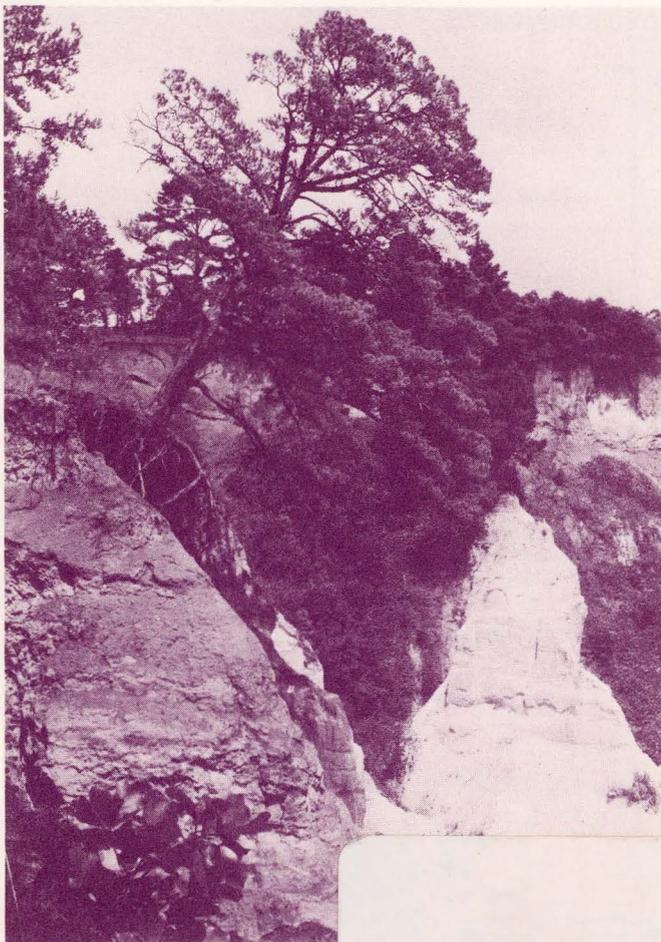


GEOLOGIC GUIDE TO PROVIDENCE CANYON STATE PARK

Lisa G. Joyce



DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

Geologic Guide 9

(in millions of years)	ERA	PERIOD	FORMS OF LIFE	EVENTS IN GEORGIA
0	CENOZOIC	QUATERNARY	AGE OF MAN earliest man 1st apes, grasses 1st monkeys	Erosion causes the development of Providence Canyon.
		TERTIARY	AGE OF MAMMALS	Deposition of the Clayton Formation.
100	MESOZOIC	CRETACEOUS	extinction of dinosaurs 1st snakes 1st angiosperms (blooming plants)	unconformity Deposition of the Providence Formation.
		JURASSIC	AGE OF REPTILES 1st birds	
200		TRIASSIC	1st dinosaurs, mammals	
300	PALEOZOIC	PERMIAN	1st frogs, evergreens	
		PENNSYLVANIAN	1st reptiles AGE OF AMPHIBIANS	
		MISSISSIPPIAN		
400		DEVONIAN	1st scale trees, ferns, amphibians AGE OF FISHES	
		SILURIAN	1st air breathing animals, land plants	
500		ORDOVICIAN	1st fishes	
600		CAMBRIAN	1st hard-shelled invertebrates	
		PRECAMBRIAN	multi-cellular life forms one-celled life forms	

Modified from 1:2,000,000
Geologic Map of Georgia

GEOLOGIC TIME CHART

Geologic Guide to
Providence Canyon State Park

Lisa G. Joyce

Department of Natural Resources
J. Leonard Ledbetter, Commissioner

Environmental Protection Division
Harold F. Reheis, Assistant Director

Georgia Geologic Survey
William H. McLemore, State Geologist

Atlanta

1985

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INTRODUCTION

Providence Canyon State Park, often referred to as "Georgia's Little Grand Canyon," is located approximately 150 miles southwest of Atlanta in a portion of the State known as the **Coastal Plain**. This physiographic province occupies the southern 60 percent of Georgia (see fig. 1). It is composed of loosely arranged sand and clay particles, called **sediments**; these particles were transported from the uplands by running water and deposited in river bottoms and shallow ocean bottom. Sea level then fell, exposing these sediments as "dry land."

The park was established in 1971 and serves as an ideal outdoor workshop where **geologic history** as observed from the rocks, and forces which shape the landscape, known as **geomorphic processes**, may be studied. The canyon, which is continually undergoing change by erosion, is believed to have begun forming approximately 150 years ago when runoff from rainfall was allowed to flow unimpeded across plowed fields. The lack of vegetation allowed the surface runoff of rainwater to carry off topsoil, forming small gullies which gradually widened and deepened to form the canyon as we see it today.

A hike to the bottom of the canyon will be a spectacular trip through time, with each step downward crossing many thousands of years in the geologic record. The results of nature's timeless struggle to maintain its precarious balance between erosion and deposition can be observed from the canyon rim trail. The most spectacular views can be observed from the canyon rim trail in the east part of the park, particularly near the picnic area.

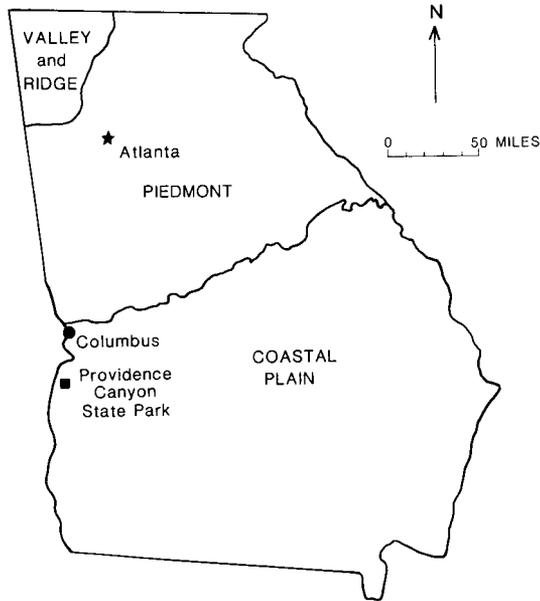


Figure 1. Location map of Providence Canyon State Park.

GEOLOGY

The guidebook has been designed to complement the geologic setting of the park and to answer questions that visitors may have about the geology of the area. Because the canyon is sculpted from loose, **unconsolidated** sediments, changes can occur rapidly. Heavy rains have removed as much as six feet of canyon floor in one night. Because change seems to be the only constant condition of the canyon, it is inappropriate to establish designated stops on the trails. Therefore, questions will be asked of the reader, thus affording him the opportunity to observe and contemplate the geology of the park. These questions will then be answered and explained with accompanying photographs and diagrams. Five of the most commonly

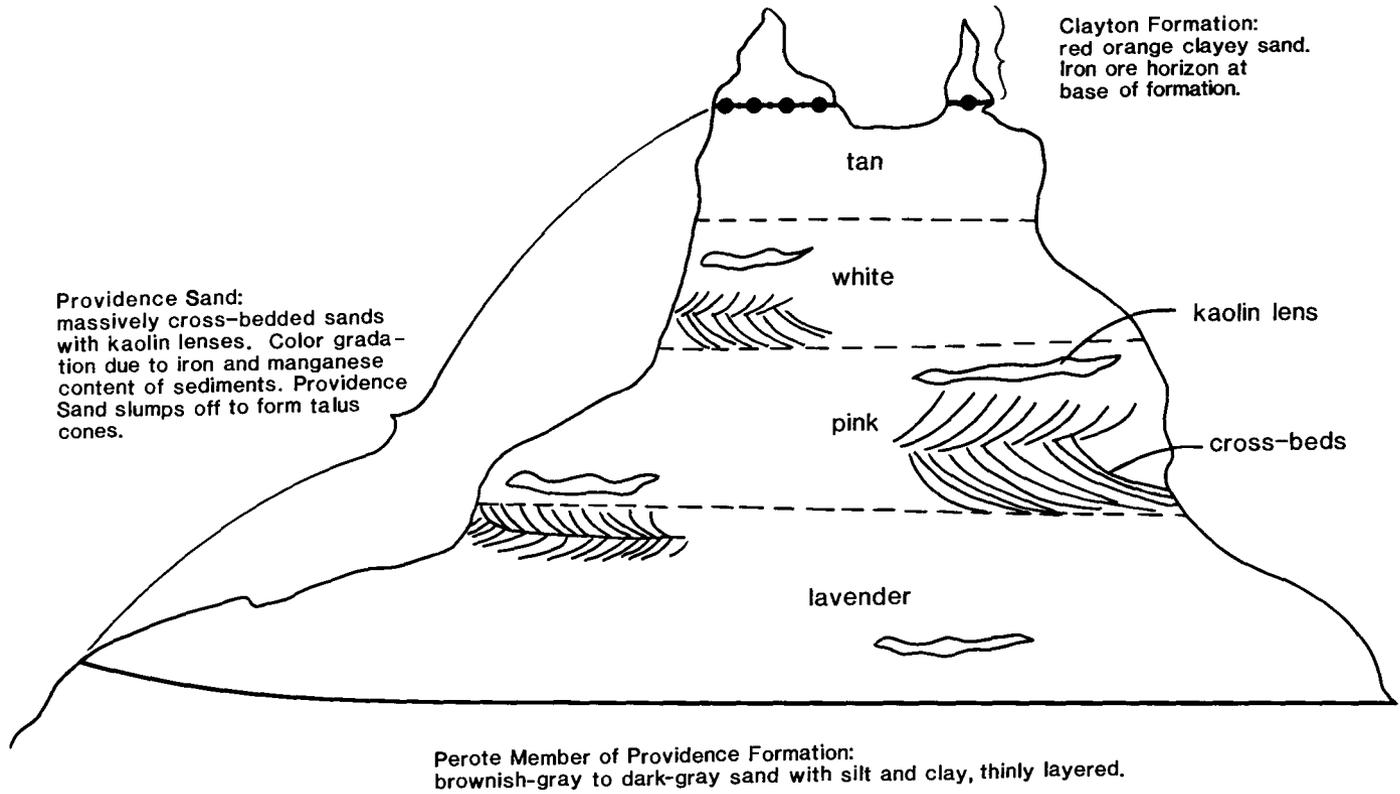
asked geologic questions about the park will be discussed. These are: 1) What kinds of sediment are present in Providence Canyon? 2) What was the environment of deposition of these sediments? or, how did the sediments get here? 3) How did the canyon form? 4) Will Providence Canyon continue to get larger? 5) What caused the different colors in the canyon wall? The evidence for the answers to these questions may be observed from the canyon rim trail, the canyon floor trail, or both.

By posing these questions, the guidebook gives the reader a chance to be a "geologist for the day." Much of the field of geology is based on observation from the record of events of earth history that is preserved in the rocks. Through the use of **geologic history**, geologists are trained to question what they observe, to apply geologic principles, and to develop interpretations.

Finally, this guidebook has been written to help make your visit to Providence Canyon State Park a more enjoyable one by increasing your knowledge of the geology of the area. It is hoped that this opportunity for you to study the geologic processes will increase your concern for the wise management of our environment and the conservation of our natural resources.

Question 1: What kinds of sediments are present in Providence Canyon?

Two distinctive, recognizable bodies of rock or sediment, known as **geologic formations**, may be observed in the canyon. These are the Providence Formation and the Clayton Formation. Each formation is obviously different and may be readily identified with the aid of some simple comparisons (see fig. 2a).



4

Figure 2a. Cross-sectional diagram of Providence Canyon sediments.

The Providence Formation is separated into two parts. The Perote Member is exposed only in the bottom of the canyon, and ranges in thickness from a few feet to approximately 30 feet. It is a brownish-gray to dark-gray **sand** with **silt** and **clay**, which looks and feels like a mixture of modeling clay and beach sand. The Perote also contains flakes of a shiny, gold or silver-colored mineral, known as **mica**, which looks like glitter (see fig. 2b).

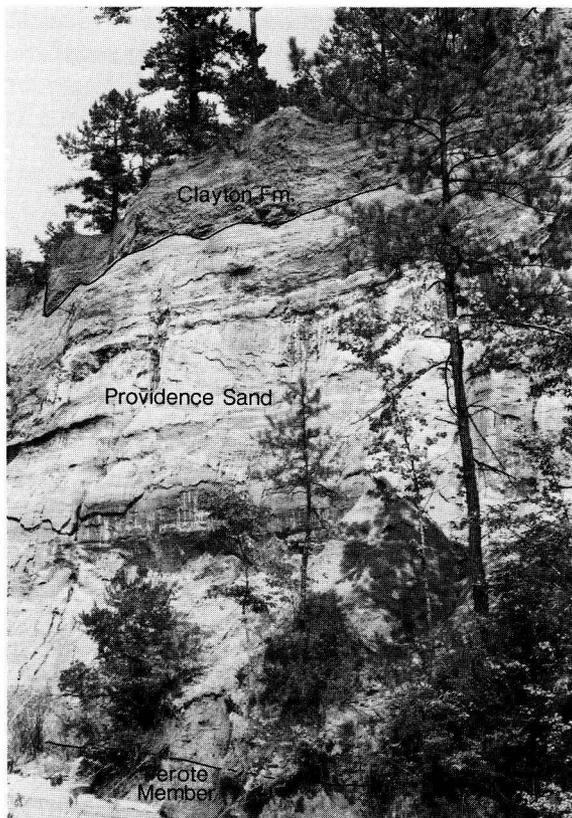


Figure 2b. View of the canyon wall from the canyon floor. All three sediment types are observed: the Perote Member, the Providence Sand, and the Clayton Formation.

The Providence sands overlying the Perote consist largely of sand with some clay. If you rub some of the sand between your hands, it will feel gritty and may leave a slippery white stain which feels like baby powder. The stain is a white clay called **kaolin**. The Providence Sand is 119 feet thick in the canyon and ranges in color from white to buff to tan, and even salmon, pink, and lavender (see fig. 2a, 2b). If you look very closely at the canyon walls from the trail, you can see that within the massive horizontal layers of sand, there are thinner layers which are at an angle to the massive layers. This structure is called **cross-bedding** and indicates that the sand was deposited in water with strong currents. (See fig. 3).

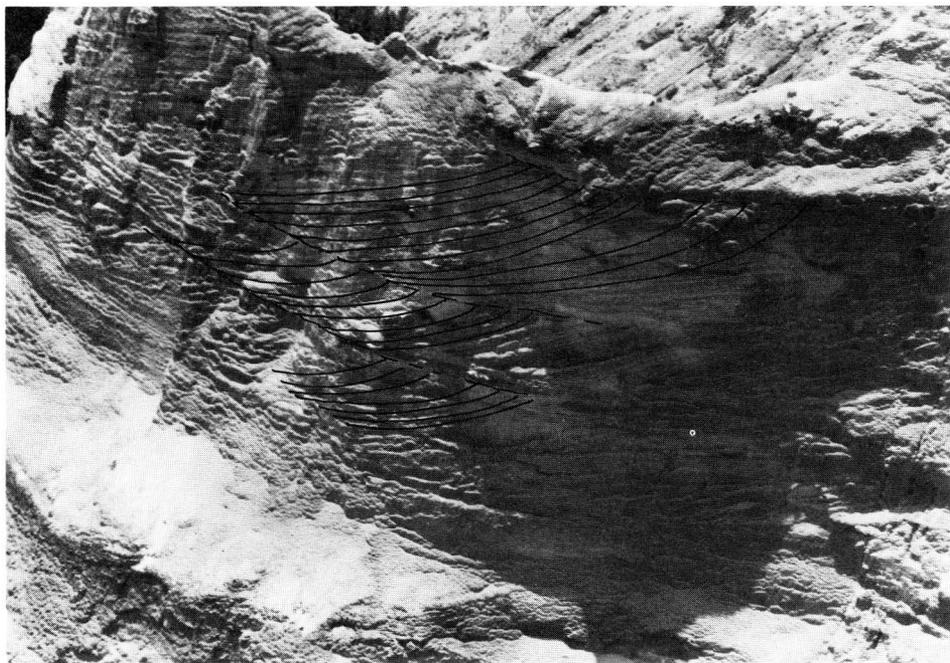


Figure 3. Cross-bedding in the Providence Sand. Thinner beds are at an angle to the wider relatively horizontal beds.

The Clayton Formation is a red-orange sandy clay and is exposed near the top of the canyon (see fig. 2a, 2b). Look at the surface where the two sediment types meet. This is the **contact** between the Providence and the Clayton (see fig. 4). Do you notice anything unusual about it? The contact is irregular and uneven. It is an ancient erosional surface, or **unconformity**, which represents a gap in the **geologic record**. The unconformity records periods of erosion. From this and other evidence, geologists have concluded that sea level has not remained constant. Rather, it has undergone fluctuations. When sea level was high, deposition occurred. When sea level was subsequently lowered, the area of previously deposited sediment was exposed, becoming "dry land." Erosion began to operate, transforming the uniform depositional surface into an irregular erosional surface. Sea level rose again at some later time, flooding the land and depositing sediments on the erosional surface. This created the unconformity, which is preserved in the geologic record.



Figure 4. Unconformity between the Clayton and Providence Formations. The rough, uneven contact represents a period of erosion or non-deposition.

The Clayton contains a layer of iron ore near the base of the formation. The iron ore can be recognized easily because it is very hard and heavy, and resembles rusted metal. In many areas near the park, the ore is high-grade and has been mined for the manufacture of steel.

Question 2: What was the environment of deposition of these sediments? or, how did the sediments get here?

The layers of sediment visible in the canyon were deposited by water between 85 million and 65 million years ago (see Geologic Time Chart - inside front cover). The presence of the fossilized remains of marine organisms in some of the layers suggests that portions of this area were once a part of the shallow ocean bottom or shoreline.

Question 3: How did the canyon form?

Because the Grand Canyon owes its origin to the erosional capability of the Colorado River and its tributaries, you might think that Providence Canyon also owes its genesis to a river. Although both canyons are the result of the erosive power of water, Providence Canyon was formed in a somewhat different manner, and, therefore, does not have a permanent river or waterfalls.

A popular legend connects the origin of the canyon with water dripping from the roof of a barn. However, based on historical accounts, the canyon apparently began forming as a result of poor soil management practices. When this region was settled in the early 1800's, most of the original forest was cleared for farming. At that time, soil management practices, such as contour plowing and strip cropping, had not been developed. Man had removed the natural vegetative cover; this caused the runoff to flow unchecked across the barren landscape to form gullies. Once

these gullies had cut through the red-orange sand and clay of the Clayton and reached the easily eroded Providence Sand, erosion progressed at a runaway rate. The gullies served to concentrate the runoff into small wet-weather streams, which increased the rate of erosion. Such streams are present in the canyon bottom today during times of abundant rainfall. A tremendous volume of sediment is carried by runoff and transferred to the stream, which has become choked with this sediment, and exhibits a branching, tangled pattern, known as a **braided stream** pattern (see fig. 5).

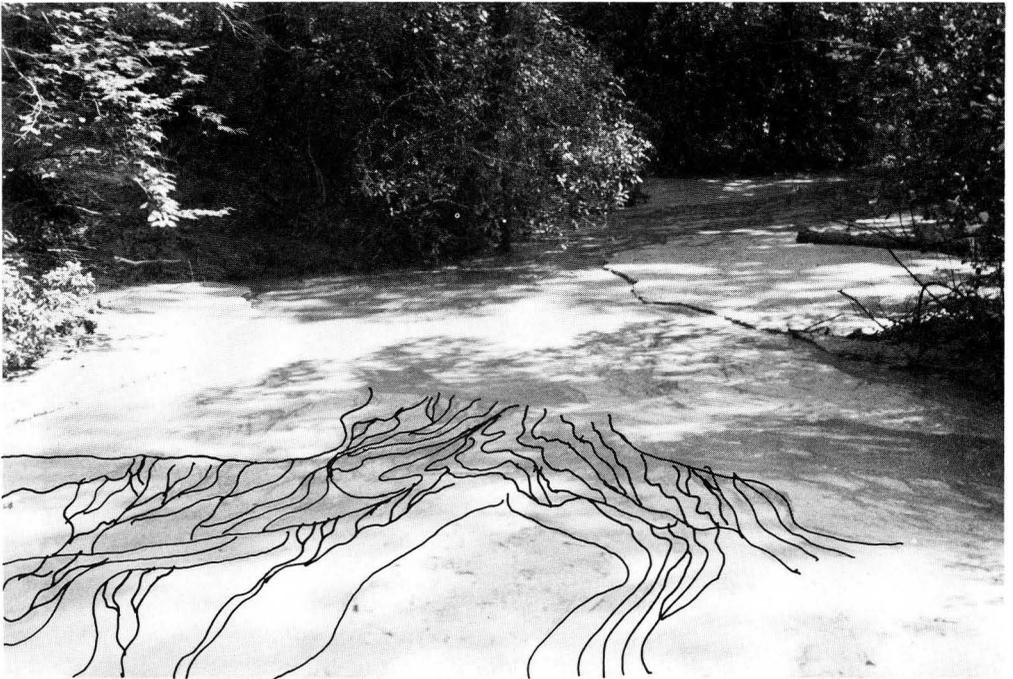


Figure 5. Braided stream pattern. A stream choked with sediments exhibits this pattern.

Two erosional processes operate in Providence Canyon. The first is surface water runoff, which was just discussed. The second is the undercutting force of underground water, or **ground water**. Some rainwater soaks into the ground and travels downward through very small open spaces between sand grains, or **pore spaces**, in the sand of Providence Canyon. As the ground water moves downward, it may pick up charged particles, known as **ions**, in solution and deposit them in concentrations at some depth. This process is responsible for the formation of the Clayton iron ore (see fig. 6). The downward movement of ground water continues through the Providence Sand until a layer that ground water cannot penetrate, or an **impermeable** layer such as a small **lens** of kaolin, is reached. Because downward movement is restricted, the water moves laterally towards the canyon wall until the side of the canyon is reached. This lateral movement weakens the sediment, causing it to become loose and unstable.

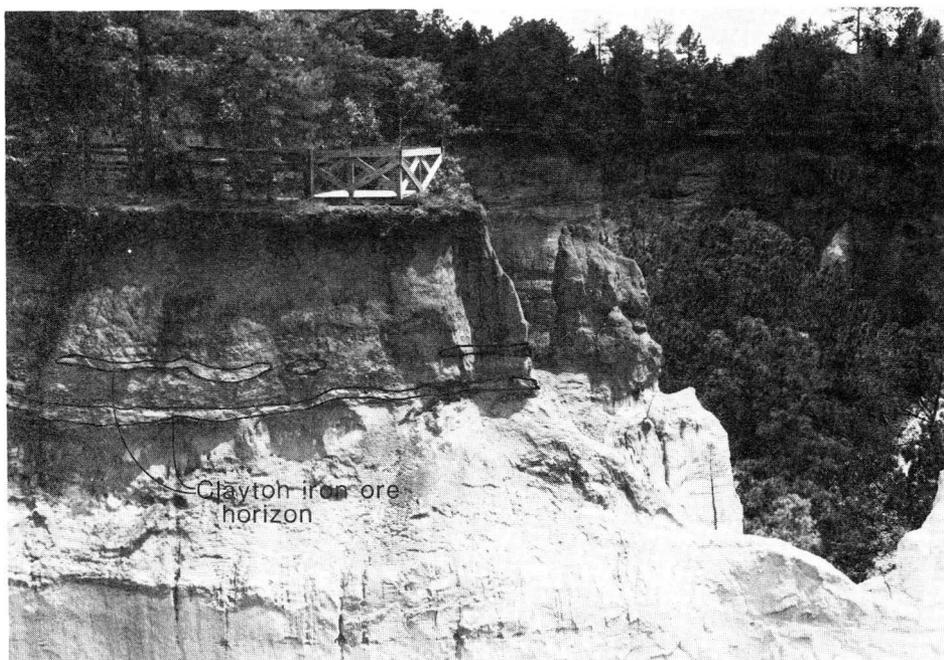


Figure 6. Clayton iron ore.

This weakened area will not be able to support the weight of the overlying sediments. It is not uncommon for large amounts of sediment to come crashing down suddenly, a process known as **mass wasting**, which forms fan-shaped deposits called **talus cones** (see fig. 7). The processes of weakening by ground water and mass wasting are responsible for the widening of the canyon (see fig. 8):

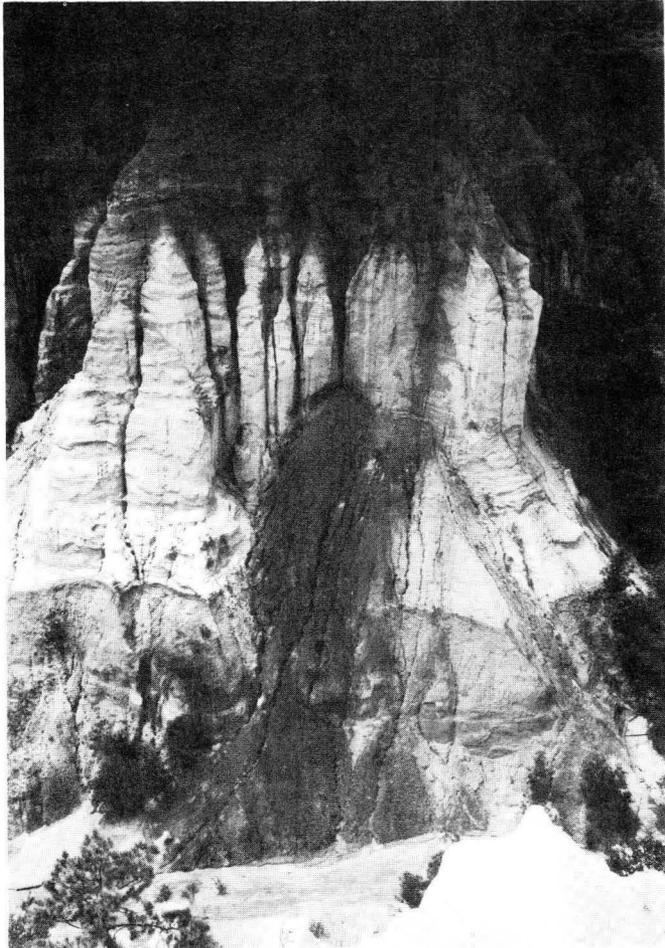


Figure 7. Talus cone. Talus material is derived from the Clayton Formation which was deposited by mass wasting over the Providence Sand.

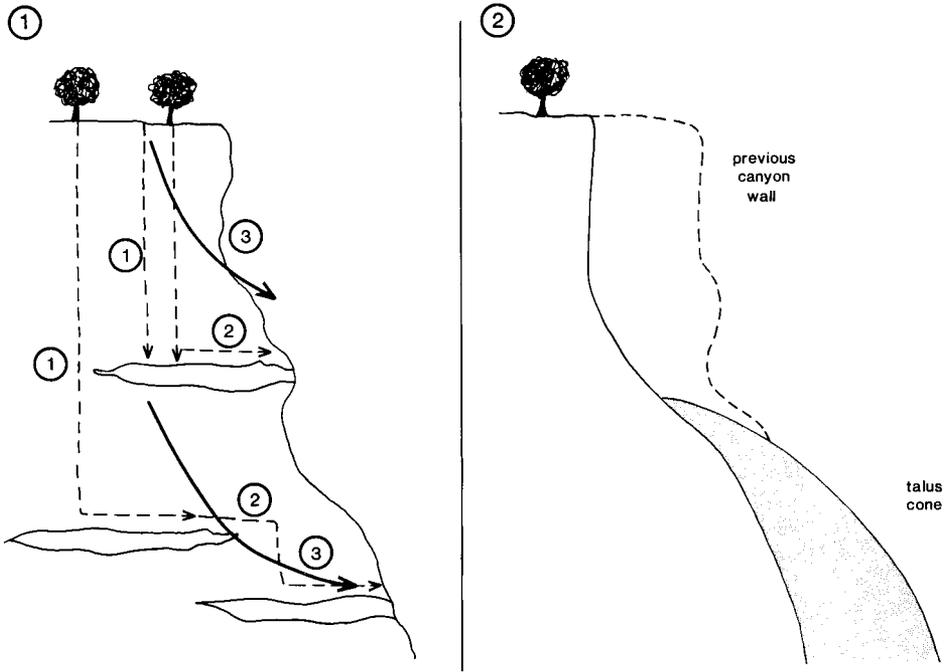


Figure 8a.1. Saturation of the soils by ground water;

- (1) Ground water moves downward until a lens of kaolin is reached.
- (2) Water moves laterally until it intersects the canyon wall, thus weakening the sediment.
- (3) Slumping will occur in these weakened zones.

Figure 8a.2. Illustration of new canyon profile once slumping has occurred. Mass wasting produces a talus cone of wall material.



Figure 8b. Slumping (in central part of picture) is a result of the sediments being weakened by ground water.

Question 4: Will Providence Canyon continue to get larger?

As long as the forces of erosion operate, the canyon will continue to expand. The average rates of erosion have been calculated by studying aerial photographs and maps of the area, and this information can aid in the determination of past, present, and future canyon growth.

Throughout the years, the canyon has not only increased in size, but has also changed in shape. By observing similar, ongoing erosional processes, geologists believe that as the canyon first began to form, the major erosional force was that of eroding downward to make the canyon deeper, or **downcutting**. The average rate of downcutting for the years 1820-1930 was calculated to be

approximately 8 inches per year and was based on an estimation of the total volume of sediment removed by erosion.

At the same time that downcutting was active, the canyon also underwent rapid erosion at the head of the canyon in an upslope direction, or **headward erosion**, thus lengthening the canyon (see fig. 9). Between 1955 and 1968, the average



Figure 9a. Effects of headward erosion. Headward erosion cuts into the head of the canyon, undermining tree roots.

rate of headward erosion was calculated to be about 6 feet per year. However, between 1968 and 1976, the average rate of erosion decreased to approximately 2 feet per year. Can you think of a reason for this decrease?

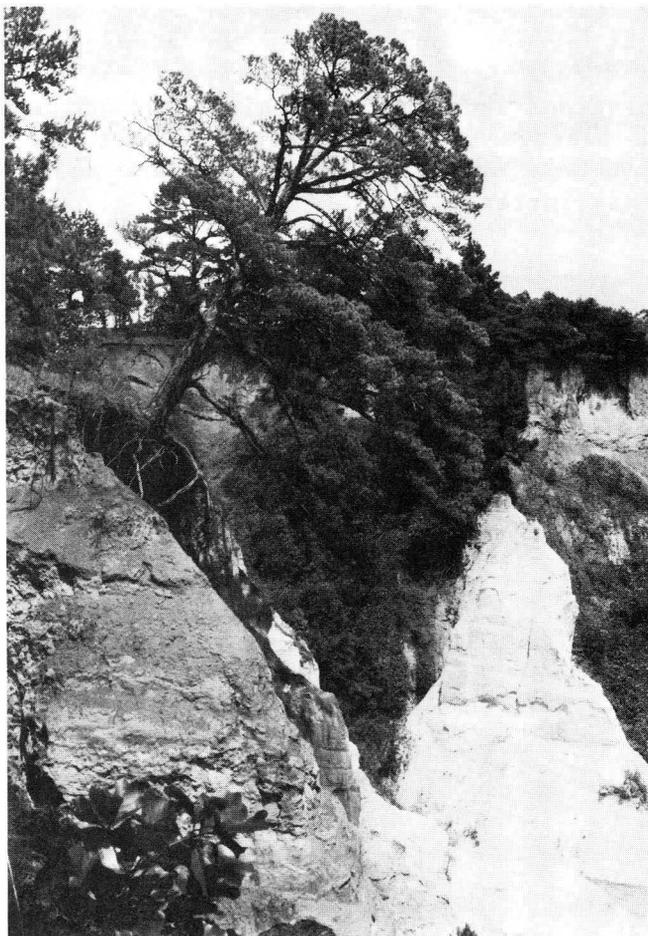


Figure 9b. Removal of sediment by headward erosion causes the tree to fall into the canyon.

A third dimension of the canyon also has changed due to erosion. The canyon has become wider due to erosion of the canyon walls, a process known as **lateral erosion**. This has been accomplished principally by slumping as a result of the saturation of the ground by ground water (see fig. 10). Between 1955 and 1968, lateral erosion operated at an average rate of about 2 feet per year, but between 1968 and 1976, calculations indicate that this rate had increased to an average of approximately 6 feet per year. Can you make observations in the park and account for this increase?

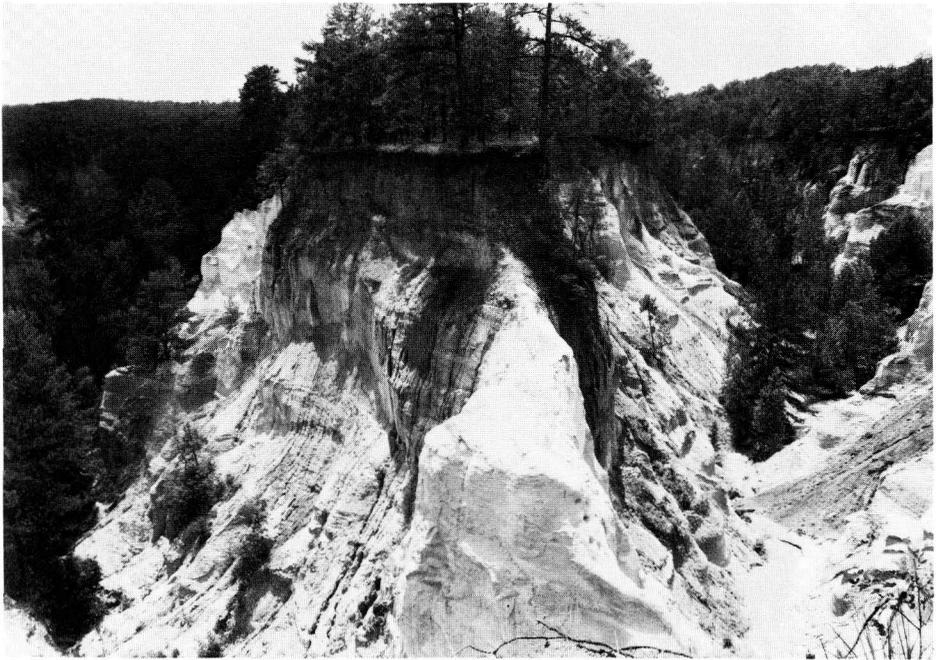


Figure 10a. Effect of lateral erosion. Lateral erosion has transformed small, narrow gullies into wide canyons. Given time, lateral erosion will cause this area to look like fig. 10b.

To answer these questions it is necessary to review what we have observed in the canyon. To understand why the rate of vertical erosion is decreasing, let's compare the Perote Member and the Providence Sand. The clay content of the Perote makes it much more difficult for water to erode than the Providence Sand, because the clay is comparatively impermeable and acts as a sealer. Therefore, the Perote is more **resistant** to erosion, allowing the rate of vertical erosion to decrease. Secondly, notice the thick stands of pine trees, laurel bushes, and other vegetation

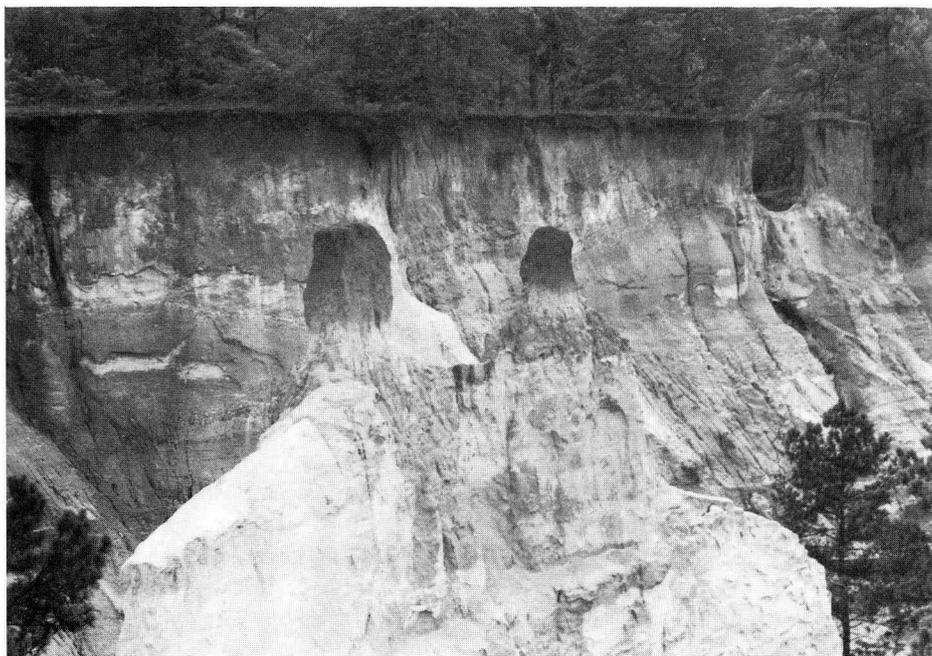


Figure 10b. Wall reduced to a pinnacle by lateral erosion. Eventually, the pinnacle will collapse, forming talus cones.

covering the floor of the canyon. This natural establishment of vegetation serves to stabilize the soil and sediment; the erosive power of surface runoff is thus reduced, causing a decrease in the rate of erosion.

If vertical erosion has decreased, why has lateral erosion increased? The area around the park has undergone substantial development in the past few years, which has eliminated more of the areas's natural vegetation, thus exposing the land to increased amounts of runoff. This excess runoff could cause erosion to occur at a faster rate. Another possible cause of accelerated widening of the canyon is the increased use of the area since its establishment as a park in 1971. Many visitors have been unable to resist climbing the canyon walls or carving on them. Besides defacing the canyon walls, this disrespect has helped to accelerate the rate of lateral erosion.

Question 5: What causes the different colors in the canyon walls?

The striking hues of tan, buff, pink, and salmon in the Providence Sand, as well as the deep orange-red of the Clayton Formation, are a result of the iron contained in the Clayton. The lavender color is caused by the presence of manganese in the Providence Sand. As ground water travels down through the sediment, it dissolves the iron. As the iron comes in contact with the water, it **oxidizes**, or unites with the oxygen in the water. (Oxidation is the same chemical process that causes steel to rust.) The oxidized iron is then precipitated at different depths, staining the sediment with the colors you see. The intensity of color is related to the amount of iron present in the sediment, and to the length of time the iron remains in contact with the ground water.

CONCLUDING STATEMENT

The landscape you have observed today reflects the forces of nature over millions of years. Vast amounts of sediment were eroded from land and deposited in ancient seas to form the Coastal Plain. Sea level rose and fell cyclically, alternately flooding coastal areas and exposing them to the elements. Finally, sea level more or less stabilized around its present level in the late Quaternary period (See Geologic Time Chart), and erosion began to operate. Rainwater washed over the barren soil of cleared fields in tiny rivulets which cut ever deeper to form gullies. Aided by ground water, canyon development progressed rapidly to its present state.

Providence Canyon is a very dynamic system: it is constantly changing. The rainfall from one storm is capable of washing away sediments which represent millions of years. Entire pinnacles have collapsed in the blink of an eye. Certainly Providence Canyon is only a temporary product of the forces of nature attempting to maintain a precarious balance. The overwhelming beauty and breathtaking scenery that we are indeed privileged to observe should be a constant reminder to us of the consequences of man's unwise interference with nature.

ACKNOWLEDGEMENTS

The author is indebted to Juergen Reinhardt, United States Geological Survey, for his technical assistance; to Bob Baxter, Park Superintendent of Providence Canyon, for information concerning the history of the area; and to Dr. Mildred Graham, Georgia State University, for her critical review. A special note of gratitude is extended to David Bland, Interpretive Ranger, for his assistance with research, photography, and critical review.

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GLOSSARY

Braided Stream. A stream that divides into or follows an interlacing or tangled network of several small branching and reuniting shallow channels separated from each other by branch islands or channel bars, resembling in plan the strands of a complex braid. Such a stream is generally believed to indicate an inability to carry all of its sediment load.

Clay. Any soft, adhesive, fine-grained sedimentary material made of particles of any composition having a diameter less than 1/256 mm.

Coastal Plain. Any lowland area bordering a sea or ocean, extending inland to the nearest elevated land, sloping very gently seaward; it usually results from the accumulation of sediment deposited by water.

Contact. A surface between different types or ages of rock.

Cross-bedding. Beds or layers of sediment which are inclined at an angle to the main bedding planes.

Downcutting. Stream erosion in which the cutting is directed in a downward manner.

Geologic Formation. A distinctive, mappable body of rock or sediment.

Geologic History. The history of the Earth and its inhabitants throughout geologic time. It comprises all chemical, physical, and biologic conditions that have existed on and in the Earth, all processes that have operated to make or modify these conditions, and all events that have affected any part of the Earth, including its inhabitants, from the beginning of the planet to the present.

Geologic Record. The "documents" or "archives" of the history of the Earth, represented by bedrock and the Earth's morphology; the rocks and the accessible solid part of the Earth. Also, the geologic history based on inferences from a study of the geologic record.

Geomorphic Processes. Processes which shape the Earth's landforms.

Ground Water. All subsurface water, as distinct from surface water.

Headward Erosion. The lengthening and cutting upstream of a young valley or gully above the original source of its stream by erosion

Impermeable. The condition of rock, sediment, or soil that renders it incapable of transmitting fluids.

Ion. An atom or group of atoms that carries a positive or negative electric charge; it combines readily with other atoms to make compounds.

Kaolin. A fine, white clay mineral composed of silica, oxygen, hydrogen, and aluminum.

Lateral Erosion. The erosion of canyon walls by water and gravity making the canyon wider.

Lens. A rock layer that is thick in the middle and thins toward the edges.

Mass Wasting. A general term for the dislodgement and downslope transport of soil and rock material under the influence of gravity.

Mica. Any of various colored or transparent minerals that readily separate into very thin leaves or flakes.

- Oxidize.** To combine with oxygen.
- Pore Space.** The open spaces in a rock, soil, or sediment through which water can move.
- Resistant.** Not easily eroded.
- Sand.** A rock fragment or detrital particle with a diameter between 1/16 mm and 2 mm.
- Sediments.** Solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, or ice, and that forms in layers on Earth's surface at ordinary temperatures in a loose unconsolidated form.
- Silt.** A rock fragment or detrital particle with a diameter between 1/256 mm and 1/16 mm.
- Talus Cone.** A small cone-shaped or apron-like landform at the base of a cliff, consisting of poorly sorted debris that has accumulated episodically by mass wasting.
- Unconformity.** A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic succession, such as an interruption in the continuity of a depositional sequence of sedimentary rock. It results from a change that caused deposition to cease for a considerable span of time, and it normally implies uplift and erosion with loss of the previously formed record.
- Unconsolidated.** A sediment that is loosely arranged with no bonding material.

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