1.7 billion years old Are you kidding me!!

The Geology Of Staunton State Park

By: Scott Knight & Ron Claussen

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INTRODUCTION

This publication is for geologists as well as those that wish to expand their knowledge about how the rocks tell the story of Staunton State Park. But first it is good to put the Staunton's story into context with a broader picture of the area. When you look at Lions Head it is a portion of a bigger picture.

Staunton State Park is located 40 miles southwest of Denver. Access to the park is by way of US Highway 285 and Elk Creek Rd. The park covers 3800 acres of pine covered landscape.

The rocks present on the surface at Staunton State Park, are some of the oldest rocks in Colorado! They range in age from 1.7 billion to 1.08 billion years old. The oldest rocks are metamorphic gneisses and schists. The younger 1.08 to 1.4 billion year old rocks are granites. The Pikes Peak granite is the most prevalent rock in the park and is centrally located within the park. The metamorphic complex and older granites are only found in the far eastern portion of Staunton. These rocks have a story to tell! How did they get here? Where did they come from? What has sculpted these rocks into magnificent and beautiful natural works of art?

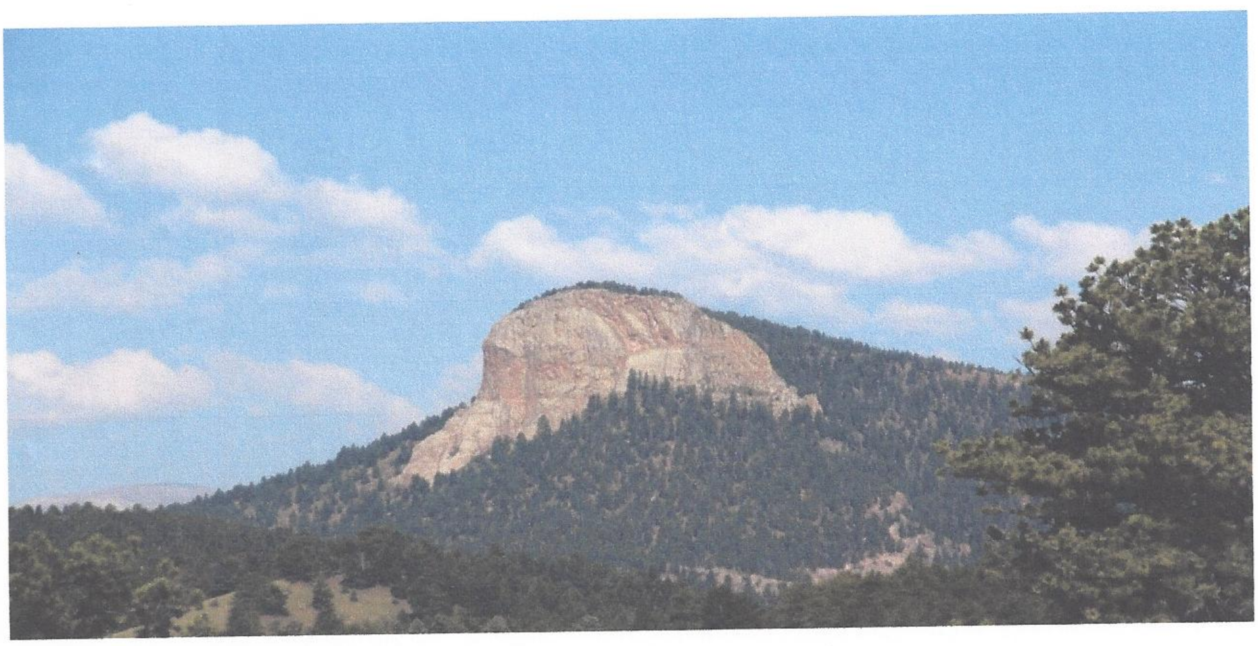


Image 1. Lions Head 1.08 billion years old granite intrusion

The rocks of Staunton were formed millions of years ago miles beneath the surface. They have only relatively recently been exposed at the surface after at least three episodes of mountain building, intermittent burial by vast oceans followed by erosion. The last mountain building event occurred during the Laramide Orogeny. This episode of mountain building spanned 20 million years between 50 and 70 million years ago. This was a period of igneous intrusion, uplift and major faulting. The result was the present day Rocky Mountains, including the Front Range. Staunton is located squarely within the Front Range.

At the culmination of this mountain building event, the detailed work began in Nature's effort to begin sculpting this state park. Through a combination of additional faulting, fracturing, erosion by water and ice and a little help from chemical and biological processes, Staunton State Park was sculpted into what you enjoy today. When you hike throughout the park, keep in mind that it is these geological and biological forces that have provided the awesome canvas before you!

Thank you to Ron Claussen, naturalist, for the photos used throughout this publication. Thank you also to Peter Laux, geologist and naturalist for his cririical review and appreciated suggestions and editing.

THE BIG PICTURE

Staunton is located in the central Front Range West of Denver, north of South Park, east of the Sawatch Range and south of North Park.

REGIONAL SETTING

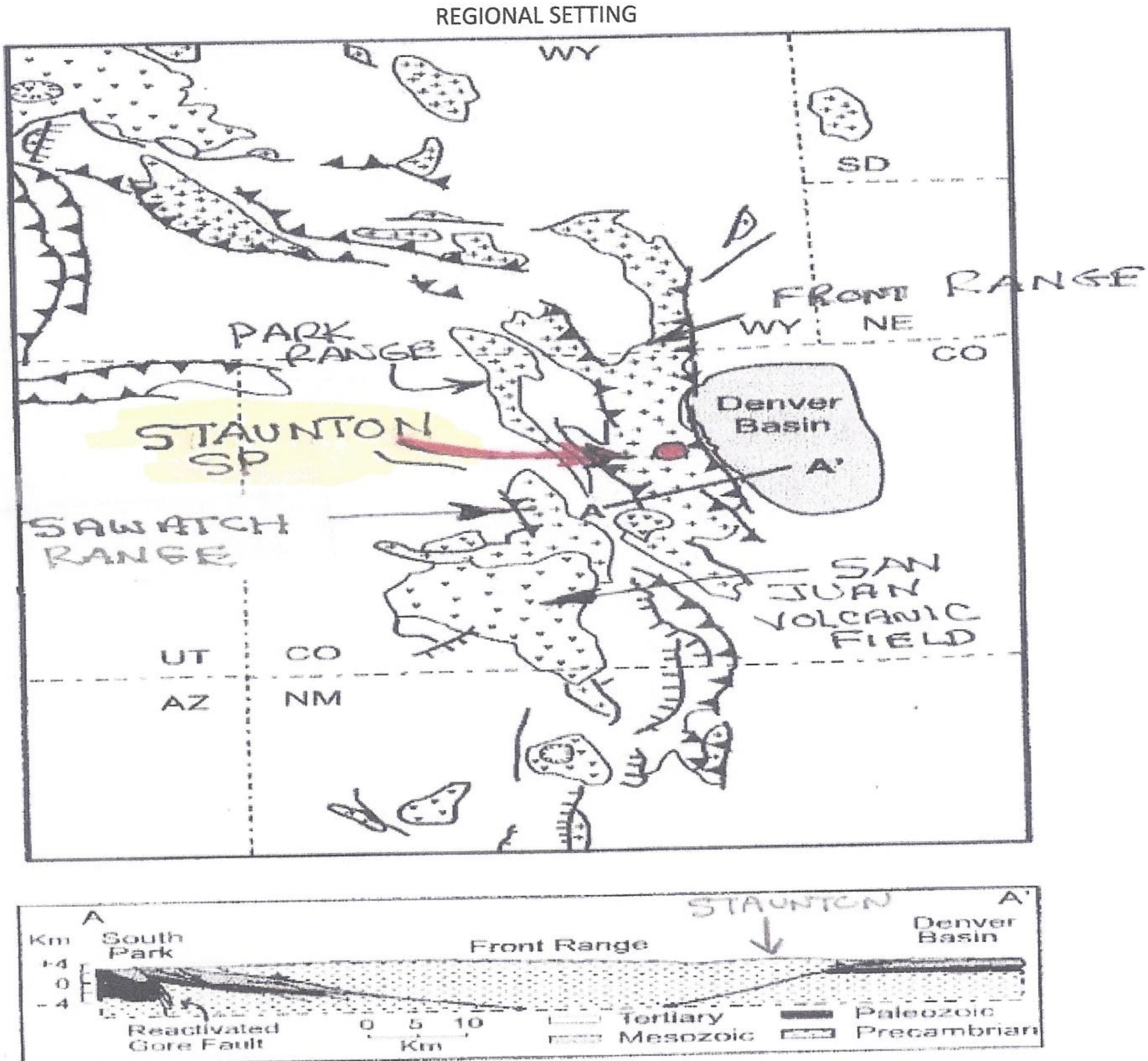


Figure 1. Index map showing location of Denver Basin and a regional cross section illustrating Denver Basin and South Park Basin developed adjacent to uplifting Front Range of Rocky Mountains.

If we look at a west to east cross section (figure 2) through the Rocky Mountains and the Denver Basin, we can see the relationship between Staunton and the plains of Colorado. Staunton State Park is located on the eastern portion of the Front Range Uplift and to the west of the Plains of Colorado. To begin narrowing our focus to the Front Range and provide you with some locations where you can see the story of the last 1.7 billion years, we include three state parks. Each has a portion of the rock story. The rock layers are color coded according to age with the older rocks at the bottom and younger rocks on top. Take a moment to look at the 1 to 1.4 billion year old granite exposed on the surface a Staunton. While on the surface at Staunton, it is buried approximately 12,000 feet under Denver and Castlewood Canyon State Parks. These older rocks were uplifted and exposed by the Golden fault.

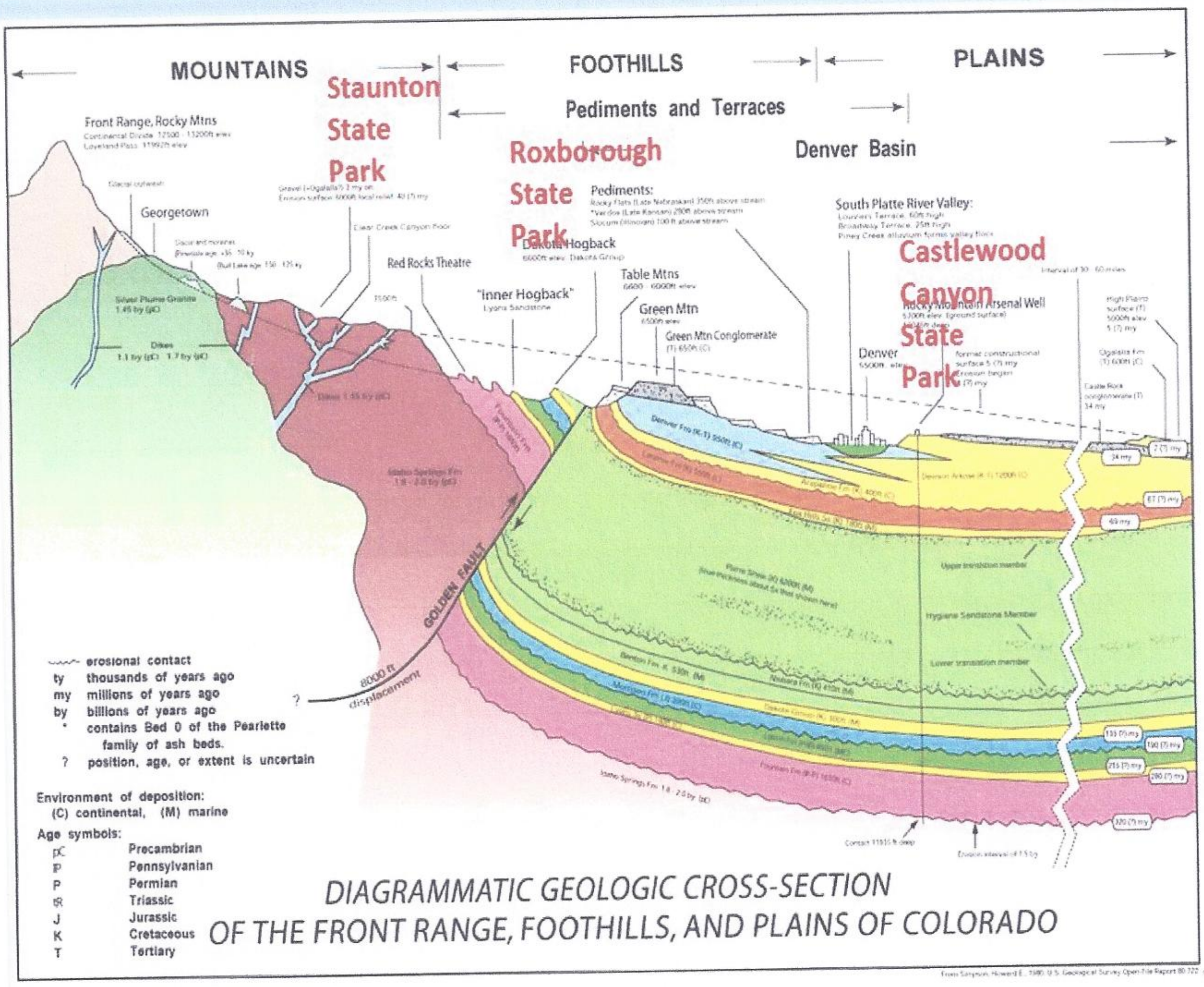


Figure 2. East/west geologic cross section. The beginning of the story of three parks.

The rocks that fill the Denver Basin above the granite, range in age from 300 million years old to recent. The older sedimentary rocks, from the Pierre Shale down, once covered the Staunton area. They have since been removed by erosion post Laramide Orogeny. Erosion is nature's never ending attempt to lower all rocks back to sea level or below. The cycle is – mountain building followed by mountain destruction through erosion followed again by uplift and mountain building to start the cycle anew!

It is interesting to note on the geologic column below(fig 3), that you can hike and see virtually all of the geologic rock formations of the Denver Basin by visiting the three nearby State Parks. At Staunton, we see the billion year old granitic and metamorphic rocks. At Roxborough we can see billion year old granites overlaid by 300 million year old to 70 million year old sediments (Fountain – Pierre Fms.) and, at Castlewood Canyon; we can enjoy the 55 to 25 million year old sediments (Dawson Arkose – Castlerock Conglomerate).

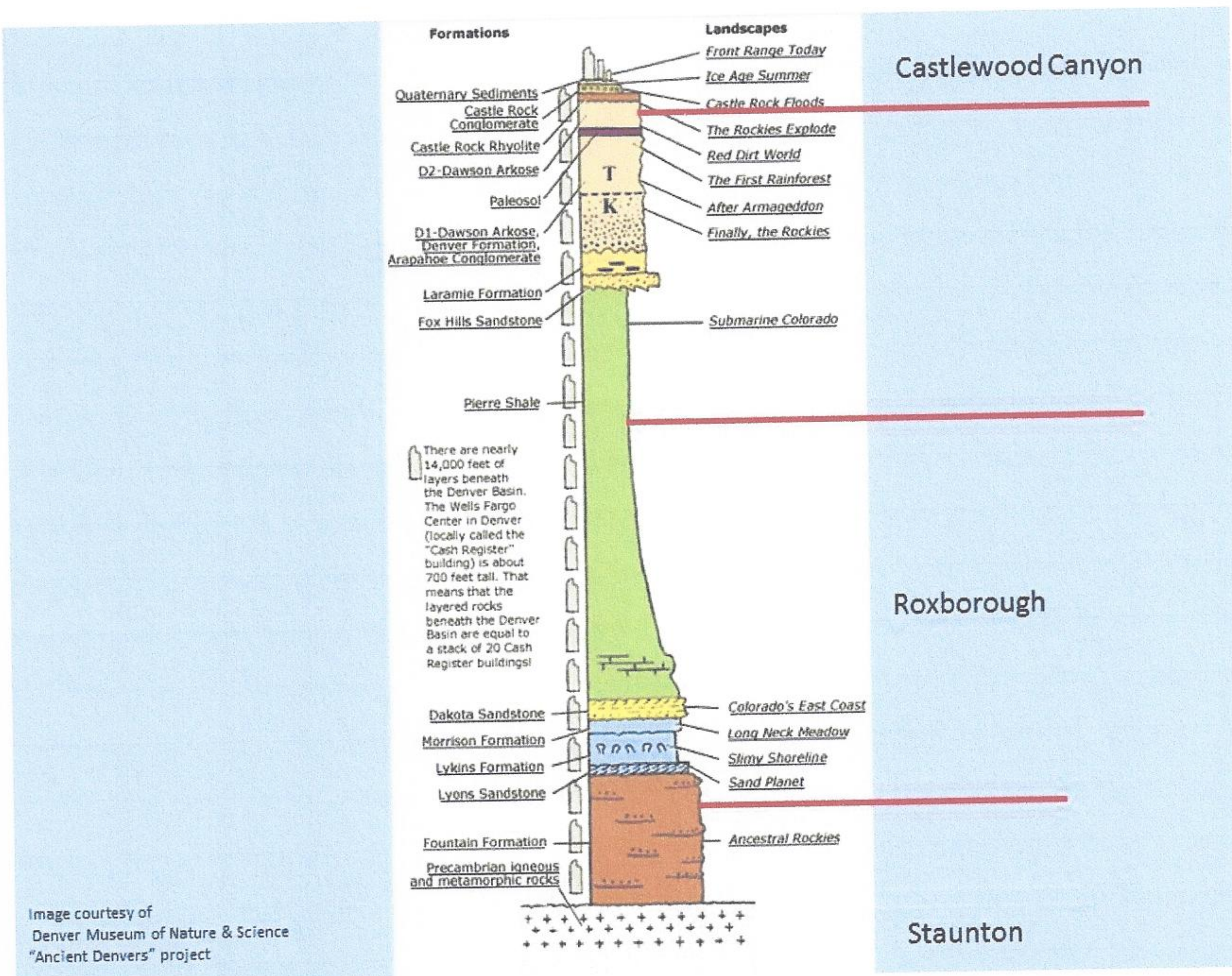


Figure 3. Geologic Column

THE ROCKS AT STAUNTON

Any discussion of rocks should begin with some basic definitions. The following basic terms and simplified definitions will help in understanding the rocks present on the surface at Staunton State Park.

Mineral –A naturally occurring inorganic element or compound with a chemical formula that is set or varies within limits and a characteristic crystal form.

Rock – an aggregate of minerals.

TYPES OF ROCKS

Igneous – Solidified from a molten state- if they solidify deep in the earth, they are in the granitic or intrusive family. If they solidify after reaching the surface, they are volcanic or extrusive rocks.

Sedimentary – Deposited from eroded material (sediment) after transport by streams, wind or ocean currents. The sediments are cemented together generally by silica or lime. Some sedimentary rocks are precipitated from water or secreted by organisms, such as salt or limestone.

Metamorphic – changed form – igneous or sedimentary rocks that are subjected to intense heat and pressures resulting in a realignment of the minerals into layers or bands. These layers are generally undulated due to plastic state flow while under pressure. Marble and quartzite are also metamorphic rocks that are not banded or foliated. Marble forms from limestone and quartzite from sandstone.

Rocks Present At Staunton Within Park Boundries

Metamorphic (heat, pressure=changed form)

Gneiss – 1.78 billion years old

This is the oldest rock present within the park. Outcrops are located in the far southeastern portion of the park. The gneiss is foliated creating bands of light pink or orange alternating with dark bands of grey or black. This gneiss probably formed from the transformation of ancient granitic rocks deep in the earth's crust.

Mica Schist/Hornfels (Found associated with the above gneiss) Dark grey to greenish color with sparkly layers of silver and gold colored mica. Commonly forms micaceous layers (schist). This rock probably formed from the metamorphosis of ancient ocean sediments and volcanics deposited in an ancient abyss deep in the ocean that was located in the Staunton area billions of years ago.

Note: The metamorphic complex is best viewed along Elk Creek Rd. on the north side just before reaching the park gate access into Mason creek.

Igneous (solidified from a molten state)

Berthoud Granite – 1.4 Billion years Old

The Berthoud granite is found in the far eastern portion of the park east of Mason Creek. It can be examined in the same area as the metamorphic complex. It is orange in color with medium to coarse grained (5mm) crystals. The Berthoud is locally associated with pegmatite dikes. The pegmatites have very large pebble size(10mm) crystals of clear quartz, pink feldspar and black mica. They can also contain various well developed gemstone minerals. These dikes form long linear features that cut across the Berthoud Granite. Erosional detritus from these dikes can be found strewn over the surface in the eastern portion of Staunton.

Note: The Berthoud Granite is found at the far eastern portion of the park east of Masson Creek.

Pikes Peak Granite – 1.08 Billion Years Old

The Pikes Peak Granite is pinkish orange color and generally contains clear to milky quartz crystals and orange feldspar crystals. Black mica is also common. The granite occurs in two phases – a **course grained phase** located in the west, south and east portions of the park. This phase is characterized by gravel sized (2.5mm) crystals. This phase appears in outcrop as more weathered, often highly fractured and with a more rounded weathered surface. The **fine grained phase** is found in the central and northern portions of the park. It can be easily examined in the central portion between the Elk Creek and North Fork faults. The fine grained phase is characterized by sand sized (<2.5mm) crystals. The fine grained phase is generally fractured into nice rectangular blocks and does not appear weathered as deeply as the coarser grained phase. The Pikes Peak Granite is by far, the most widespread and common rock in Staunton State Park.

Note: The Pikes Peak Granite is found in the central and western portions of the park. The fine grained phase is best examined in the central portion of the park and the coarse grained phase is best examined in the western portion of the park.

Decomposed Granite

Decomposed granite **is** Pink and clear to white angular pieces of weathered granite. It is abundant along roads and along slopes below granite outcrops.

Image 2. META SEDIMENTS (changed Form/Heat & Pressure) – Note the banded layers

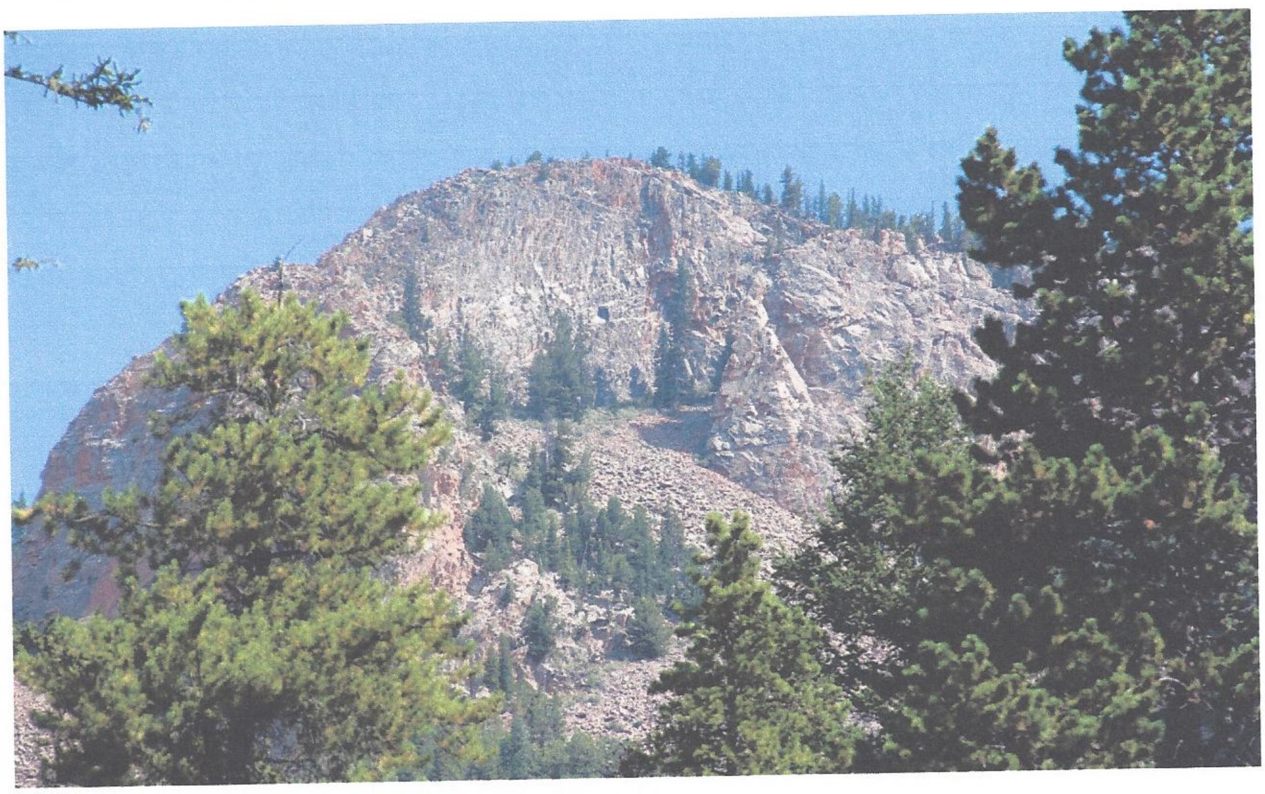


Image 3. IGNEOUS ROCK INTRUSION (solidified from molten state)

THE GEOLOGIC PROCESSES THAT NATURE USES TO SCULPT THE LANDSCAPE

Course sculpting – Uplift and mountain building

Finer sculpting – faulting and fracturing

Detailed sculpting – weathering

Let's examine Uplift and Mountain building and faulting processes in a little more detail! There are three primary processes that have resulted in mountain building at Staunton State Park throughout geologic time. These are igneous intrusion, compressional folding and faulting and finally block faulting.

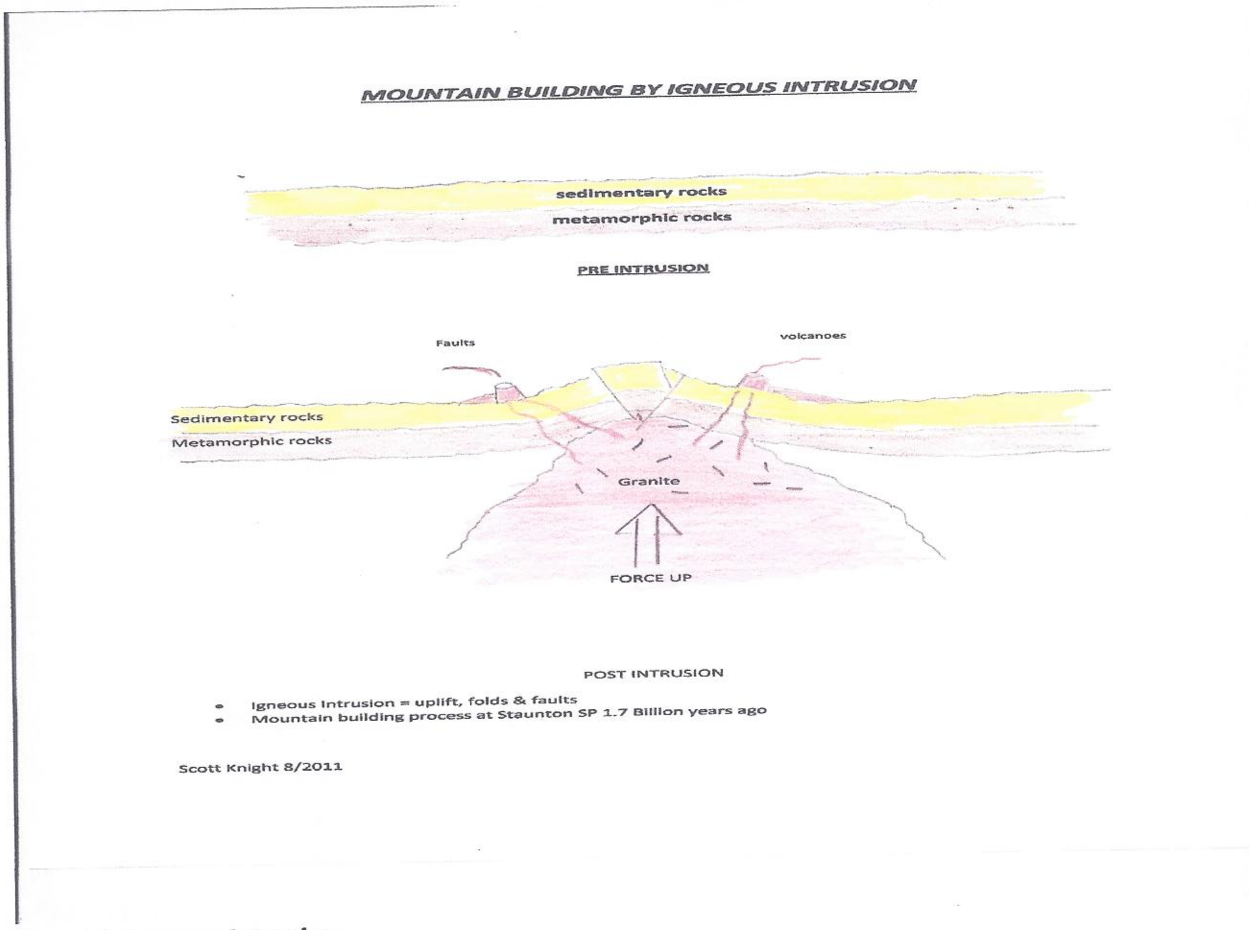


Figure 4. Igneous Intrusion

Uplift & Erosion Due To Igneous Intrusion

Igneous intrusions are molten rock that comes from deep in the earth. The mass is forced upward toward the surface. In the process, it pushes and folds and faults the rocks above it forming mountains. The mass then reaches equilibrium and cools into solid rock miles below the surface. A broad uplift is formed at the surface along with faulting and fracturing of the overlying rocks. This is one form of Mountain building. This form is responsible for mountain building and emplacement of the Pikes Peak Granite over 1 billion years ago at Staunton State Park.

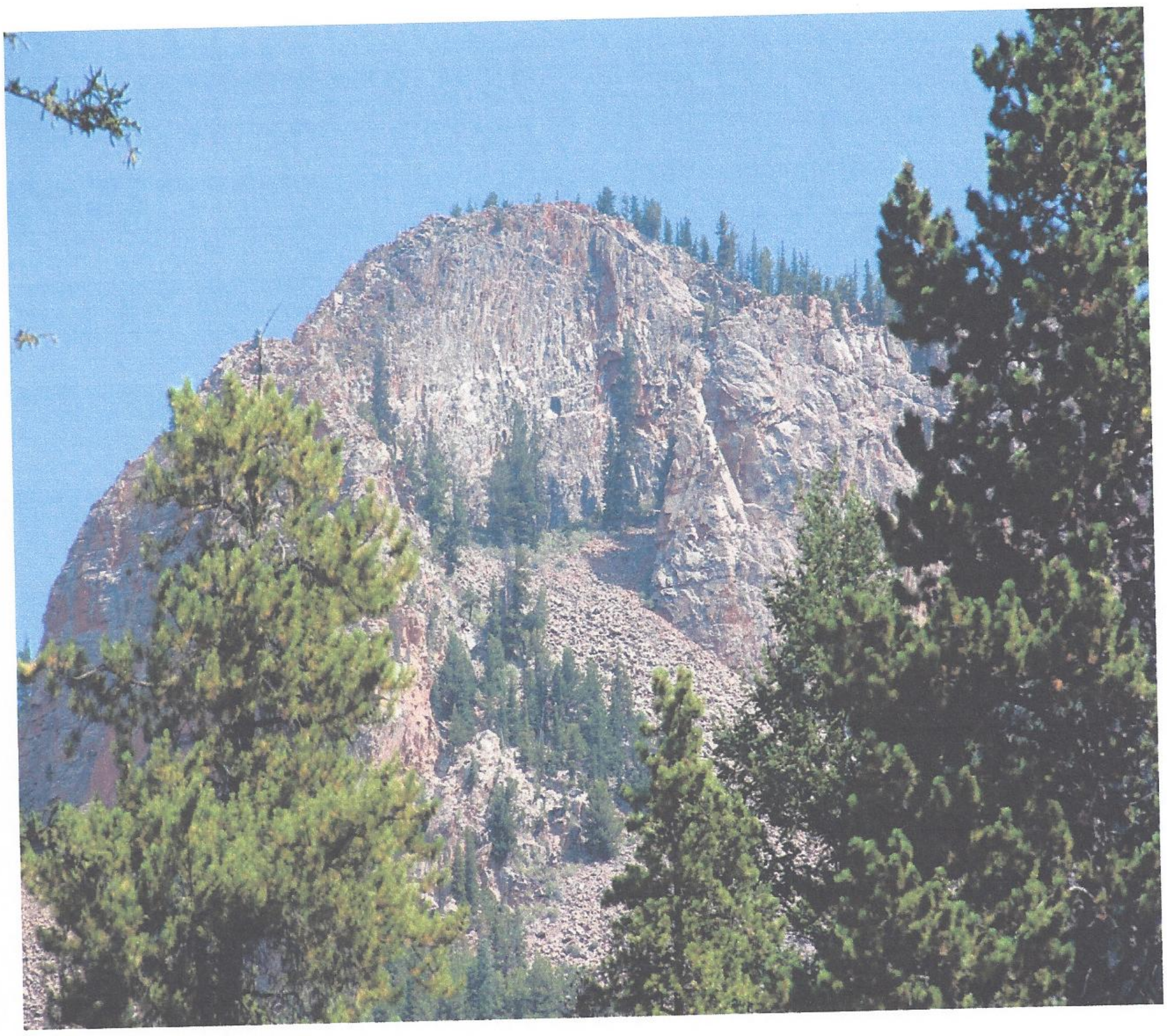


Image 4. 1.08 billion year old igneous intrusions brought to the surface over the past 25 – 5 million years

Compressional folding & Faulting

Another process of mountain building that occurred in the Staunton area 300 million and approximately 66 million years ago was the result of regional east – west compressional forces that twice forced up the northwest trending Rocky Mountains. This process is analogous to holding a magazine in both hands and compressing the edges together. The end result is folding of the rock layers (represented by the magazine). Recurrent movement along the older one billion year old fault zones accompanied these folding periods and the deeply buried older granites moved closer to the surface, with each successive uplift. The period of time between uplift was characterized by renewed erosion, a resulting lowering of the mountain surface and finally intermittent oceans covering the Staunton area. The resulting sediments that were shed off of these old mountains were primarily deposited to the east in the Denver Basin. These are the rock formations that are present on the surface today at Roxborough and Castlewood Canyon State Parks.

The faulting that resulted from these mountain building episodes have a primary orientation of northwest-southeast, and a secondary orientation of northeast-southwest. Movement along these same fault zones occurred multiple times over the 1.74 billion year history of Staunton State Park. The major nothwest trending valleys and ridges in the park follow these old zones of weakness.

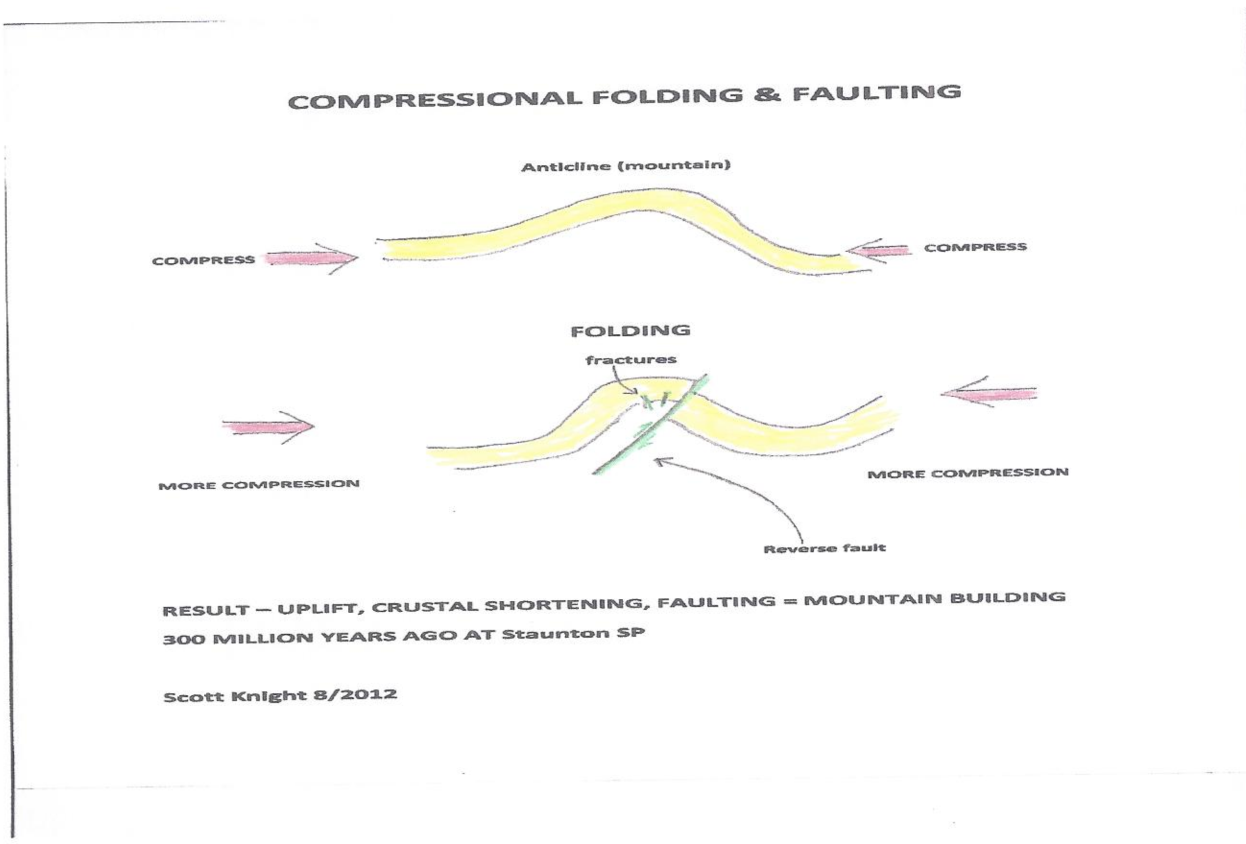


Figure 5. Compressional Folding and Faulting

Block Faulting & Tilting

Approximately 25 million years ago, there was a regional relaxation of compressional forces that resulted in block faulting accompanied by tilting of these blocks in the Staunton area. These are the forces that allowed nature to apply her fine sculpting techniques through erosion and weathering one more time at Staunton.

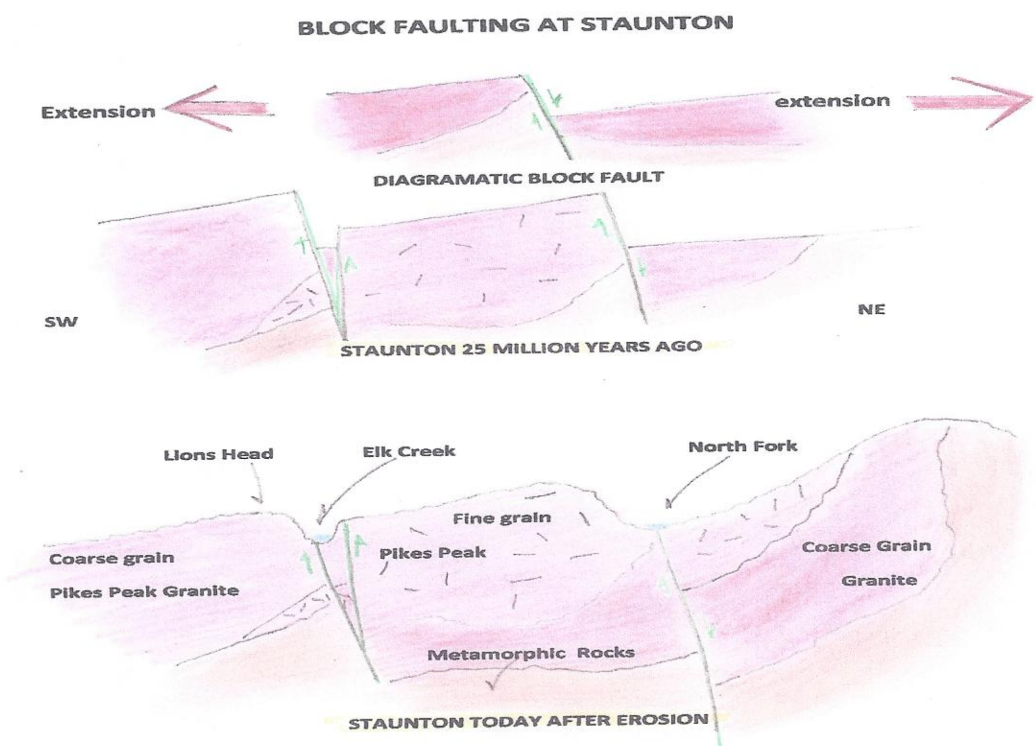


Figure 6. Block Faulting at Staunton

This block faulting resulted in long linear northwest trending high blocks separated by northwest trending low areas. The low areas filled with water forming creeks, including Elk Creek. Subsequent erosion has sculpted the park into a magnificent work of nature! The photo below shows the Elk Creek valley and the pond by the cabin. The long linear fault controlled valleys and ridges are evident. Let's now take a look at some of these finer sculpting tools that nature has used to shape this Staunton masterpiece.

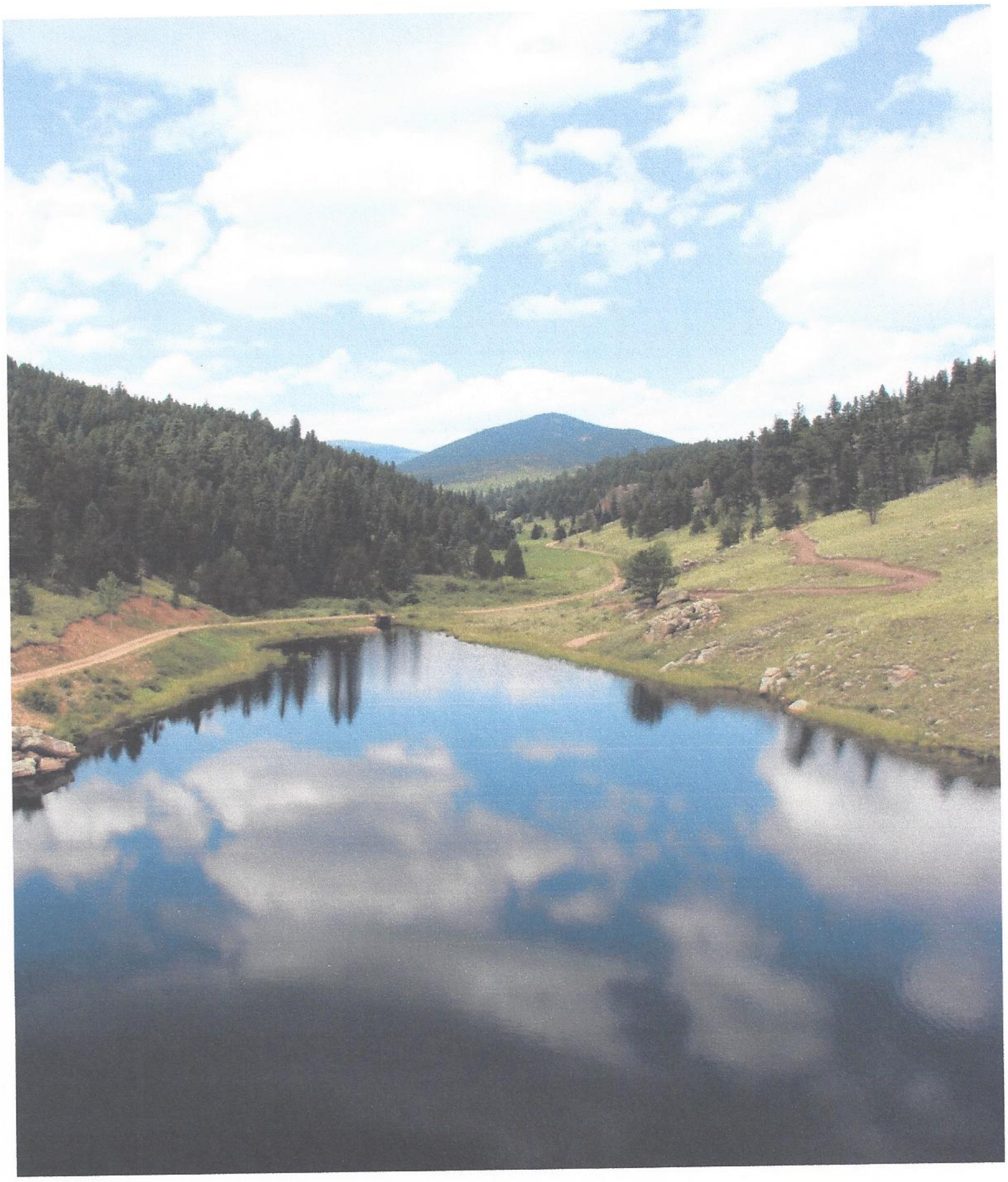


Image 5. Block faulted valley – looking northwest from the "fishing cabin" pond dam

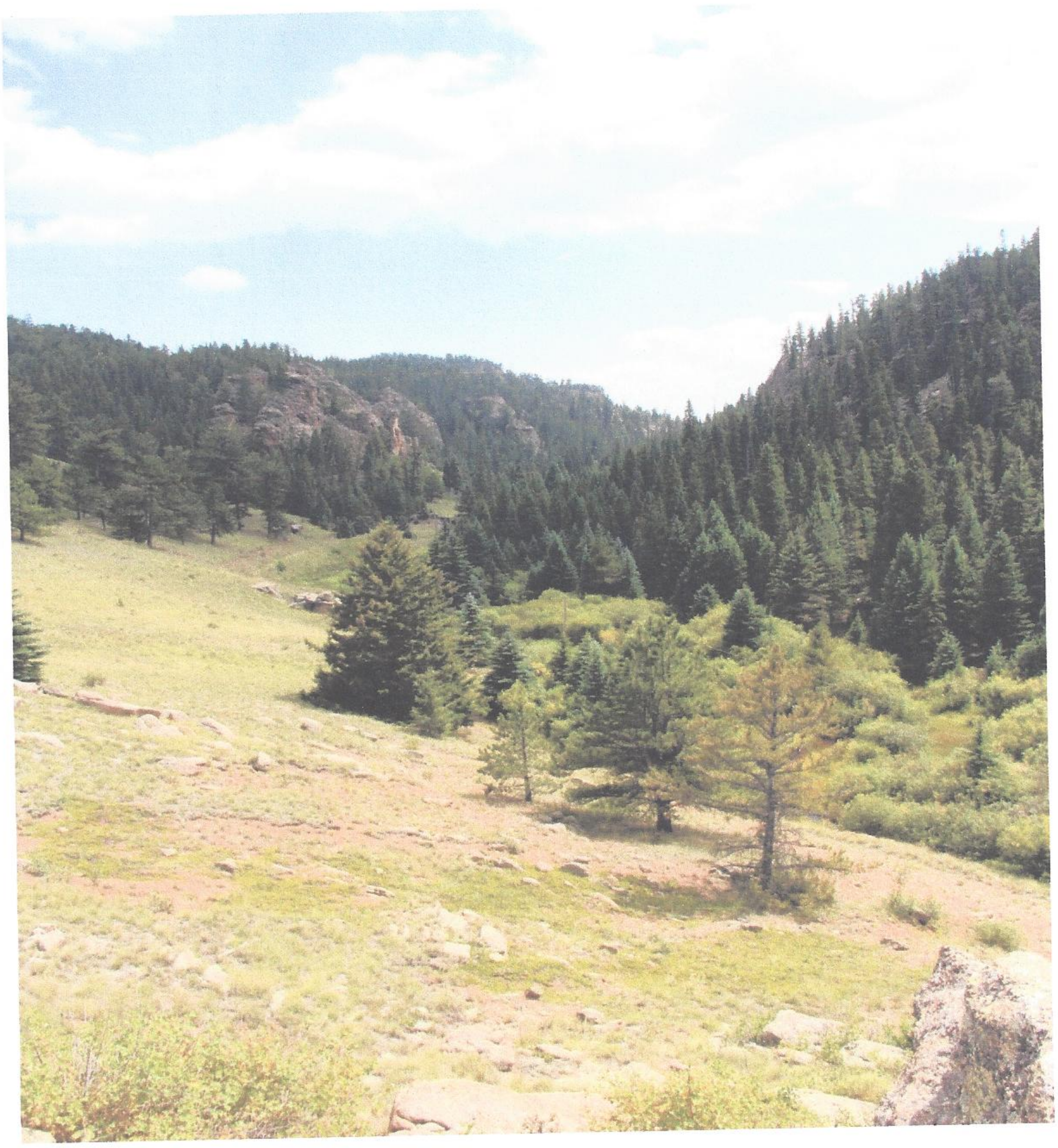


Image 6. Block faulted valley – looking south east from the "fishing cabin" dam down Elk Creek toward the falls.

FINER DETAIL – EROSION AND WEATHERING

When rocks are exposed at the earth's surface, weathering immediately is set into motion. Gravity acts in concert to move the weathering products to lower ground. This sometimes takes place quickly in the form of landslides or flash floods. It can also happen more slowly over millions of years. Nature's goal is to move all material to sea level and eventually try to lower all landforms to sea level or below. The three principal agents responsible for sculpting Staunton, in concert with the already discussed igneous intrusion, faulting and fracturing, are: water/ice, wind and chemical/biological weathering.

Image 7. ELK CREEK FALLS –slowly eroding the Pikes Peak Granite. The falls will move northward with time.

Water Erosion

Water, as it flows downhill, is an excellent sculptor. The faster it moves the quicker it sculpts. It breaks apart various sized rocks through continual impact and eventually renders all rocks in its path to sand, silt and clay sized particles. The water moves all material downstream in its continual quest to reach the sea. Some of the sediment from Staunton may very well have travelled all the way to the Mississippi Delta and once there, it was unceremoniously subjected to a lonely burial at sea. All this to eventually be buried deeper by younger sediment; lithified and compacted once again into rock – only to be subjected to this whole cycle one more time after that area is uplifted above sea level. As we can see geology is all about recurrent cycles.

Water, in the form of streams and sheet flow off of the mountain slopes, has sculpted Staunton. The major stream channels including Elk Creek, Black Mountain Creek and Mason Creek follow old fault or fracture zones. As the water flows, particularly during storms and spring runoff, erosion has sculpted the park. The result is the beautiful valleys and ridges that magnificently grace the park. These valleys grow ever deeper and the mountains are carved downward with each passing year! The high blocks or ridges will one day be eroded flat by the running water.

Water is aided in this quest by ice, fracturing and chemical/biological weathering. The granite ridges are nicely fractured into neat blocks as a result of faulting and uplift as well as relaxation. In the winter, as water freezes in these cracks and fractures, it expands. The end result is pressure against the fractures which in time pushes them farther apart. Eventually gravity takes over and in one quick and massive landslide the rocks topple down toward the stream to be processed and sent farther on their way. The picture below is of one of those blocks ready to fall!

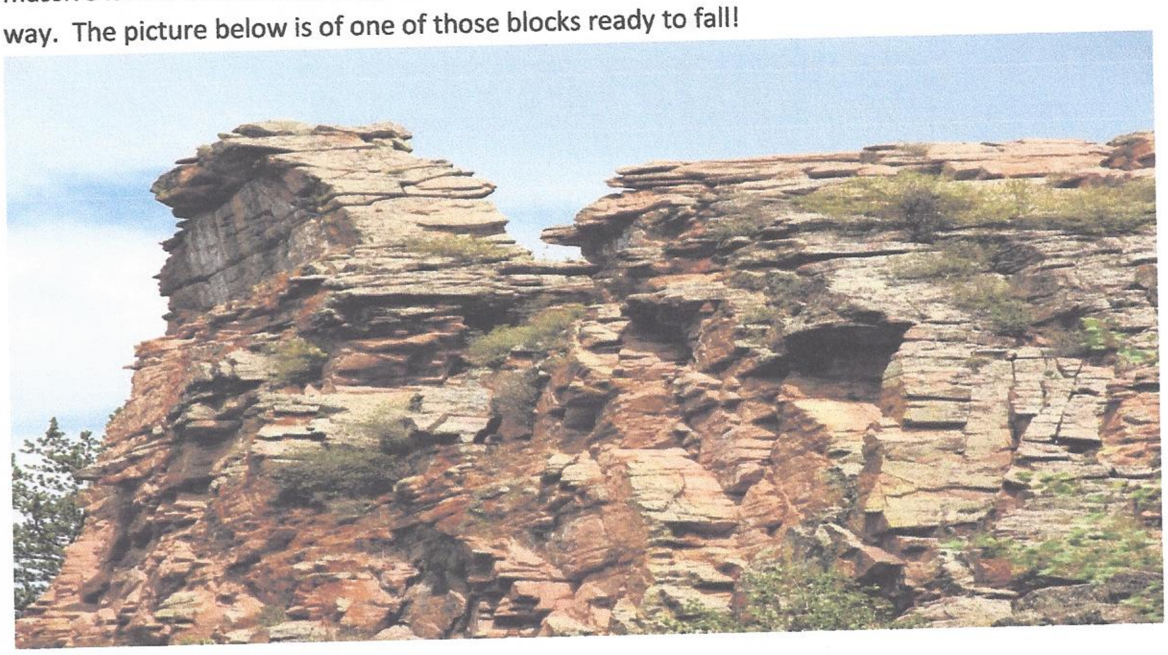


Image 8 Fractures resulting from faulting & uplift augmented by freezing & thawing of water

Chemical/ Biological weathering

There are a few more tools that nature has in store to sculpt with. These include chemical/biological weathering and wind. If you examine the picture below, you will detect two forms of chemical/biological weathering in the process of helping to break the rocks down. The first is the plants growing in the fractures. As the wind blows seeds into the cracks, they are preserved and protected. Water percolates through the cracks and plants and trees begin to grow. When the roots grow larger, they begin to open the fractures wider.

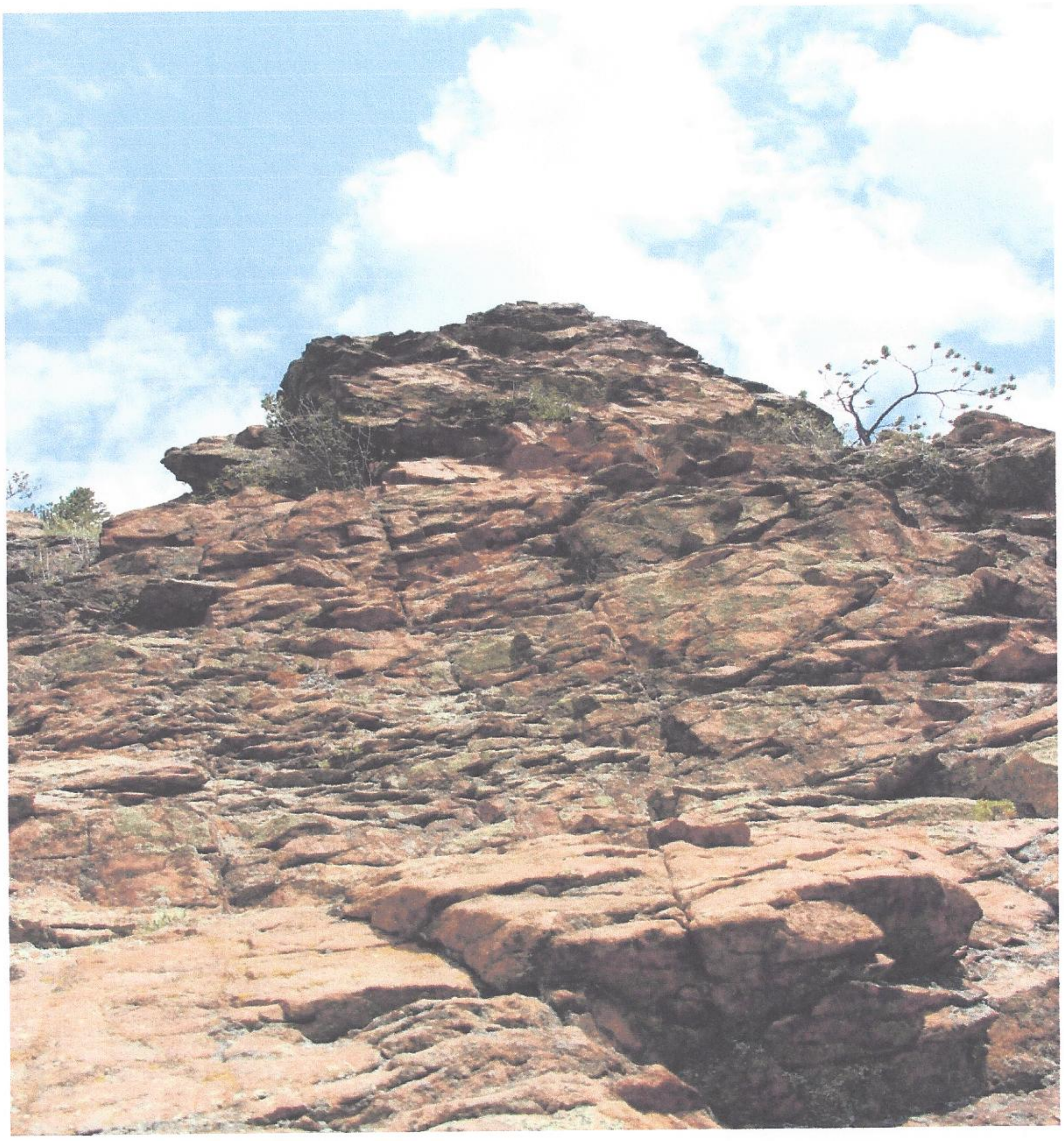


Image 9. Weathering and biological put the finishing touches on the rock story.

The other agent working here is lichen! Lichen very slowly weakens the granites through chemical processes and eventually makes it easier for the other weathering agents to erode the rock. It also adds fascinating colored patterns to the outcrops. As you hike in the park, notice the different colors of lichen. Each color is a different colony with identical DNA. Some geologist are conducting research to see if they can use lichen distribution of individual colonies to date how long a rock has been exposed to the surface. Lichen draws its nutrients from the minerals in the rock. As it draws on these chemicals, it actually breaks down the minerals that form the rock. The end result is a weakened rock surface.

The granites of Staunton originally solidified miles under the surface where pressures and temperatures were extreme. Many periods of uplift and erosion of younger overlying sediments have now brought these rocks to the surface at Staunton. The minerals that make up the granitic rock are unstable at the cooler surface temperatures and lower confining pressures. These minerals as they are exposed to atmosphere, immediately begin changing form and eventually transform into softer clays and compounds. These compounds are then more easily attacked by the other weathering processes. This is chemical weathering.

Wind Erosion

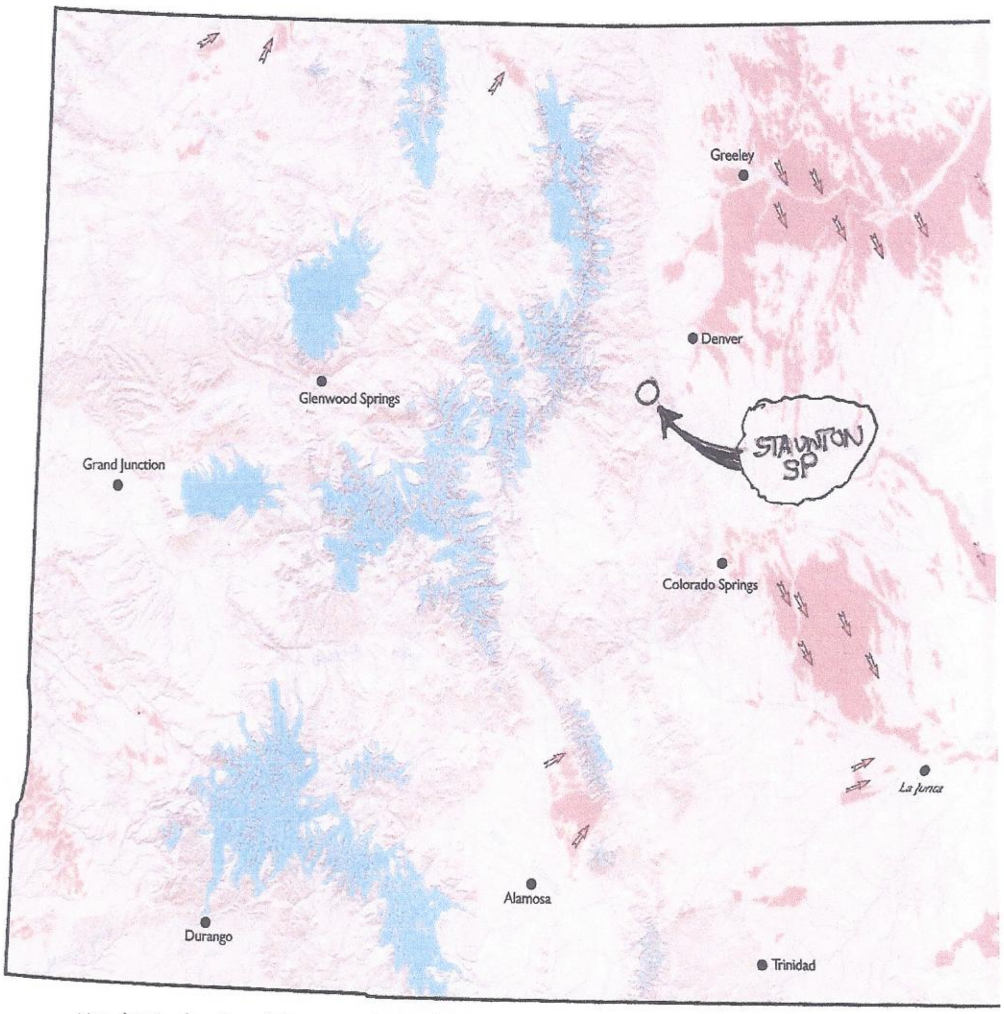
Wind is also a sculpting tool that quite often contributes to the "hoodoo" look of some of the outcrops of granite. Wind can carry small particles of sand that act as abrasives much like sand paper. These abrasives slowly round the blocky outcrops through many years of wind storms.

Glaciation

Let's include a quick note about glaciation. Glaciers are grand sculptors!! Erosion by moving glaciers sculpts beautiful knife edge ridges, pointed peaks, broad U-shaped valleys and awesome tarn lakes. At Staunton, within the park, there is no clear evidence of glaciation. However, as you find occasion to stand on top of one of Staunton's many high peaks and ridges, check out the view toward the higher Rocky Mountains to the north and west. The evidence of glacial sculpting is breathtaking! Most of the glaciation that you see in this area occurred above 10,000 feet. Those glaciated peaks are found west of Staunton State Park as shown in blue in Figure 7.

All of these tools of nature have combined to sculpt this beautiful and picturesque Staunton State Park. This is what geology and its processes are all about. ENJOY THE EXPERIENCE – ENJOY THE STORY THAT THESE ROCKS TELL!

Quaternary Glacier and Sand Distribution



Map showing location of Quaternary glaciers (blue), major sand deposits (tan), and dominant wind directions (arrows). The Quaternary climate was one of warming and cooling, warming and cooling, over and over again. In the Colorado mountains we find evidence of at least three glaciations, with hints of more. The map shows the maximum extent of glacial ice based on the location of glacial erosion and deposits of till.

Sand sheets and dunes on the eastern plains of Colorado h... tory coinciding with the glacial periods. Windblown sand r... ness from 10 to greater than 120 feet and is primarily the r... sand deposition during the last glacial period. Subseque... droughts reduced vegetation cover, allowing strong winds fr... west to redistribute the sand into parabolic dunes. The ar... the dominant wind direction based on analysis of the orie... parabolic dunes. Interestingly, fossils provide evidence o... and camels living among the dunes.

Distribution of glaciers by John C. Reed; distribution of sa... directions by Richard F. Madole, USGS Geologists Emeriti.

Figure 7.

GEOLOGIC HISTORY OF STAUNTON

1.7 Billion Years Ago

- Giant crustal plates were on the move.
- A deep ocean basin formed between continental plates in Western Colorado and Wyoming.
- The abyss was filled with ancient ocean sediments and volcanic rock.
- These rocks were later deeply buried and heated to intense temperatures forming gneiss and schist.

1.4-1.08 billion Years Ago

- Regional igneous activity occurred along a northwest trending band in west central Colorado.
- Several episodes occurred over the ensuing 4 million years, culminating with the Pikes Peak granite emplacement miles under the surface beneath Staunton State Park.

780 Million Years Ago

- A period of Intense global warming and abrupt worldwide melting of glaciers.
- Over the following years, the mountains in the Staunton area slowly eroded into a broad highland.
- This highland, during a rise in sea level, was covered by ancient oceans from time to time and marine sediments were deposited over top of the Staunton area.

300 Million Years Ago

- The Ancestral Rockies raised high into the air during east west compression and were high and dry!
- The north trending mountains immediately began shedding eroded sediments to the east into the Denver Basin.
- Over the next millions of years, Staunton was once more leveled to a broad gentle highland.

50-70 Million Years ago – Laramide orogeny -Armageddon

- Renewed east west compression was once again the name of the game.
- A northwest trending chain of mountains once again rose up into the air – The Rocky Mountains were formed, including the Front Range and Staunton.
- Widespread igneous activity and volcanos spread vast quantities of ash into the atmosphere causing temperatures to drop. The result – the extinction of the dinosaurs!

Note: Some scientist theorize that the extinction of the non- avian (bird) dinosaurs was caused by one or more asteroid impacts. Several impact craters have been located and age dated to be in the 66 million time range. This catastrophic event may have knocked the earth slightly off of its rotation,

resulting in cracking and movement of crustal plates and increased volcanic activity worldwide. The volcanic eruptions filled the atmosphere with smoke and ash and blocked the sun from warming the surface. A period of global cooling resulted and the cold blooded dinosaurs were doomed to extinction.

25 Million Years ago

The once more eroded gently rolling low relief surface over Staunton underwent another mountain building event. This event was due to relaxation of crustal forces and resulted in large northwest trending block faults. These faults occurred along the older fault zones imprinted in the crust during the previous mountain building events 300 and 66 million years ago.

- Large northwest trending valleys and ridges were the result, raising the Rocky Mountains high up into the sky yet again.
- The 1.0 to 1.7 billion year old metamorphic rocks and granites were now pushed up close to the surface and exposed due to renewed erosion.

5 Million Years-Present

- Regional uplift over all of Colorado resulting in accelerated erosion and sculpting of the Staunton area
- The rivers and creeks that ran through the canyons cut them deeper and smoothed them out.
- The ridges were molded and sculpted due to weathering and erosion into a masterpiece of nature.
- Although the Elk Creek Valley at Staunton is relatively small by Colorado standards, it is still beautifully impressive as are its larger cousins – the Black Canyon of The Gunnison, Glenwood Canyon, Clear Creek the Big Thompson and Castlewood Canyon which all were formed by the same geologic processes and at generally the same time. The accompanying ridges of sculpted granite, like Lions Head are equally impressive.
- The ensuing erosion over the last 5 million years has indeed sculpted a masterpiece.

Geologic Map & KEY

Included below, is a geologic map of Staunton State Park. A geologic map simply shows the distribution of various rock types exposed on the surface. If you picture yourself hovering in a helicopter over Staunton State Park, looking down, this map represents the rock types, the faults and the geographic features that you would see. Each different type and age of rock is depicted by a different symbol and color and the age noted within that color. Faults are shown as green lines with the up side annotated "U" and the downside annotated with a "D". The geologic map key that precedes the map shows the respective colors and rock types (formations) depicted on the map.

This map was modified from The USGS Denver West Quadrangle mapping done by Karl Kellogg et al. The modifications and reinterpretation was based on field work conducted in August of 2012 by Scott Knight.

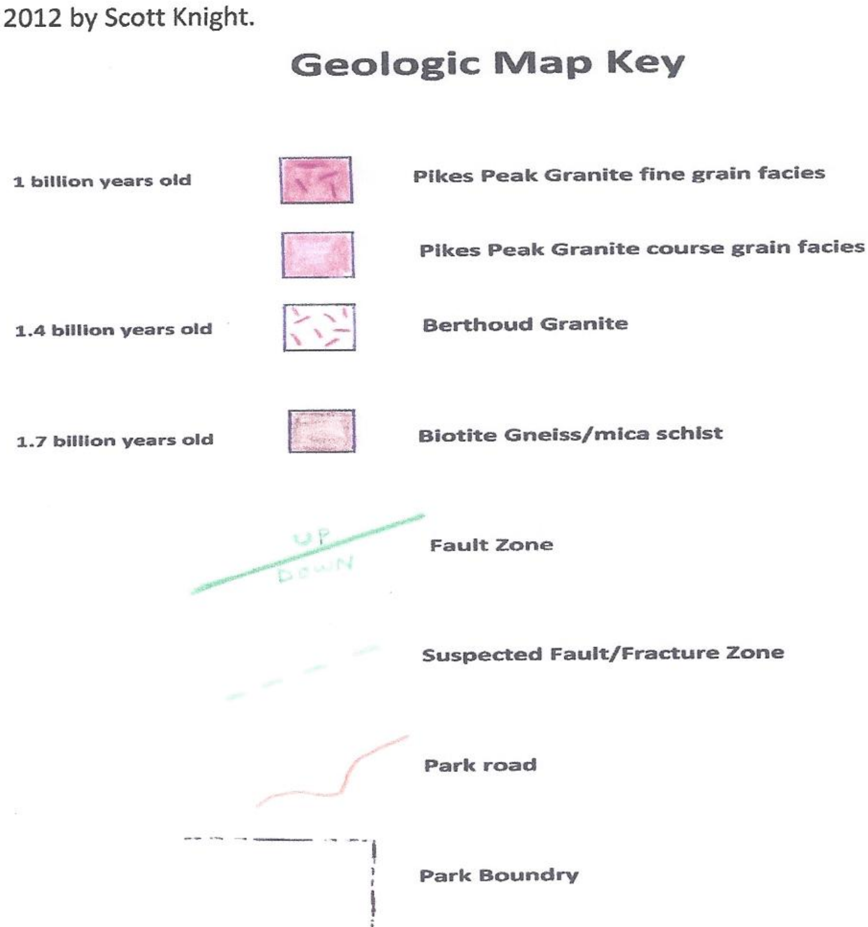


Figure 8. Legend to Geologic Map of Staunton State Park

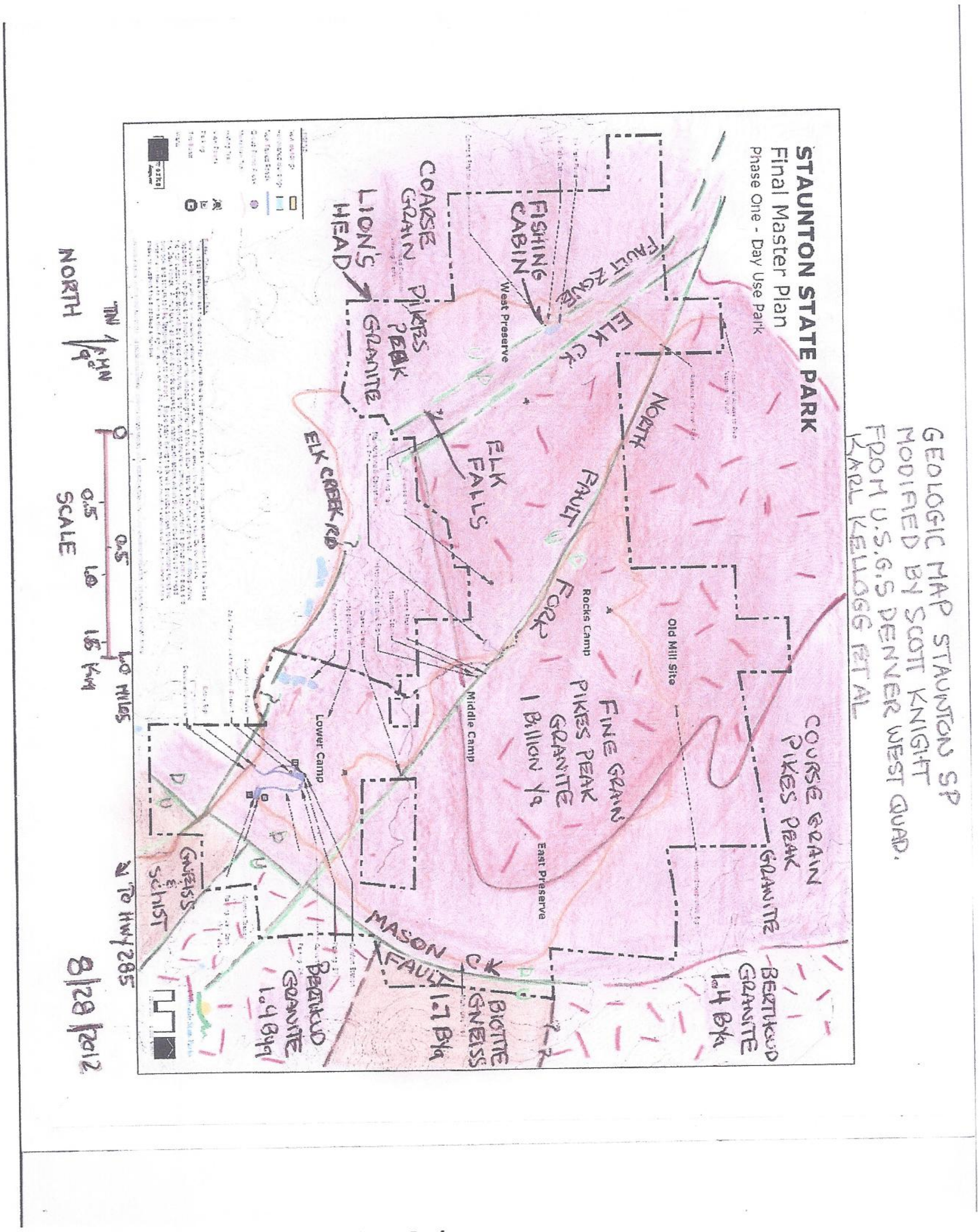


Figure 9. Geologic Map of Staunton State Park

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