

Grand Canyon Geology



The Geologic Record as Told by the Rocks

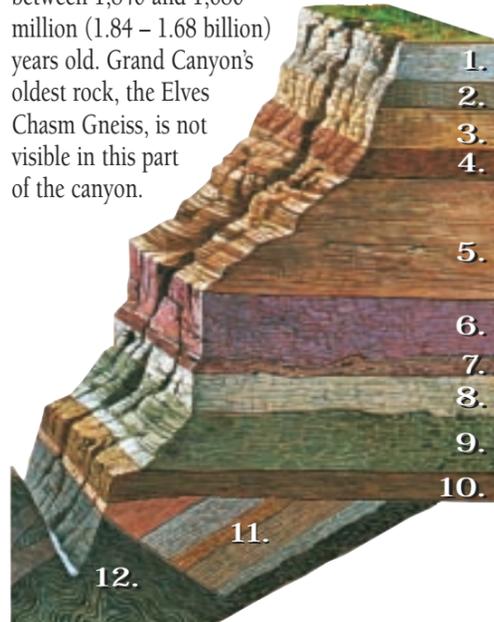
Nowhere on this planet are the scope of geologic time and the power of geologic processes as superbly and beautifully exposed as in these canyon walls. Rocks equivalent to many of these strata may be found scattered throughout the United States, and flowing water has sculpted other landscapes. Yet, at Grand Canyon, a remarkable geologic assemblage is exposed in sequence and intact in an amazing erosional landscape.

The canyon walls reach about 5,000 feet (1,500 meters) below the rim to the river. The thickness of all Grand Canyon rocks, if present in one spot, would total more than 15,000 feet (4,600 m). Some rock units, however, appear only in some parts of the canyon. The strata of Grand Canyon do not present a continuous record of Earth's history. Some rock layers eroded away before newer layers were deposited on top producing unconformities, millions of years of missing time and unknown geologic stories.

Each rock layer represents a period when a particular environment of deposition prevailed. For example, the Kaibab Formation, the rock that makes the canyon rims, is the youngest of Grand Canyon's layers. The Kaibab limestone formed in shallow, warm seas about 260 million years ago, a bit before dinosaurs roamed the Earth. Below the Kaibab limestone caprock, the strata become progressively older.

The oldest rocks lie more than 3,000 feet (900 m) beneath the rim in the walls of the Inner Gorge. The Vishnu basement rocks consist of ancient igneous and metamorphic rocks that formed deep within the Earth when island arcs collided with the continental mass. These crystalline rocks—schist, gneiss, and

granite—are very different in origin and structure than the sedimentary rocks above them. The Vishnu basement rocks, including Vishnu Schist, are between 1,840 and 1,680 million (1.84 – 1.68 billion) years old. Grand Canyon's oldest rock, the Elves Chasm Gneiss, is not visible in this part of the canyon.



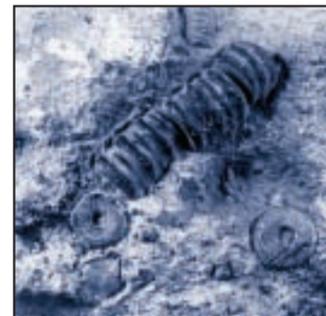
Geologic Cross Section of Grand Canyon

- | | |
|-----------------------------|-------------------|
| 1. Kaibab Formation |270 my |
| 2. Toroweap Formation |273 my |
| 3. Coconino Sandstone |275 my |
| 4. Hermit Formation |280 my |
| 5. Supai Group |315–285 my |
| 6. Redwall Limestone |340 my |
| 7. Temple Butte Formation |385 my |
| 8. Muav Limestone |505 my |
| 9. Bright Angel Shale |515 my |
| 10. Tapeats Sandstone |525 my |
| 11. Grand Canyon Supergroup | ...1,250–740 my |
| 12. Vishnu basement rocks | ...1,840–1,680 my |

Canyon Origins

Although the origin of Grand Canyon is complex and not totally deciphered, the forces that shaped it are well understood. Grand Canyon is the result of erosion, specifically incision by a river into a high, arid plateau. The Colorado River carved the depth of the canyon as it cut its way through the Kaibab Plateau which is more than 7,000 feet (2,100 meters) above sea level. Side canyons, scoured by summer thunderstorms and winter snow melt, produce much of Grand Canyon's 10 – 16-mile (16 – 22 km) width.

Compared to the rocks exposed in its walls, Grand Canyon is geologically young. Excavation of the canyon occurred within the last six million years or so. The question of how the Colorado River evolved its present course is still unresolved, even though geologists have hypothesized for years about how the river first established its path across the plateau and carved this immense chasm. Much of the uncertainty regarding the exact age and history of the canyon centers on the reality that we have only scattered bits of evidence to reconstruct its history and to precisely date its origin. The history of the Colorado River is obviously complex and will be the subject of geologic research for years to come.



Fossils of crinoids, marine animals that look like sea lilies, can be found in the 260 million year old Kaibab Formation.

The Landscape

The grandeur of Grand Canyon lies not only in its size, but also in the beauty of its landscape. In this respect, Grand Canyon shares many characteristics with its neighbors — Zion, Bryce, Canyonlands, Arches, and Capitol Reef National Parks. Like Grand Canyon, these neighboring parks lie within the geologic province known as the Colorado Plateau, a region characterized by mostly flat-lying sedimentary rocks that have been raised thousands of feet above sea level, then carved by erosion.

Landforms here are beautifully sculpted and well exposed due, in part, to climate. The semi-arid climate that predominates in the Southwest means that instead of tree-covered slopes and thick soils, bedrock is at the surface. Therefore, rain does not soak into the ground; instead it runs off in huge floods carrying away grains of rock. Cycles of freezing and thawing in the winter widen cracks in the rocks, eventually producing rockfalls. Soft layers erode more rapidly undermining the hard layers above. Bit by bit, flashflood by flashflood, and rock fall by rock fall, the canyon continues to grow.

Each of the rock units within the canyon erodes in its own manner, yielding the characteristic stepped-pyramid look of the canyon. Shales erode to slopes, while harder sandstones and limestones tend to form cliffs. The extremely hard metamorphic rocks at the bottom of the canyon produce the steep-walled and narrow Inner Gorge, as these rocks are more resistant to erosion than the softer sedimentary rocks above.

Color is also an important feature of this landscape. Many of these colors are due to the presence of small amounts of iron oxides and other minerals that are either in the rock itself or stain the surface and mask the true color of the rock.

The River Below

The Colorado River flows 277 river miles (446 km) from Lees Ferry to the Grand Wash Cliffs, the accepted beginning and end of Grand Canyon. Hidden in the narrow Inner Gorge, the river is visible from only a few spots along the trail. From the rim, the river looks puny, yet it averages 300 feet (90 m) wide and features a series of fierce rapids. From its origins high in the Colorado Rockies, the river drops more than 12,000 feet (3,700 m) and passes through a series of canyons, including the Grand Canyon, on its 1,450-mile (2,300 km) journey to the Gulf of California.

The name *Colorado* is derived from Spanish for reddish, reflecting the heavy sediment loads the river once transported. Dams now bracket Grand Canyon — Glen Canyon Dam (Lake Powell) upstream and Hoover Dam (Lake Mead) downstream. As a result of these dams, the dynamics of the Colorado River through Grand Canyon changed dramatically. Gone are the large annual floods that carried hundreds of thousands of tons of sediment through the canyon each day.

Today, the Colorado is seldom its natural muddy red-brown color. Only when tributaries downstream from Glen Canyon Dam, such as the Paria and Little Colorado Rivers, contribute significant amounts of sediment during flash floods or spring snowmelt, does the river change from clear blue-green to its natural reddish-brown.

The North Rim

On the far side of the canyon lies the North Rim, ten miles away as the raven flies. Although it is not apparent, the north wall of the canyon rises a thousand feet higher than the South Rim, giving the North Rim nearly twice the annual precipitation received here. This considerable difference in elevation results from the fact that the apparently flat-lying rocks of the Kaibab Plateau are dipping gently to the south.



Life Along the Rim



National Park Service
U.S. Department of the Interior

Grand Canyon National Park
Arizona



Life Along the Rim



Grand Canyon National Park

The **South Rim** of Grand Canyon marks the northern edge of a high plateau whose gray-green forests stand out in vivid contrast to the arid lands below the rim. From here the cliffs of Grand Canyon drop 5,000 feet/1,500 meters to the Colorado River, crossing several biotic zones. This is a landscape characterized by abundant sunshine, extremes of temperature, and long periods of drought, punctuated by downpours in summer and snow in winter. Precipitation on the South Rim averages fifteen inches/38 centimeters per year, twice that received at the river but half that received on the North Rim, just ten miles across the canyon. Even here at 7,000 feet/2,100 meters above sea level the climate is semi-arid.

It is not what most plants and animals would call a paradise. The soil is thin; bedrock lies just a few inches below the surface. The competition for moisture in this arid land is keen. All the plants and animals that live here must adapt to the lack of moisture and extremes of temperature that characterize the region.

Rugged as it looks, it is a fragile land whose scars persist for many years. Walk softly. Be alert to the sights, sounds, and smells that surround you, for there is much to experience here.

The plants and animals described here are common throughout the South Rim and may be seen wherever you choose to walk along the Rim Trail. There are no numbered stops to follow. Use caution near the edge—humans are among the less surefooted creatures at Grand Canyon.

The tallest tree on the South Rim is the **ponderosa pine**. It has an extensive root system to acquire as much moisture as possible. Stiff competition for water results in an open, park-like forest. The bark on young trees is dark (hence the name “black jack” often applied to younger ponderosas), but by the time ponderosa pine trees mature, the bark is cinnamon in color and smells faintly of vanilla. This is the only long-needled pine in the park.

Wherever you see ponderosa pines, look for evidence of the **Abert squirrel**. It is one of two varieties of tassel-eared squirrels found in the park—the other being the **Kaibab squirrel**, found only on the North Rim. Both are entirely dependent upon ponderosa pines for food and habitat.

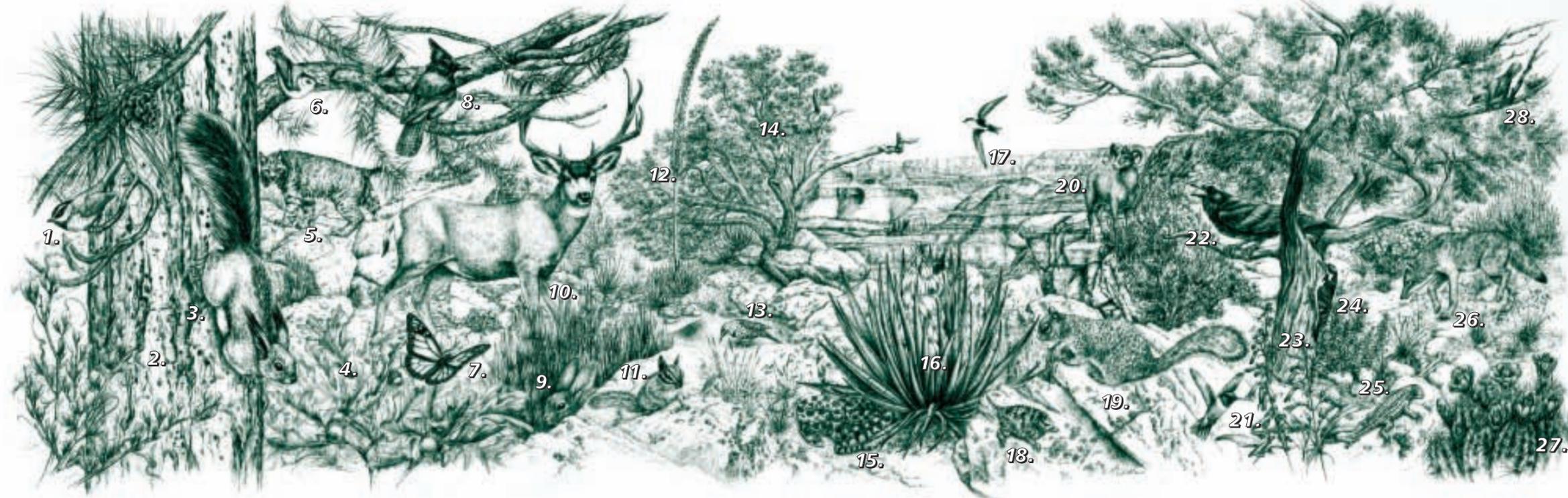
Scattered among the trees are a variety of drought-resistant shrubs. In late spring and early summer you will likely smell **cliffrose** before you see it. A member of the rose family, this evergreen shrub produces fragrant cream-colored flowers. These blossoms give way to seeds whose feathery white plumes allow the wind to scatter them some distance. Also common here is the **banana yucca**, one of the most common and useful plants in the American Southwest. Native Americans have traditionally used it in the manufacture of soap, as a source of fiber for rope and sandals, and for its edible fruits that resemble small bananas.

The **mountain chickadee** and the **nuthatches** are small, acrobatic birds common in these coniferous forests. The mountain chickadee is easily recognized by its black bib and the white stripe over its eye. Gleaning insects from the outer branches of conifers, this small bird will often hang upside down in search of insects. The nuthatch similarly uses its slender bill to search for insects in the bark of trees, but it is unusual in that it will scurry down a tree headfirst.

Only the most observant and cautious hikers are likely to see the **bobcat**, a shy creature who frequents the North and South Rims but is rarely seen. **Mule deer**, on the other hand, are among the most readily seen mammals on the South Rim. Surefooted and nimble, they travel in and out of the canyon with ease as food and water dictate. The earliest trails into the canyon were likely built along deer paths. Mule deer are readily distinguished by their large ears.

The **coyote** is relatively common and ranges throughout the park from rim to river, but you must be alert to spot one. This close relative of the domestic dog is primarily nocturnal; their late night or early morning howls are among the most distinctive songs of the canyon region. Their diet consists mainly of rodents and insects.

At elevations below 7,000 feet/2,100 meters the **pinyon pine** and **Utah juniper** become the dominant members of the South Rim forest. The short-needled pinyon is prized for its edible seeds. The juniper, with its shaggy bark, is particularly well adapted to this arid climate: leaves have been reduced to scales covered by a waxy cuticle, both of which



1. Mountain Chickadee, 2. Ponderosa Pine, 3. Tassel-eared Squirrel, 4. Scrub Oak, 5. Bobcat, 6. Nuthatch, 7. Monarch Butterfly, 8. Steller's Jay, 9. Desert Cottontail, 10. Mule Deer, 11. Cliff Chipmunk, 12. Utah Agave, 13. Red Shafted Flicker, 14. Pinyon Pine, 15. Gopher Snake, 16. Banana Yucca, 17. White-throated Swift,

reduce water loss and insulate the tree against extremes of temperature. Many of these gnarled trees are a good deal older than they look. Both trees grow slowly in this arid climate, and many of them are over 200 years old. Clumps of **dwarf mistletoe** are common in conifers throughout the forest. This parasitic plant draws nutrients and water from its host tree.

Although many people expect to encounter poisonous snakes at Grand Canyon, the handsome **gopher snake** is the only snake you are likely to see on the rim. A non-poisonous predator, it mimics the threatening behavior of poisonous species, but kills its prey by squeezing it until it suffocates. Most of the water this snake needs is obtained from the rodents it consumes.

Among the reptiles commonly seen along the rim are **eastern fence lizards**. Look for a blue patch on either side of their throat. They prefer open, rocky areas along the rim and, like most reptiles, are very well adapted to arid environments.

While standing on the rim, listen for the “whoosh” of **white-throated swifts** and **violet-green swallows**. Swift, agile fliers, they dive through the air in relentless pursuit of insects. The large black bird commonly seen perched along the rim or soaring above the canyon is the **raven**. Larger than crows, these birds are extremely intelligent and mimic a wide variety of animal noises.

18. Short-horned Lizard, 19. Rock Squirrel, 20. Desert Bighorn, 21. Black-chinned Hummingbird, 22. Raven, 23. Utah Juniper, 24. Hairy Woodpecker, 25. Northern Plateau Lizard, 26. Coyote, 27. Claret Cup Cactus, 28. Pinyon Jay. Illustration by Elizabeth McClelland.

Among the largest hoofed mammals in the park are the **desert bighorn sheep**, but they are relatively scarce along the rim, preferring the rocky slopes of the inner canyon. They do not shed the long, curved horns that continue to grow throughout their lives. Like many mammals of the region, they are likely to be found near reliable sources of water: springs, seeps, or pools of summer rain.

In developed areas along the rim **rock squirrels** have lost their natural fear of humans and are often seen begging for handouts. It is dangerous and illegal to feed them. **Do not offer them food!**

The bright red **claret cup** is the more common of two species of hedgehog cactus at Grand Canyon. At lower elevations its showy red blooms appear in April. Here on the rim it favors the sunny, warm areas on the canyon's edge (blooming in May or June) and gives one a hint of the diversity and beauty that await those who venture beyond the world of the South Rim into the inner canyon.

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