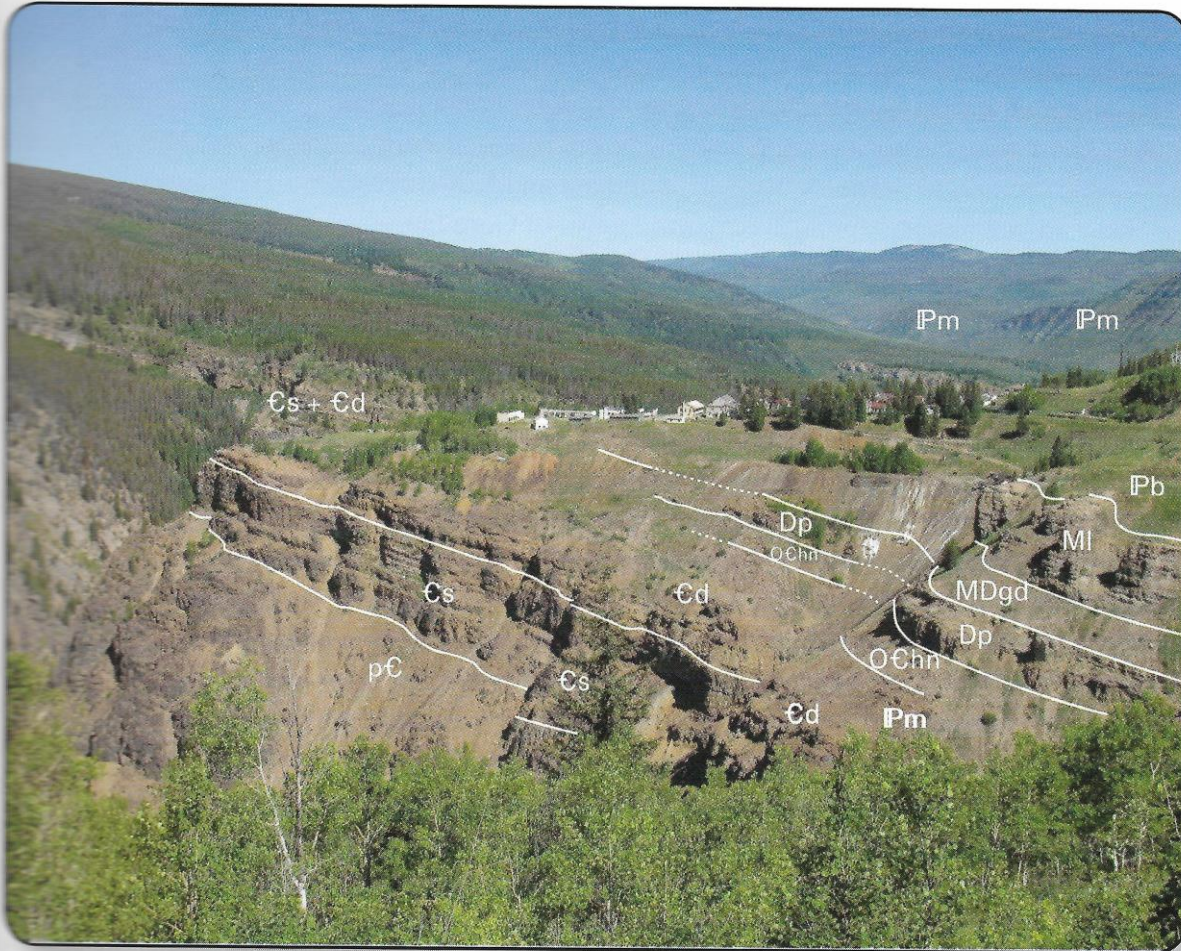
Cryogenian Period (720- 635 mya)



- **Recent geological studies indicate that the planet was completely covered or almost completely covered with glaciers and ice during the Late Proterozoic Era. This phase of Earth history has been called Snowball Earth.**
- **Two major periods of glaciation occurred in this period resulting in glacial scouring of the continents, which eroded most of the Proterozoic sedimentary rocks.**

Stop Two

Lower and Middle Paleozoic Rocks of Colorado



- **Lower and Middle Paleozoic rocks are poorly exposed in Summit County.**
- **Good exposures exist in Eagle River Canyon along U.S. Highway 24 and in Horseshoe Gulch southwest of Alma.**
- **Rocks consist mainly of sandstones and carbonate rocks deposited on the western platform of the North American craton.**
- **Note the Great Unconformity.**

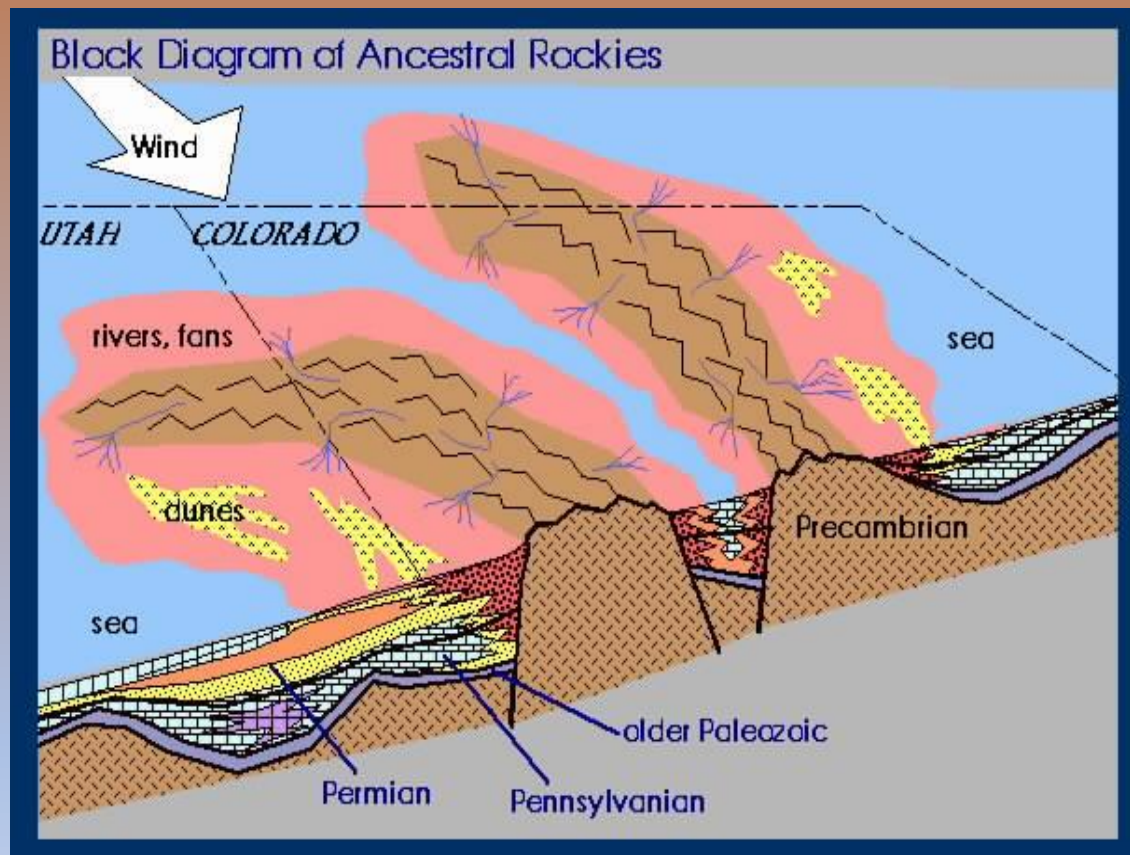
Stop Three

Red Sandstones of the Vail Pass/Shrine Pass Area



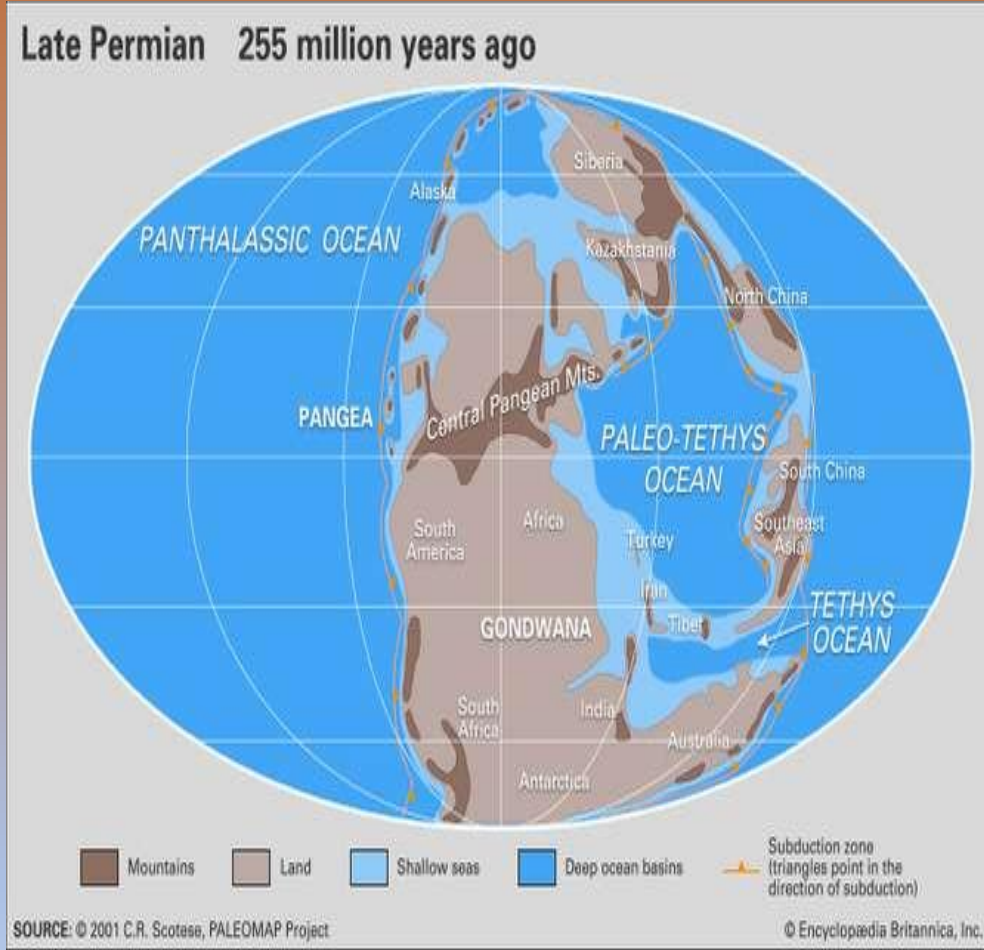
- **Photo of Middle Pennsylvanian to Lower Permian Maroon Formation taken along I-70 between Vail Pass and East Vail.**
- **Maroon Formation consists mainly of non-marine sandstones and shales deposited in the Eagle Trough.**
- **The Minturn Formation is mainly grey in color.**
- **The Maroon and Minturn Formations are over 7000 feet thick in the area, and are well exposed in the Copper Mountain and Vail areas.**
- **Why the change from platform carbonate rocks to red sandstones and what does it mean?**

Ancestral Rocky Mountains of Colorado Illustrating Frontrangia and Uncompahgria



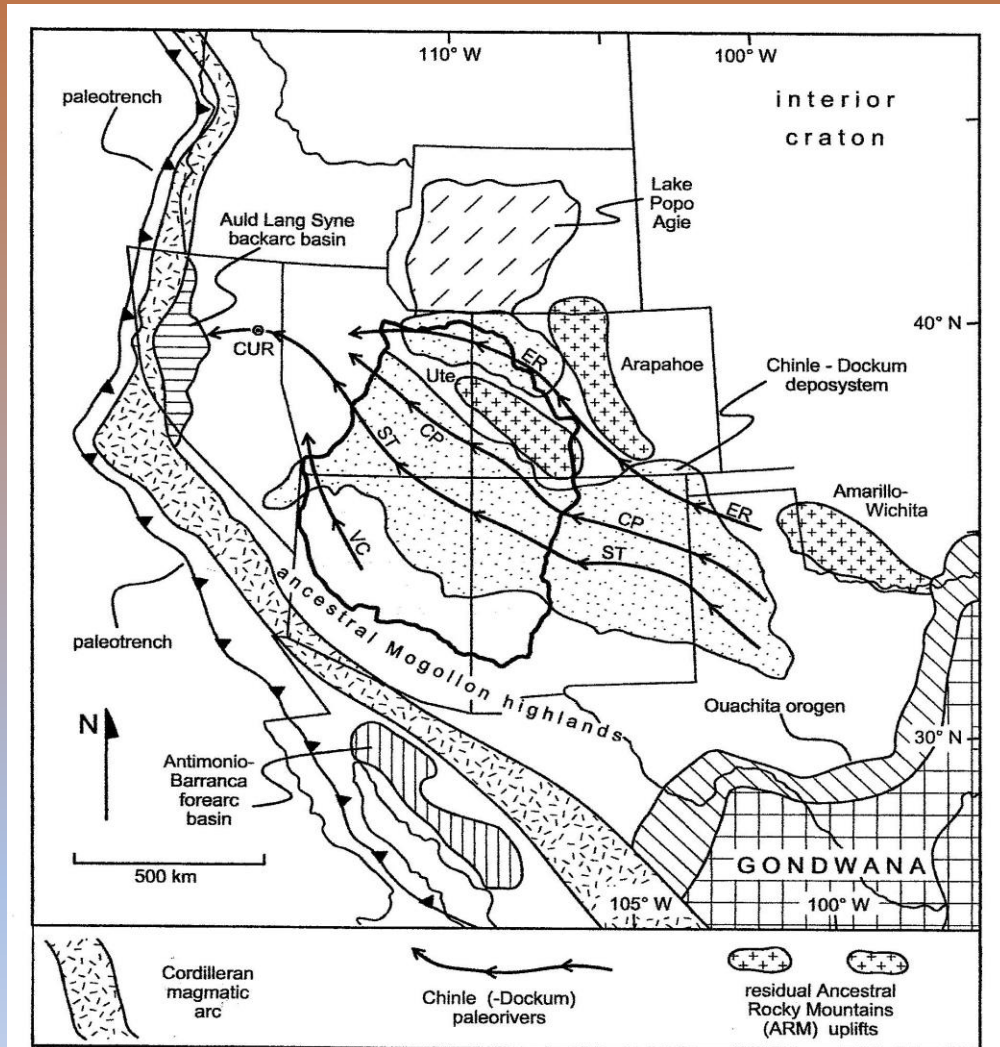
- **Basinal areas are the Central Colorado Trough and the Paradox Basin.**
- **Central Colorado trough was filled mainly by non-marine sediments shed from Frontrangia.**
- **Colorado was near the equator during the Pennsylvanian and Permian time.**
- **However the changing sea level resulted in deposition of thin limestones and evaporites in the trough**

Formation of the Pangea Supercontinent



- **Continuing collision of Gondwana (South America-Africa) with North America-Europe formed a new supercontinent.**
- **The suturing formed the Central Pangean Mountains from the continent-continent collision.**
- **These are the Ouachita and Appalachian Mountains of North America.**

Triassic Rocks of Summit County



- **During the Triassic, a magmatic arc (like the Andes of Today) was forming along the proto-Pacific margin of the North American part of Pangea.**
- **In the Colorado area, the Ancestral Rocky Mountain uplifts were still predominant.**
- **The interior of the continent was fairly arid and predominant deposition was continental aeolian and river deposits. These are the red Triassic sandstones and mudstones that area seen in the Moab area of Utah.**
- **Note the location of the westward flowing Paleo Eagle River.**

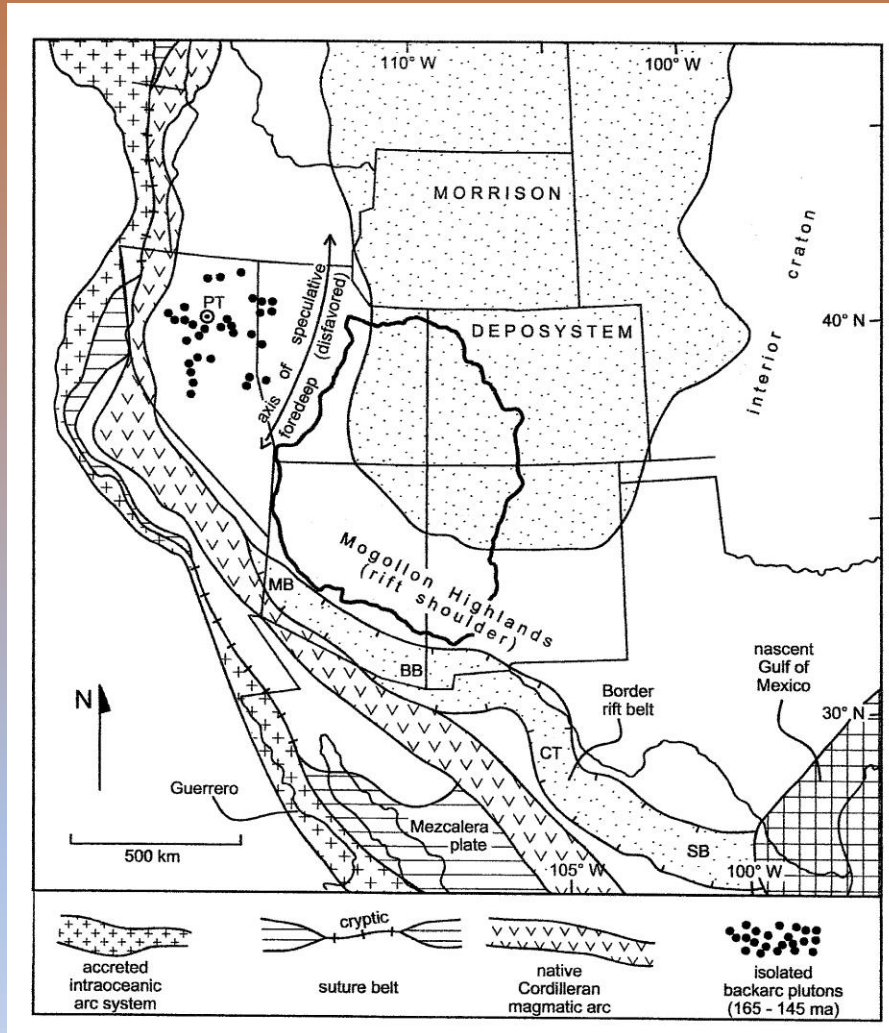
Stop Four

Triassic Rocks of Summit County



- **USGS geologist next to outcrop of Garta Sandstone Member of the Chinle Formation. Garta consists of about 20 feet of cross-bedded sandstones deposited in the paleo Eagle River drainage.**
- **The USGS has, also, mapped some Chinle Formation at the base of the Dillon Dam.**

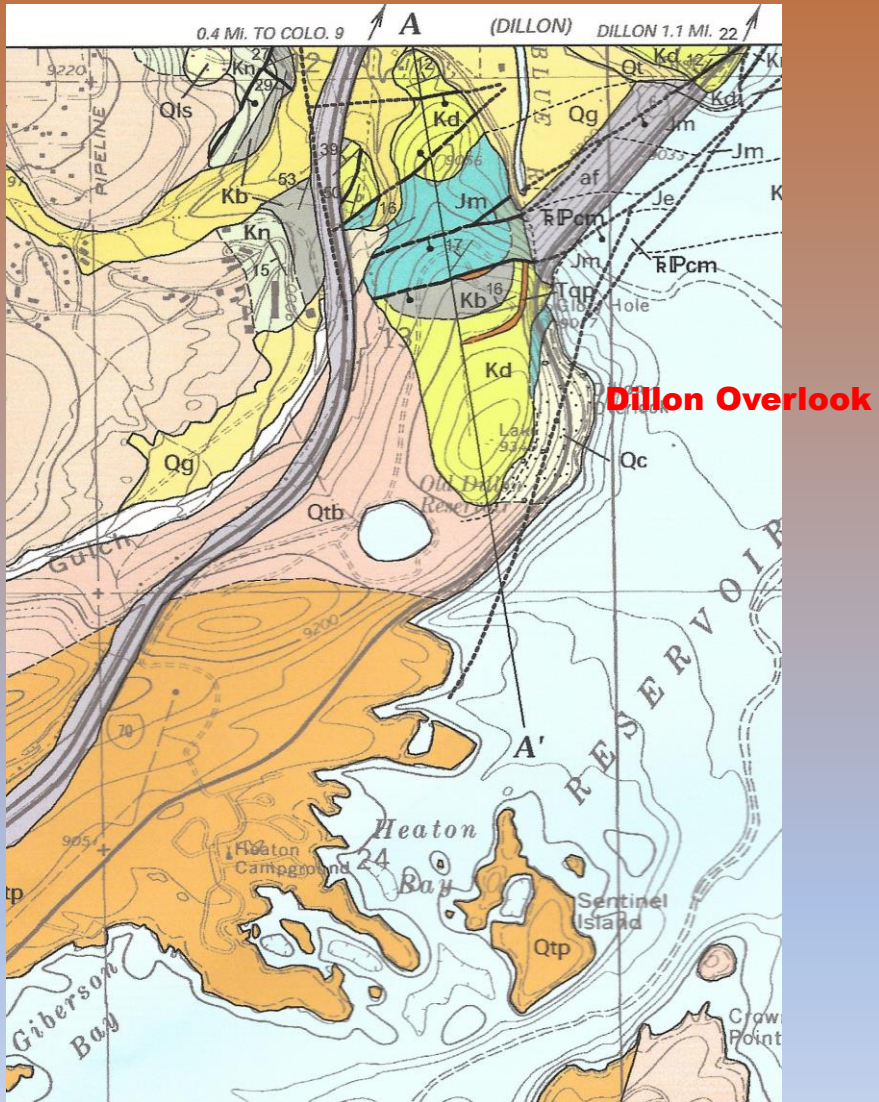
Jurassic Rocks of Summit County



- **The regional setting during the Jurassic in Colorado was an interior drainage system of continental and fluvial deposition.**
- **The Morrison deposystem was named after the outcrops found outside the town of Morrison, Colorado in the Front Range near Denver.**

Stop Five

Portion of Geological Map of Frisco Quadrangle



- **Note the location of I-70 and Dillon Dam Road.**
- **Stop two is at Dillon Overlook parking area at west end of Dillon Dam.**

Stop Five

Jurassic Rocks of Summit County



- **Photo shows the outcrop of Morrison Formation along the Dillon Dam Road at the western end of the dam.**
- **The Jurassic Morrison Formation in Summit County consists of rocks deposited by slow moving rivers in streams and mud flats and in fresh water lakes.**
- **At the Dillon Dam outcrop, the Morrison Formation is mostly light-gray, greenish gray and maroon claystone lake deposits.**
- **The greenish color is due to iron minerals in the ferrous state as a result of deposition in a reducing environment in the lake bed.**

Western Interior Seaway



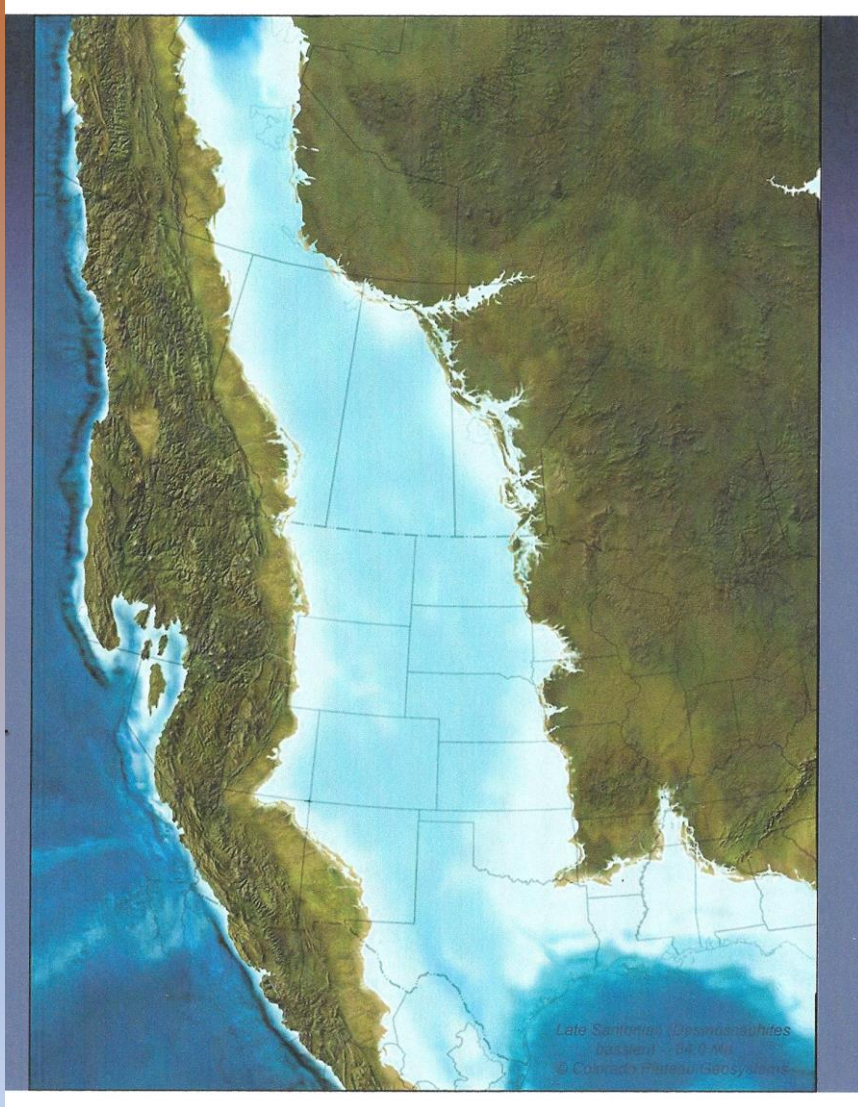
- **Rising sea level in the Cretaceous coupled with the foreland basin formation resulted in a seaway splitting the North American continent.**
- **The deposition of the near shore marine Dakota sandstone is the first manifestation of the seaway in Colorado.**
- **The massive Dakota sandstone lies above the Morrison Formation at the Dillon Dam outcrop.**

Western Interior Seaway



- **Paleogeographic map of western North America during Dakota sandstone deposition – 99 mya.**
- **From Paleogeography and Paleotectonic of the Western Interior Seaway, Jurassic-Cretaceous of North America, R. C. Blakely, 2014.**

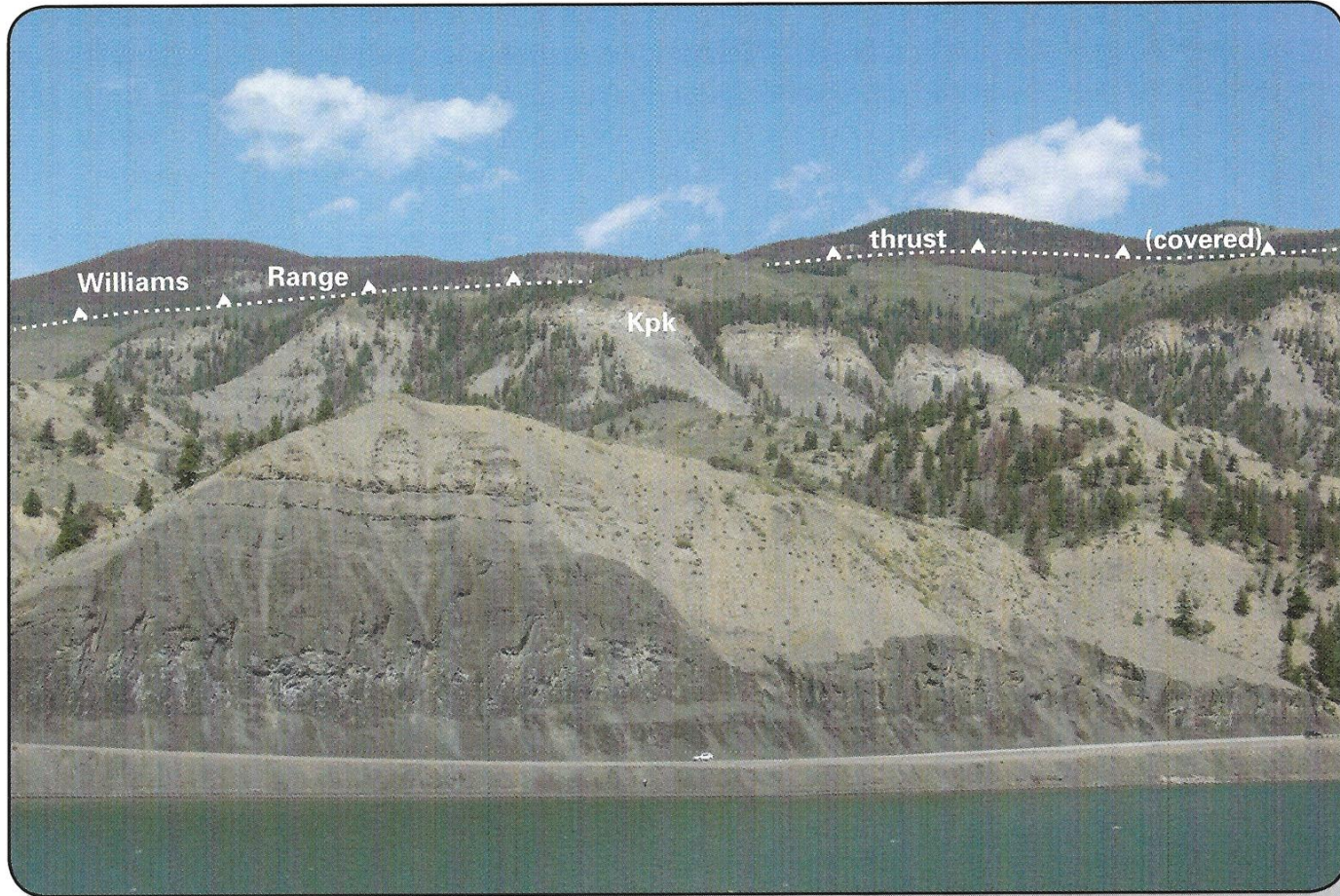
Western Interior Seaway



- **Paleogeographic map during Pierre shale time – 84 mya.**
- **Maximum extent of the seaway.**

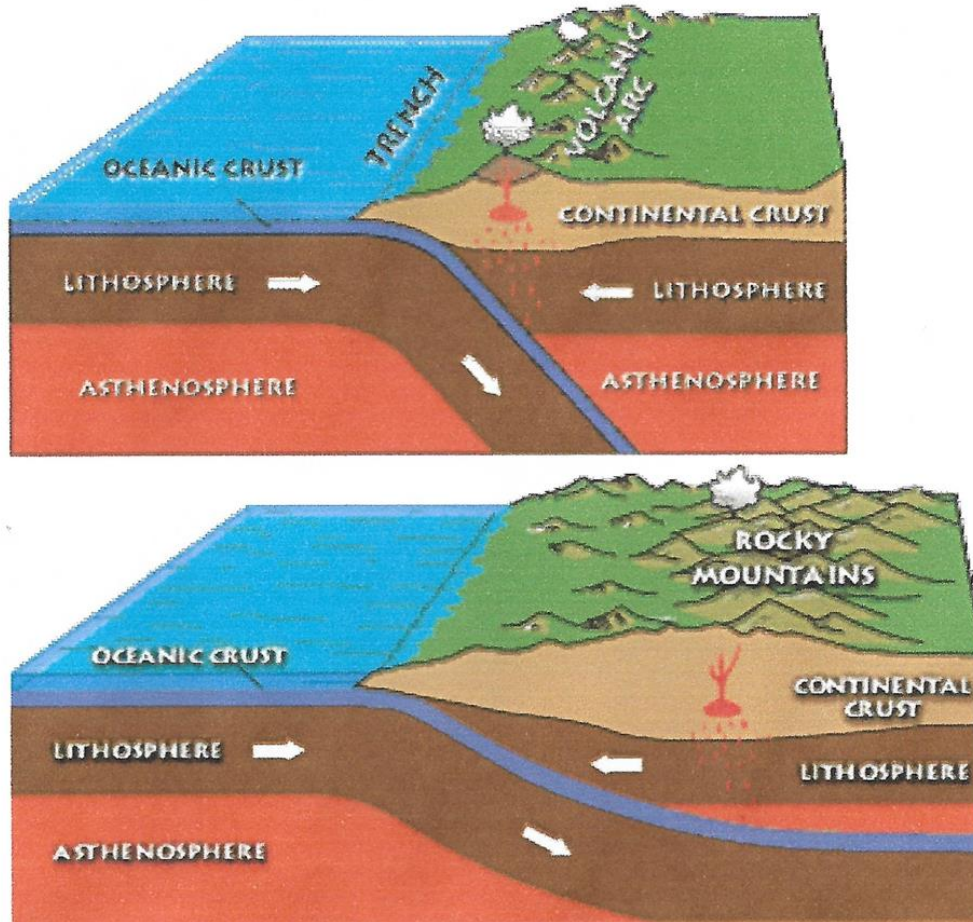
Stop Six

Western Interior Seaway



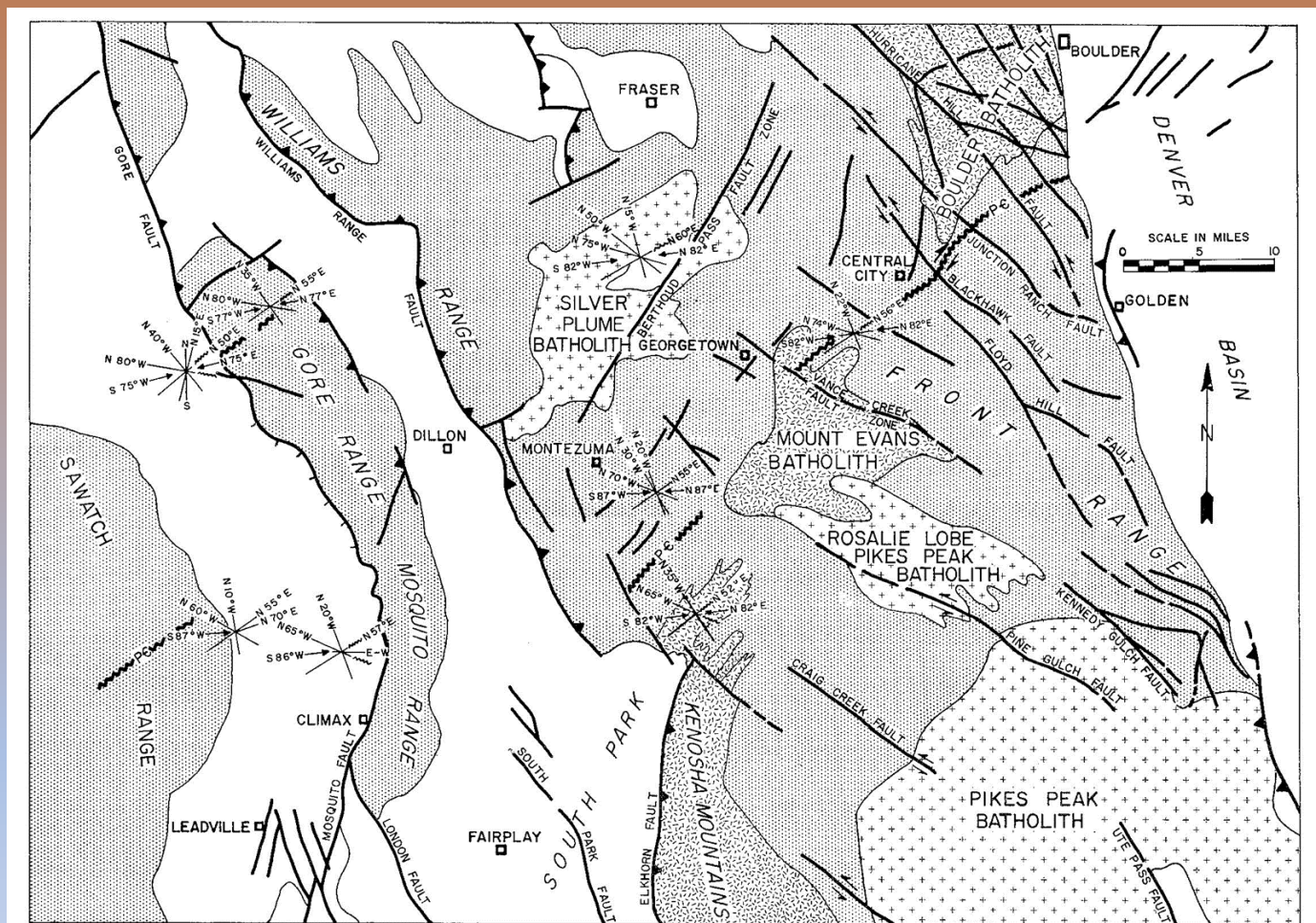
- **Photo of Pierre shale outcrop along Green Mountain Reservoir in northwestern Summit County.**
- **Note the vehicle on Highway 9 for scale.**
- **Pierre shales is dark-gray to black marine mudstone. May have been 8500 feet thick with upper 3300 feet removed by erosion.**

Laramide Orogeny – Rocky Mountains Uplift



- **Change in subduction to flat subduction (80-75 mya) as a result of subduction of thicker/hotter and more buoyant oceanic crust.**
- **Flattening subduction pushed the area of deformation eastward into the continent forming the Rocky Mountain uplifts.**

Rocky Mountains Uplifts in Colorado 66-45mya



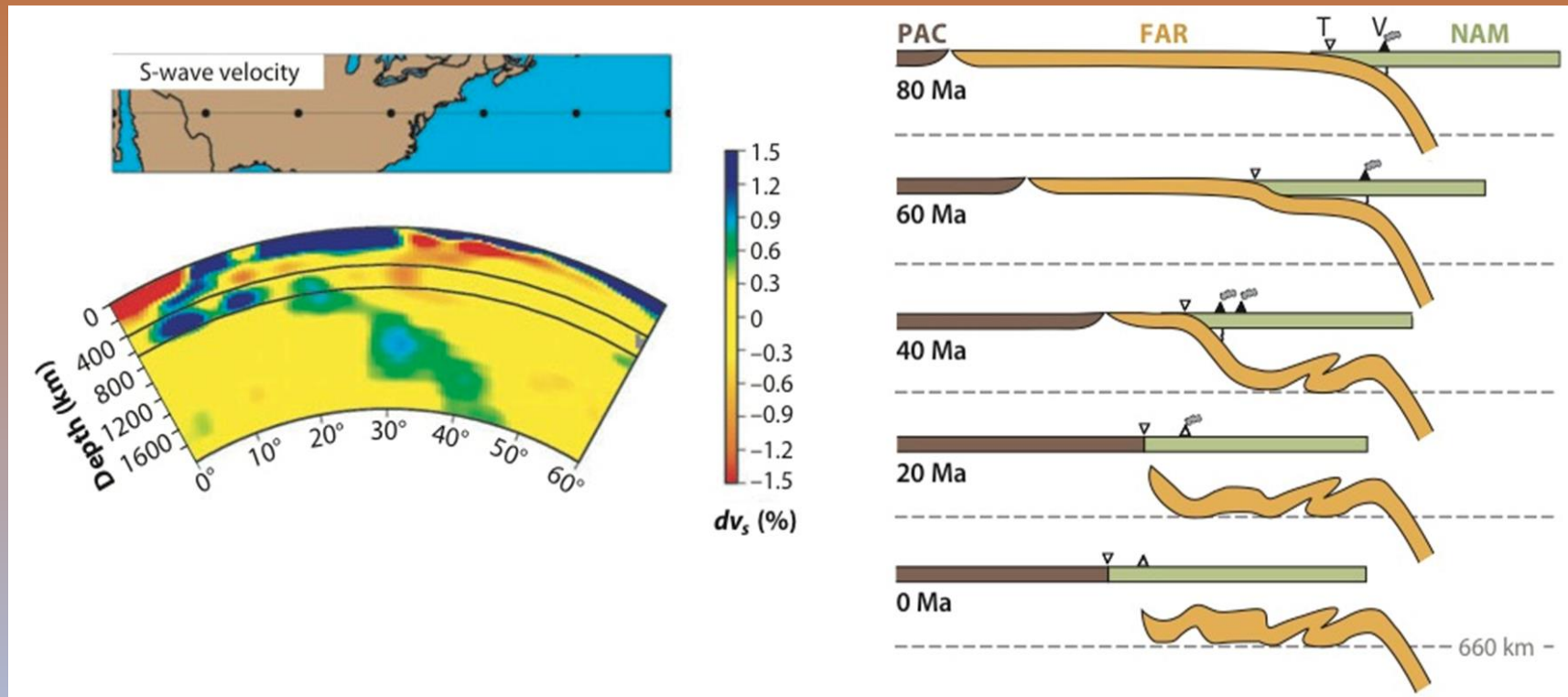
- **Deformation/Uplift reached Central Colorado 66 mya as dated by the synorogenic sediments deposited along the Front Range.**
- **Williams Range thrust fault pushed Proterozoic rocks westward over the Pierre shale in Summit County.**
- **Gore Range fault was reactivated.**

Stop Seven

Folded Dakota Sandstone at Lower Cataract Lake



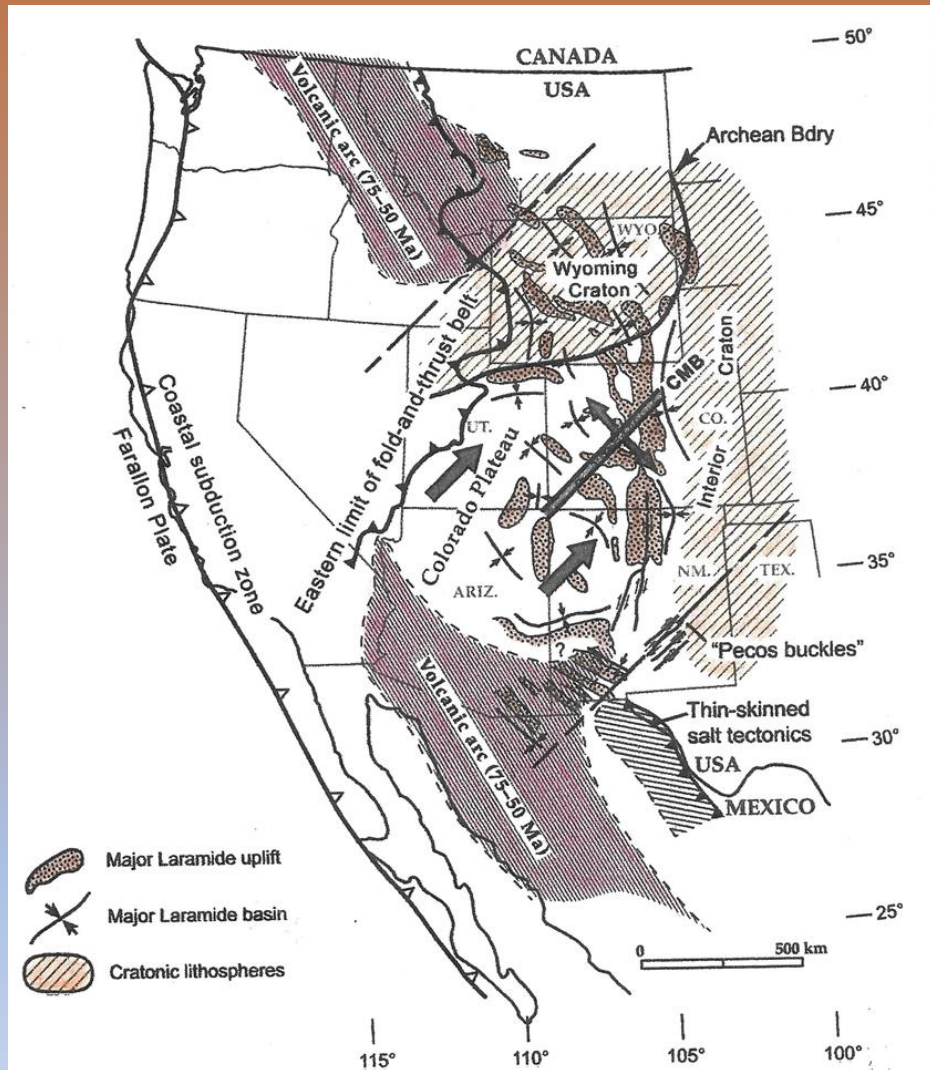
Subduction of the Farallon Plate 45 mya to Present



Flat Subduction ended around 45 mya ending the Laramide Orogeny. The subducting Farallon Slab steepened until around 20 mya, when the Pacific Plate impinged on the North American Plate ending subduction and initiating the transform continental margin and Basin and Range extension that is seen today.

Stop Eight

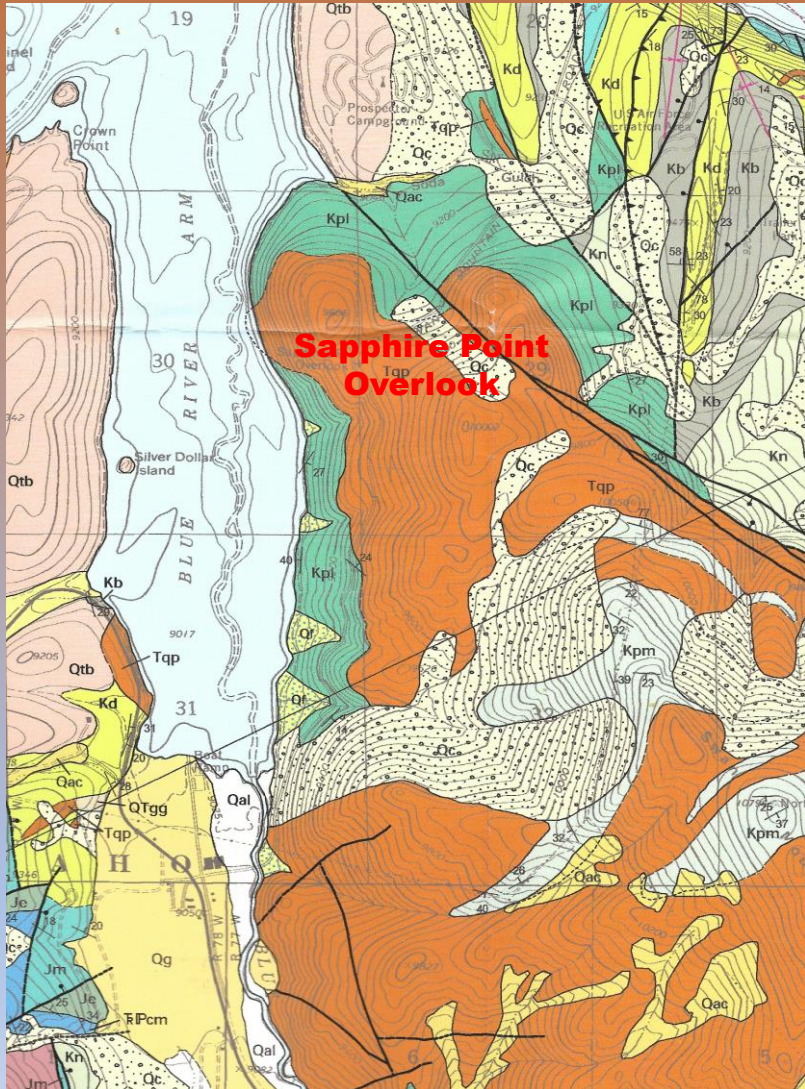
Formation of the Colorado Mineral Belt



- **Illustration is a paleotectonic map of the western U.S. at the time of Farallon plate foundering - 45 mya.**
- **Large arrows show transport direction of Farallon flat slab. Narrow arrows show oblique stresses that dilated or sheared the slab allowing magmas to rise into the Colorado Mineral Belt.**

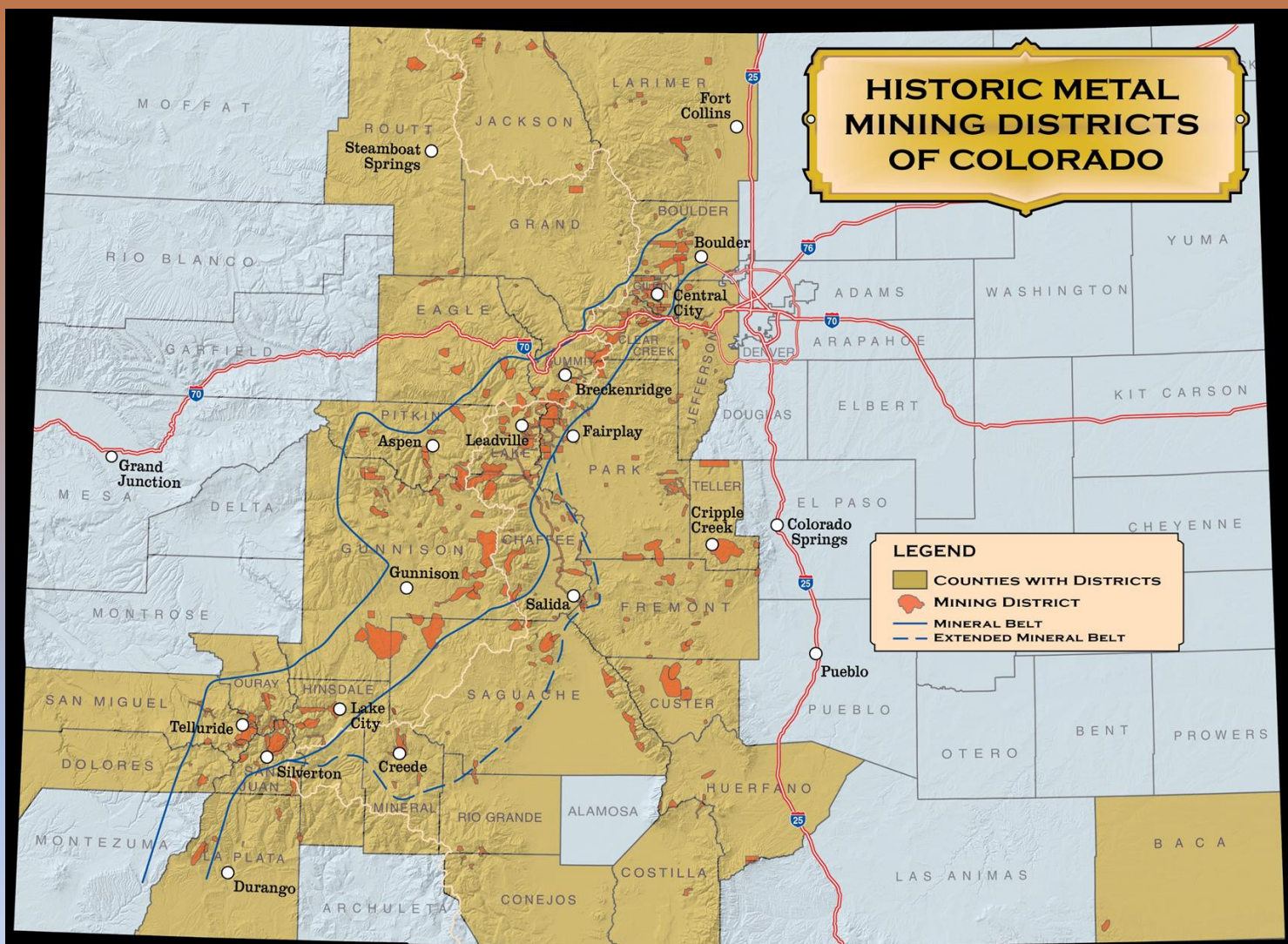
Stop Eight – Sapphire Point

Portion of Geological Map of Frisco Quadrangle



- **The orange pattern on the geological map (Tqp) is the Eocene Quartz monzonite porphyry .**
- **These igneous magmas were intruded into the surrounding rocks at 44 mya.**
- **These magmas carried the minerals which were deposited in the Breckenridge portion of the Colorado Mineral Belt.**

Colorado Mineral Belt

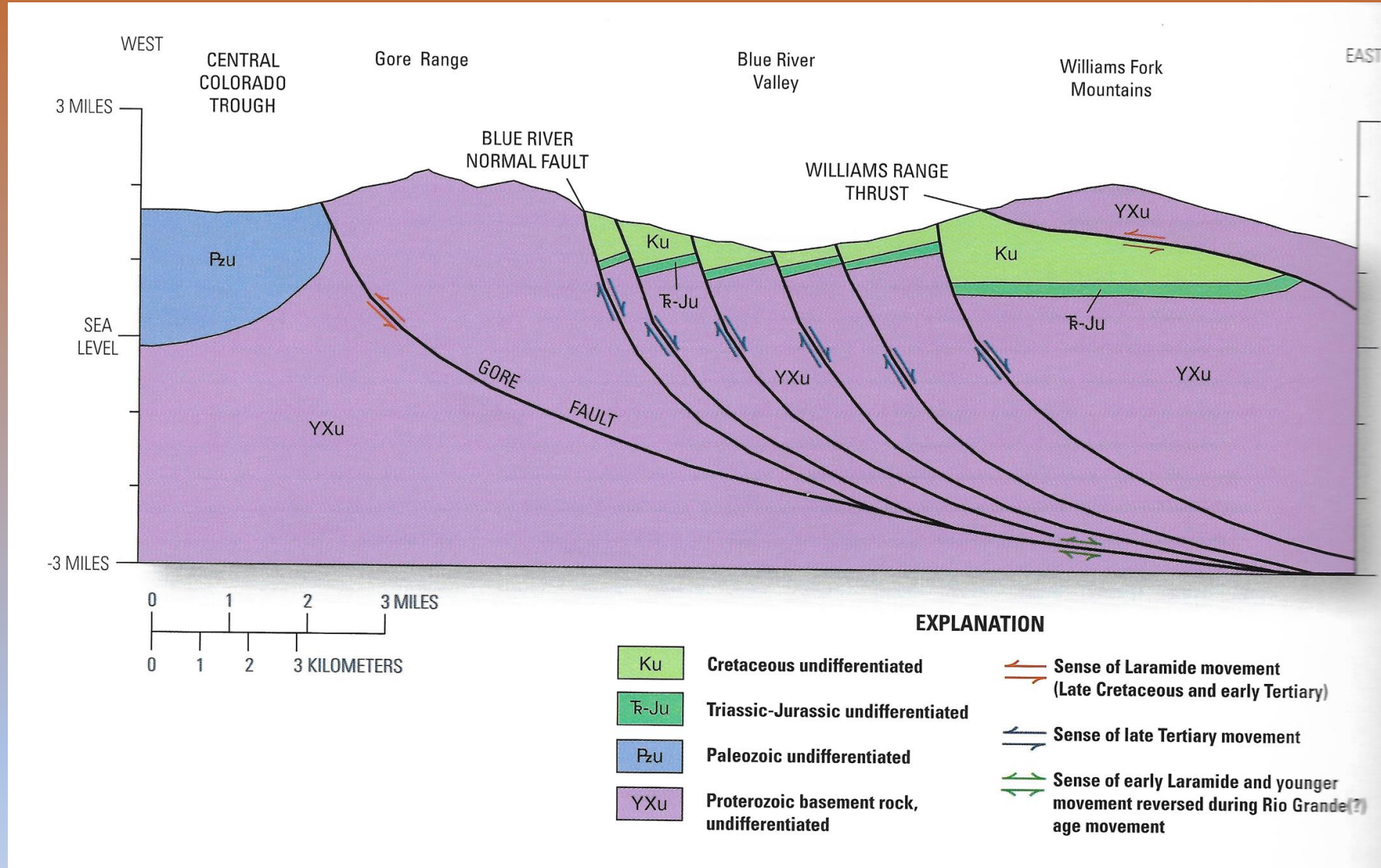


- Illustration is from Colorado Geological Survey website.
- Cenozoic Intrusives and Mineralization occurred in two pulses in Central Colorado at 44 and 30 mya.
- Leadville/ Breckenridge mineralization occurred around 44mya.
- Climax molybdenite mineralization occurred around 30mya.

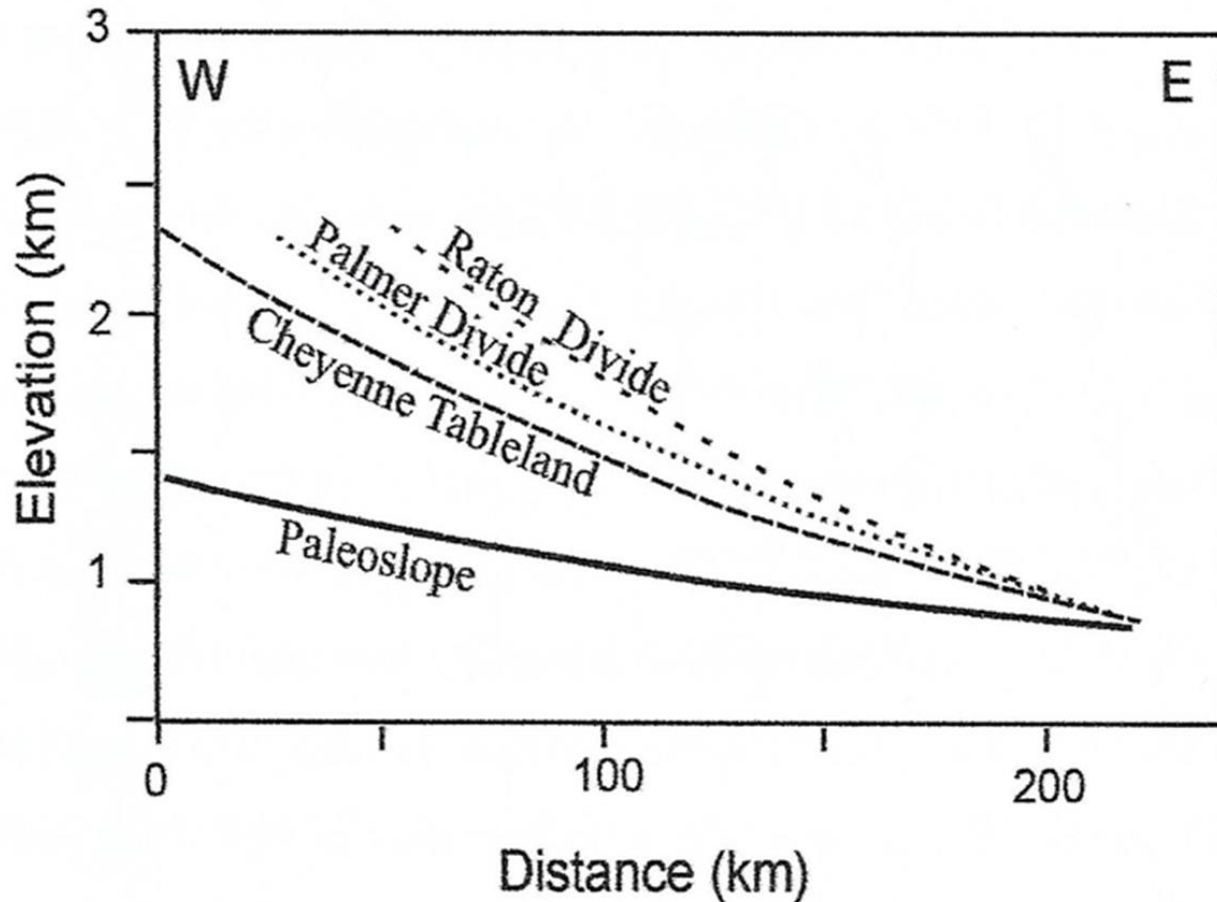
Photo of Blue River Valley from Sapphire Point



Formation of the Blue River Valley – 28-11 mya



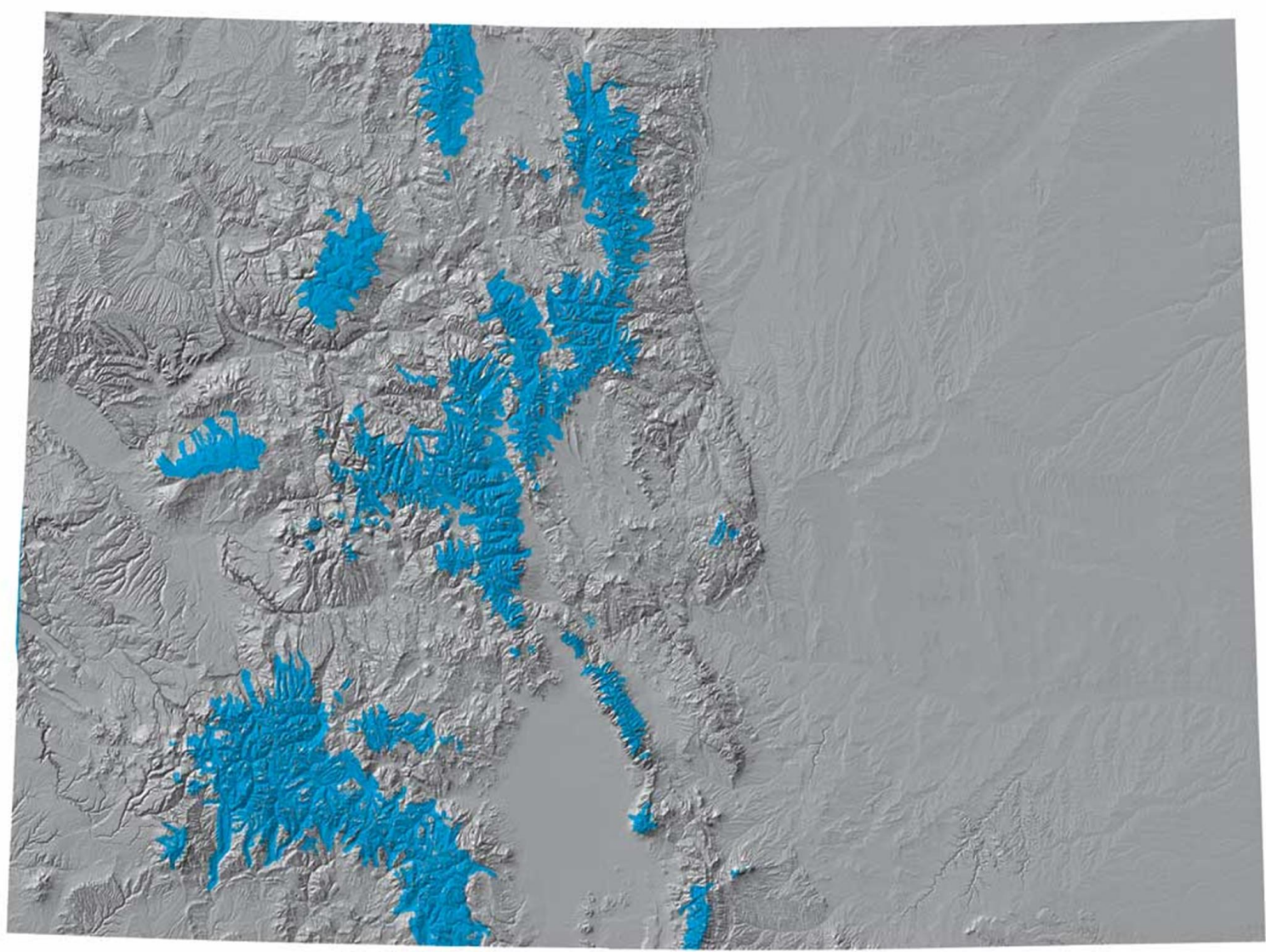
Miocene Uplift of the Colorado Plateau and Great Plains - 6-10 mya



- **Diagram illustrates the gradients of Major Interfluves in Western Great Plains**

- **Modern gradients are significantly greater than the paleo-slope calculated from preserved gravels of the Miocene-Pliocene Ogallala Formation. This difference indicates tilting up to the west of 1-2 km or 3000-6500 ft.**

Pleistocene Alpine Glaciation in Colorado



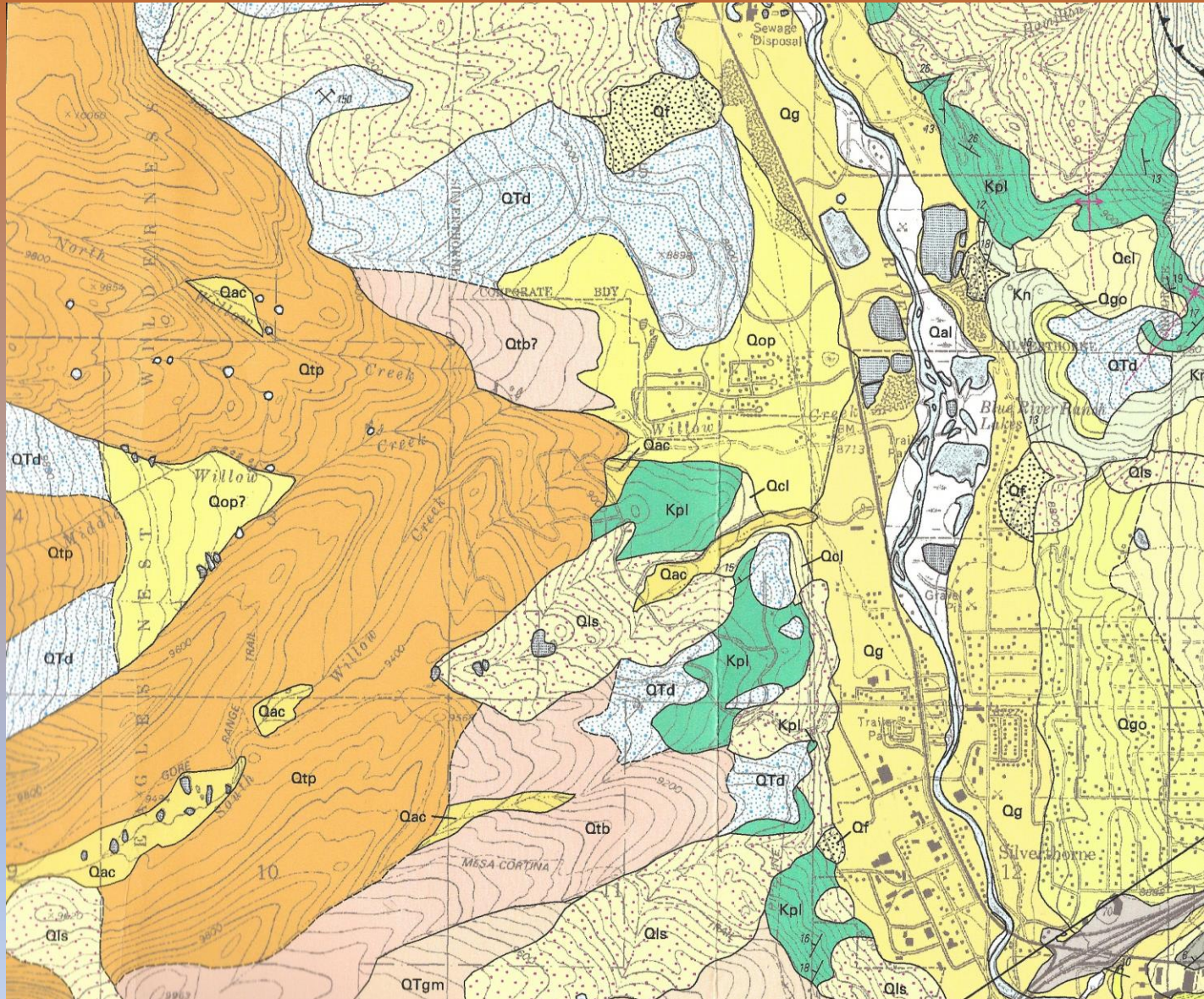
- Global climatic cooling began about 2.6 mya and intensified about 900 kya resulting in glaciation
- The blue area on the map illustrate the area in Colorado that were glaciated during the Pleistocene.
- The map is courtesy of the Colorado Geological Survey.

Stop Nine – Dillon Overlook



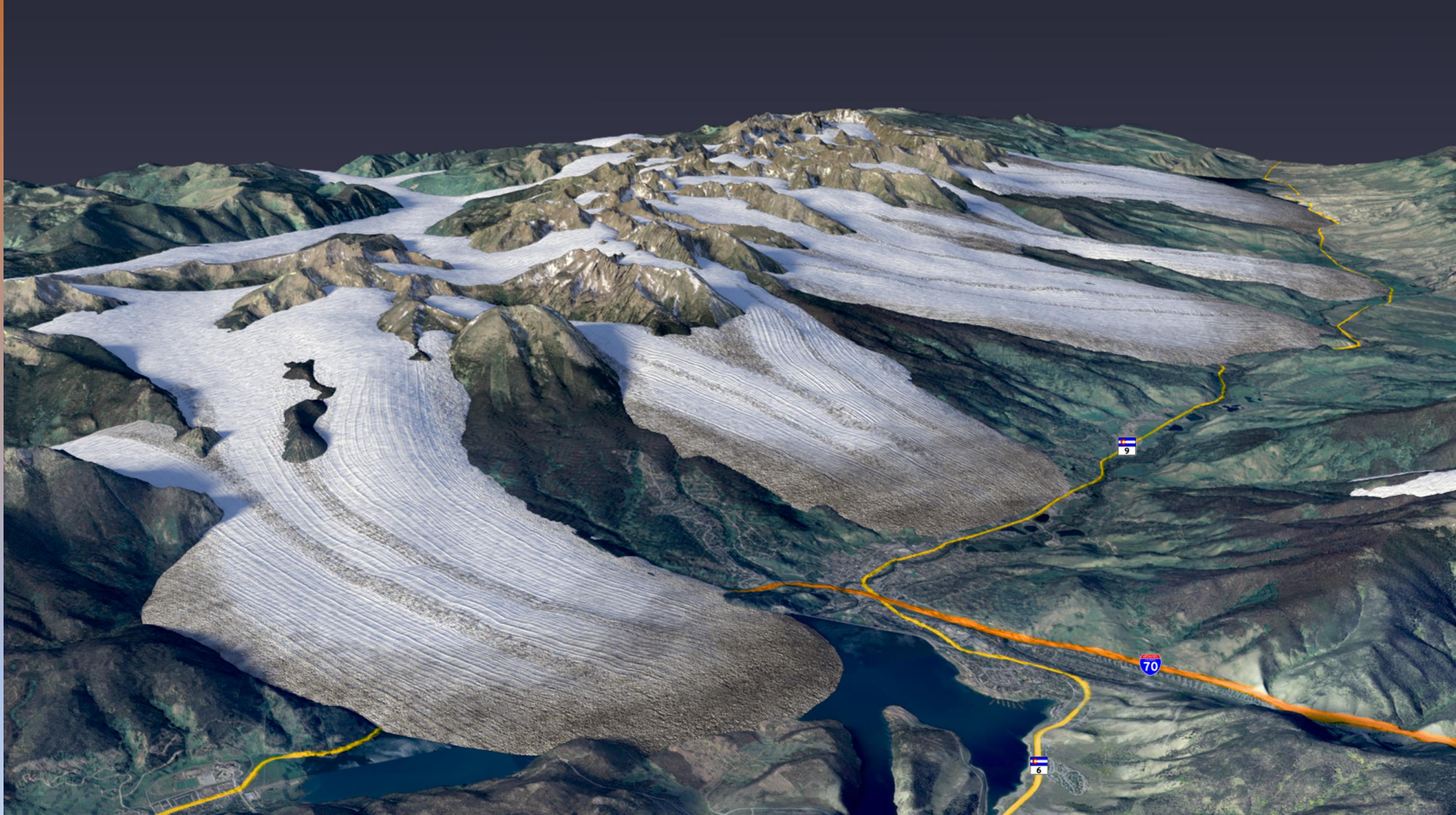
- **Glaciated U-Shaped Valley between Buffalo Mountain and Red mountain,**
- **Glacial striations are present along the trail above South Willow Falls.**

Stop Nine – Dillon Overlook

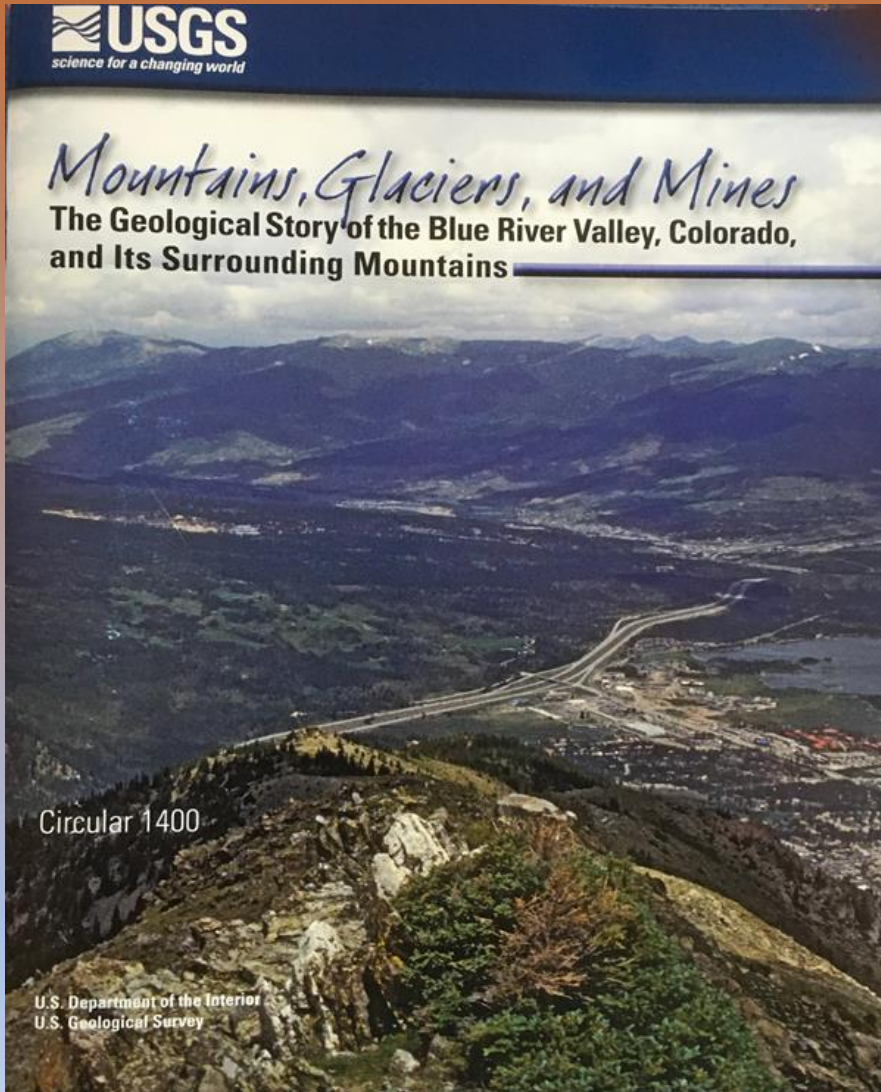


- Portion of the Geological Map of the Dillon Quadrangle.
- This map illustrates the two phases of alpine glaciation in the Rockies
 - Bull Lake glaciation (Qtb)) 190-120 kya.
 - Pinedale glaciation (Qtp) 30-12 kya.
- There were 4 periods of continental glaciation in North America during the Pleistocene.
- One of the earlier glacial periods may be represented by the Mesa Cortina gravels of late Pliocene/Early Pleistocene age. The Mesa Cortina gravels were mined for placer gold in the 1860s and 1870s.

Glaciation in the Gore Range



Further Reading



- **Circular 1400 published by USGS in 2016.**
- **Good general discussion of what has been covered in today's discussion.**
- **Can be downloaded from the USGS Website**
- **<http://dx.doi.org/10.3133/cir1400>**