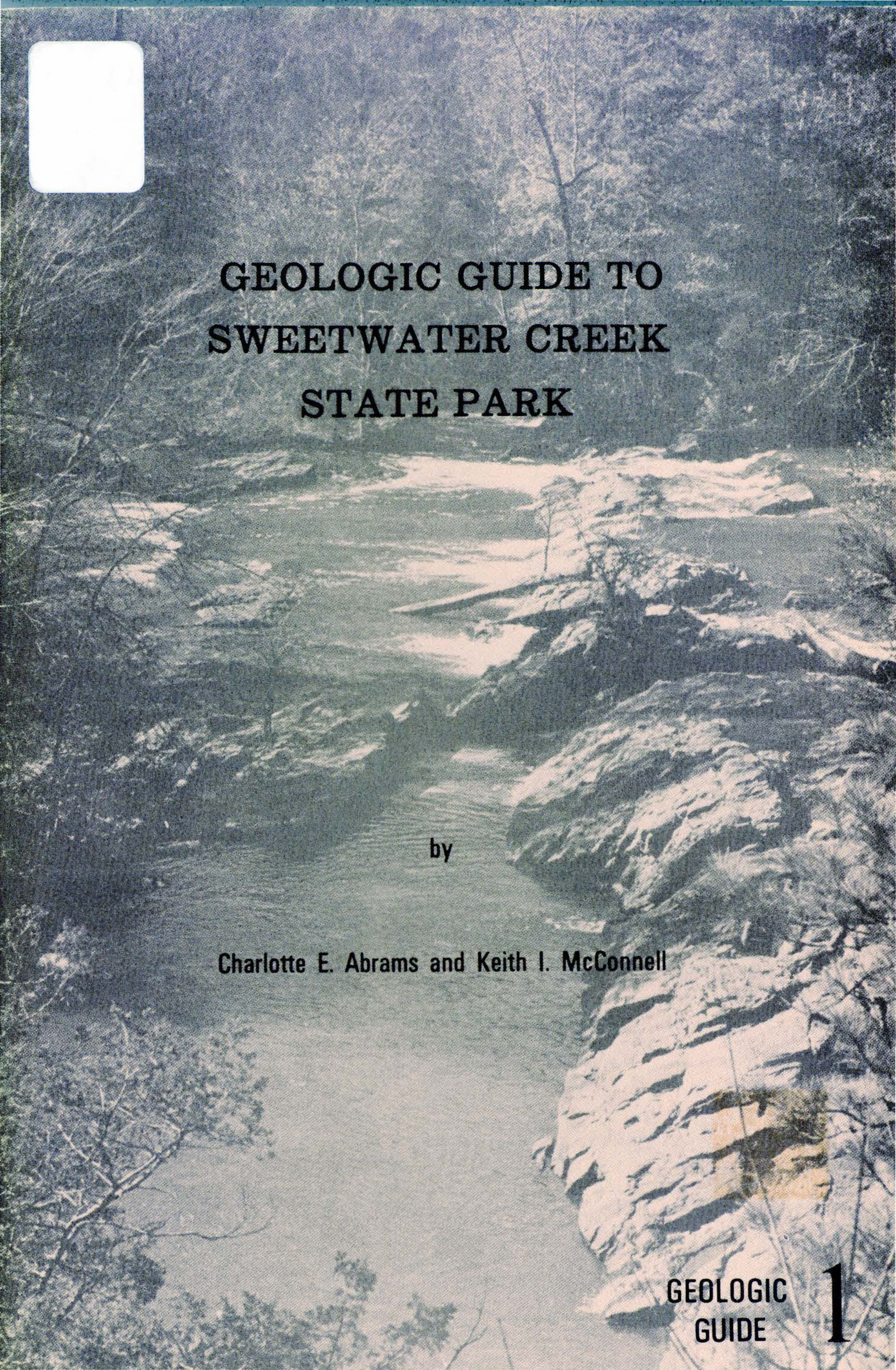

GEOLOGIC GUIDE TO SWEETWATER CREEK STATE PARK

by

Charlotte E. Abrams and Keith I. McConnell

GEOLOGIC GUIDE 1

TIME (in millions of years)	ERA	PERIOD	FORMS OF LIFE	EVENTS IN GEORGIA
0	CENOZOIC	QUATERNARY	AGE OF MAN earliest man	
		TERTIARY	1st apes, grasses 1st monkeys AGE OF MAMMALS	
100	MESOZOIC	CRETACEOUS	extinction of dinosaurs 1st snakes 1st angiosperms (blooming plants)	Deposition of the Coastal Plain sediments, which is still occurring.
		JURASSIC	AGE OF REPTILES 1st birds, mammals	
200		TRIASSIC	1st dinosaurs	
	PALEOZOIC	PERMIAN	1st frogs, evergreens	
300		PENNSYLVANIAN	1st reptiles AGE OF AMPHIBIANS	Erosion of the Piedmont by streams, which is still occurring.
		MISSISSIPPIAN		
		DEVONIAN	1st scale trees, ferns, amphibians AGE OF FISHES	
400		SILURIAN	1st air breathing animals, land plants	Uplift, folding and faulting of the rocks and the formation of a mountain range in the Piedmont.
		ORDOVICIAN	1st fishes	
500		CAMBRIAN	1st hard-shelled invertebrates	Throughout the Paleozoic there was deposition of sediments which formed shales, sandstones, and greywackes.
600		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 SWEETWATER CREEK STATE PARK

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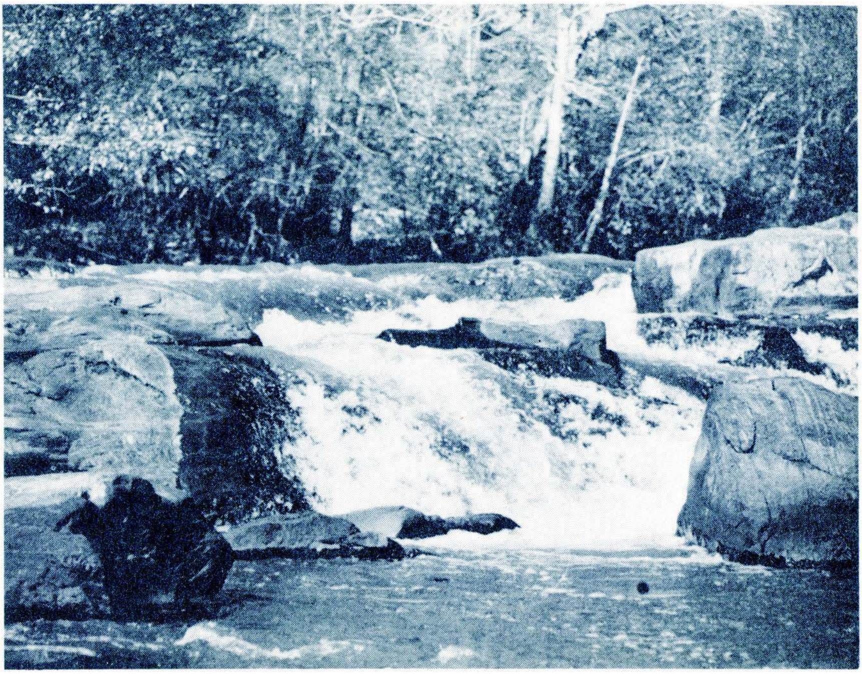

DEPARTMENT OF NATURAL RESOURCES
Joe D. Tanner Commissioner

THE GEOLOGIC AND WATER RESOURCES DIVISION
Sam M. Pickering, State Geologist and Division Director

ATLANTA
1977

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Introduction

Sweetwater Creek, near Austell, Georgia, has served many purposes; it has served as a factory site, a local municipal water source, and as the local fishing and swimming hole. To the beaver that inhabit its banks Sweetwater Creek is home. Signs of their work are visible along the park trails. To the botanist the creek is an ideal place to study various plants unique to this area, and to the geologist it is a spot where the past is revealed in the rocks, and changes in the land's surface can be seen taking place day by day.

The Creek, Past and Present

The mill ruins within Sweetwater Creek State Park are the visible remains of a once prosperous factory and town. The Sweetwater Factory was one of several factories located on *tributaries* of the Chattahoochee River in the nineteenth century. These factories used the water of the local creeks to provide power for the factories' machinery. (See stop 3, Factory Ruins Trail.) During the Civil War the workers at the Sweetwater Factory produced cloth for Confederate uniforms until the Union army destroyed the factory and surrounding town leaving only the ruins that remain today.

During this century Sweetwater Creek has provided water for several cities in this area of Georgia. Until 1971, Austell used the creek for its water supply, and today the city of East Point still relies on Sweetwater Creek for its water. A pumping station is located downstream from the park where an average of 7½ million gallons of water are pumped out of the creek each day for East Point residents. Although 7½ million gallons may seem to be a considerable amount of water to remove from the creek, this amount is negligible when compared with Sweetwater Creek's average discharge of 299 million gallons per day.

In recent years the land within the creek's *drainage basin* has undergone considerable development. Towns near the creek have grown and residential areas have increased in size and number. Some industries have also located along the creek or on its tributaries. Pavement and buildings now stand where trees and vegetation once were. *Runoff* of water into the creek after a rainfall has increased due to this decrease in vegetation or soil cover. As a result, recent flood levels along Sweetwater Creek are higher than in the past, because the channel of the creek can no longer hold the larger amounts of water it receives as runoff after a heavy rain. Flood waters generally recede within a day, but while flooding is at its peak, portions of the park trails are covered by water and the creek becomes a raging torrent. At this time the largest amount of erosion takes place.

Figure 1. Sweetwater Creek flood, April 1977

The Land and the Creek

The drainage basin of Sweetwater Creek encompasses an area of 246 square miles 637 sq. km. within the Georgia Piedmont. The northern and southern sections of the creek are distinctly different in character The northern section of the creek flows quietly through a wide, often swampy stream valley In the northern section, from where it originates near New Georgia, in Paulding County until it reaches Austell, Sweetwater Creek flows in an eastward direction. This eastward direction of flow is unusual for a major stream in this part of the Piedmont and is due to the influence of a regional geologic structure known as the Austell-Frolona *Anticlinorium*, an up-warped fold composed of many smaller folds (fig. 2). The Austell-Frolona is higher in elevation than the surrounding rocks, preventing Sweetwater Creek from crossing the anticlinorium and forcing the creek to flow around the nose of the structure.

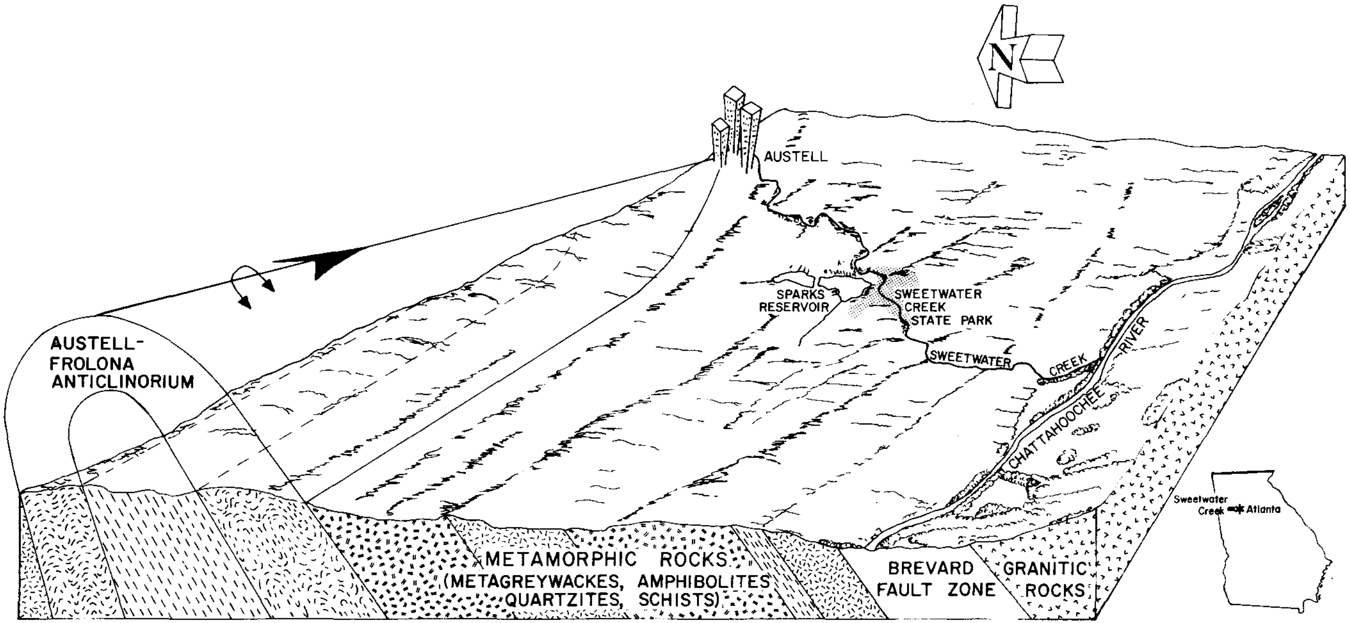


Figure 2. Block diagram.

Sweetwater Creek State Park lies along the southern portion of the creek. At Austell the creek bends to flow in a southeastward direction until it enters the Chattahoochee River. The characteristics of the creek change as well as its direction as it encounters the resistant rocks of this area. *Relief* increases, the creek valley sides steepen, and falls and turbulence disrupt the previously tranquil creek. This section of Sweetwater Creek closely resembles a mountain stream.

The Chattahoochee River flood plain lies within the *Brevard Fault Zone* at a lower elevation than the surrounding portion of the Piedmont. Sweetwater, as well as the other creeks that enter the river, is constantly downcutting in its effort to reach the lower elevation of the Chattahoochee River. From Austell to its junction with the Chattahoochee River, Sweetwater Creek drops 120 feet in elevation, 80 feet of which are inside the park. This change in *gradient* was an important factor in the choice of the Sweetwater Factory site.

Before Sweetwater Creek enters the *Brevard Fault Zone* and the Chattahoochee River, it crosses a series of northeast-trending rock units. Some of these rocks, such as quartzites, are more resistant to erosion than the surrounding rocks. These quartz-rich rocks divert the creek at right angles to its southeastward direction of flow. Other rocks in the creek contain open *joints* and allow the creek to flow through these openings and across the rock units. This control of the creek's direction by the rocks and the structures within them gives Sweetwater Creek a rectangular drainage pattern. Rectangular drainage is characterized by right angle bends in a stream and its tributaries. The map of the drainage basin of Sweetwater Creek (Fig. 3) shows this drainage pattern.

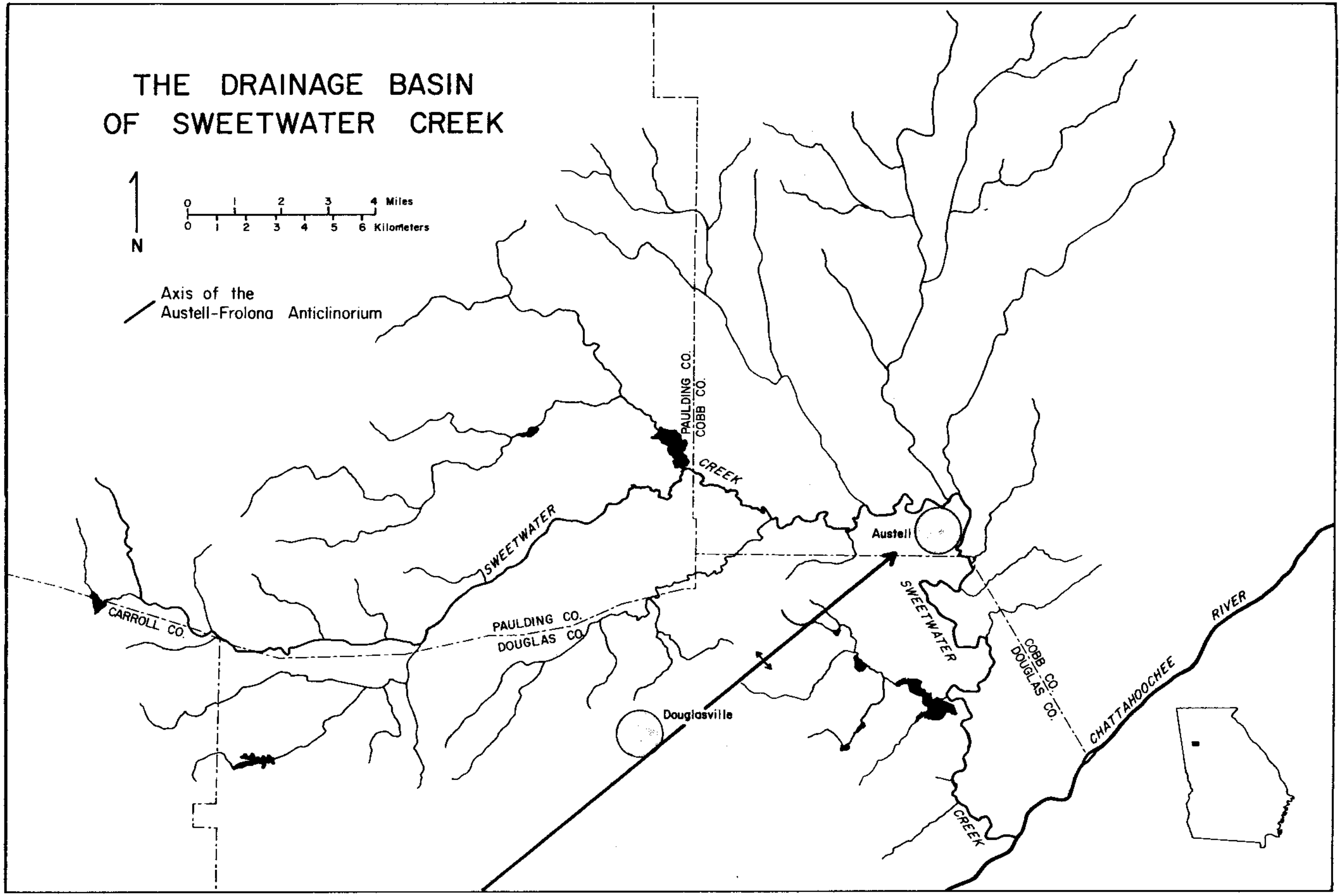


Figure 3. Map of the drainage basin of Sweetwater Creek.

Geologic History

This historical geology of Sweetwater Creek State Park can be separated into three periods. In order of occurrence these are: deposition of sediments, *metamorphism* and folding, and uplift and erosion (See Geologic Time Chart on inside of cover).

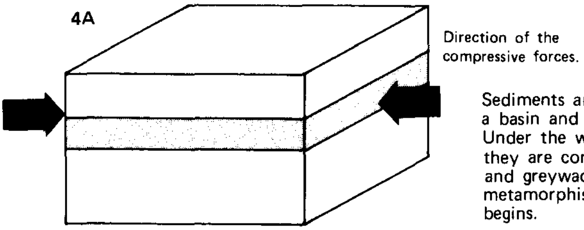
Deposition

The rock units presently exposed at the surface at Sweetwater Creek were originally deposited at least 450 million years ago as a series of sediments which formed rocks: shales, sandstones and greywackes (dark, impure sandstone). These sediments were deposited in an environment similar to that existing off the coast of Georgia today. Deposition occurred continuously in a slowly subsiding basin where older deposits were covered by younger ones and buried to depths of several miles (Fig. 4A). These sediments were later blanketed by basaltic lava flows which poured into the basin from volcanoes located near the basin's margins. As time passed thousands more feet of sediment were added to the basin, covering the lava flows.

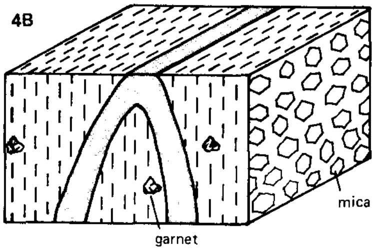
Metamorphism

Deposition in the basin probably continued until approximately 450 million years before the present. Until this time the increasing weight of the sediment in the basin caused it to subside slowly allowing deposition to continue; now, however, the direction of the forces acting on the basin changed and the basin began to be compressed from the sides. Subsidence stopped and uplift began. Compression caused increases in the temperature and pressure acting on the rocks in the basin, which eventually led to a complete reforming of the rocks buried there. Increasing temperature recrystallized the minerals in the rocks to new minerals. During *recrystallization* the pressure applied to the rocks by the compressive forces caused the new minerals, primarily the micas, to be *preferentially oriented.* These minerals were oriented so that their broad, flat bases were all in the same position (Fig. 4B). Because of this mineral orientation, the rock now breaks more easily along the layers of mica. This plane of weakness is termed *foliation.* Recrystallization of the minerals and the development of foliation changed the shales, sandstones, greywackes and basalts into mica schists, quartzites, metagreywackes and amphibolites respectively (defined in table 1, page 10). Metamorphism, the process whereby the rocks are altered under heat and pressure, also destroyed any fossil remains that may have been in the original rock units.

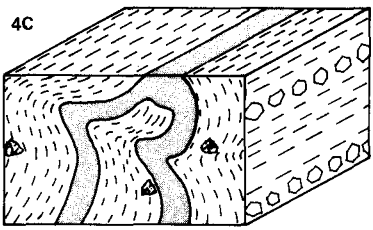
Increasing pressure occurring deep within the earth's *crust* played two other significant roles in addition to the metamorphism of the rocks of Sweetwater



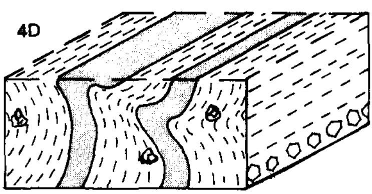
Sediments are deposited horizontally in a basin and covered by additional deposits. Under the weight of the overlying sediments they are consolidated into shales, sandstones, and greywackes. Then compression and metamorphism of rocks within the basin begins.



Under the heat and pressure accompanying metamorphism the rocks are recrystallized into schists, gneisses and quartzites. The newly formed minerals are preferentially oriented to form foliation and the horizontal layers are compressed to form folds.



Later, a second set of folds is produced, but the heat necessary for a recrystallization of the rocks is not present during this event.



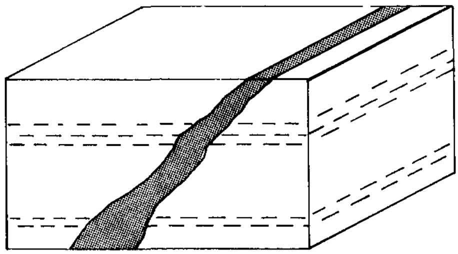
The crest of the fold is eroded away exposing the rocks in its core at the surface.

Figure 4. Metamorphism, folding and erosion of the rocks.

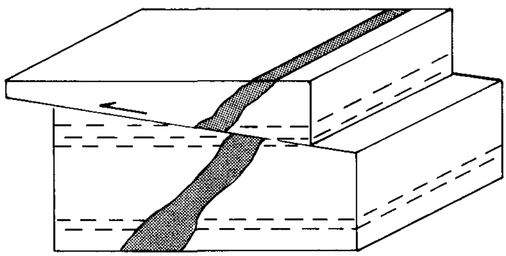
Creek State Park. These were folding and faulting of the rocks. Pressure resulting from compressive forces folded the rocks into a series of troughs and ridges giving the rocks a roller coaster appearance. Two separate periods of this folding are observed in the rocks at Sweetwater Creek with the first set of folds being refolded by a later set (Fig. 4C & photo page 25). Pressure also caused the rocks to break and be thrust up and over each other. This type of movement is called faulting (Fig. 5). Finally, both faulting and folding forced rock buried deep within the crust of the earth to be squeezed up towards the surface. This uplift led to the formation of a mountain range in the Piedmont of Georgia which may have been similar to the present Blue Ridge Mountains or even the Rocky Mountains in the western United States.

Uplift and Erosion

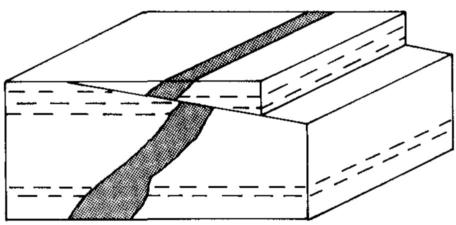
Uplift, folding and faulting of the rocks continued until approximately 250 million years ago when the compressive forces stopped. During and after uplift streams began to cut into and change the appearance of the newly emerging land surface. Dissolved *organic acids* carried by streams and groundwater caused the rock to decompose into sediments just as these processes are decomposing the rock at Sweetwater Creek State Park today. These sediments were carried by streams to the south towards what is now the Coastal Plain of Georgia. In fact, rock eroded from the Piedmont is the major source for the material making up the Coastal Plain sediments. Streams flowing southeastward eroded and changed the mountain range into the present rolling hills of Piedmont Georgia. Uplift and erosion exposed rocks in the Piedmont and at Sweetwater Creek that had once been several miles beneath the surface of the earth (Fig. 4D).



Metamorphic rock was intruded by a pegmatite.



The pegmatite was offset by a thrust fault.



The rock was eroded. Erosion can continue until all signs of faulting are removed.

Figure 5. Development of a thrust fault.

THE ROCKS AT SWEETWATER CREEK STATE PARK

NAME	DESCRIPTION	COLOR	ORIGINAL ROCK
Mica schist	Biotite and muscovite mica, quartz and feldspar. Garnets are present in most of the schist units within the park. Some units also contain kyanite.	Grey to silver with garnets appearing brown	Shale
Metagreywacke	Fine to medium grained quartz, biotite (black) mica, muscovite mica and feldspar. Layering can be distinguished. Some units contain smaller garnets.	Light to medium grey	Greywacke
Quartzite	Quartz. Fairly uniform in texture. Becomes sugary with weathering.	Light brown	Sandstone
Amphibolite	Medium-grained (black) hornblende, quartz and feldspar. Layered. Weathered rock is ochre in color.	Dark grey to black	Basalt
Pegmatite	Coarse grained rock made up primarily of quartz and feldspar with some large flakes of mica.	White with some pink	Injected, once molten rock

Scene at the end of the Factory Ruins Trail.

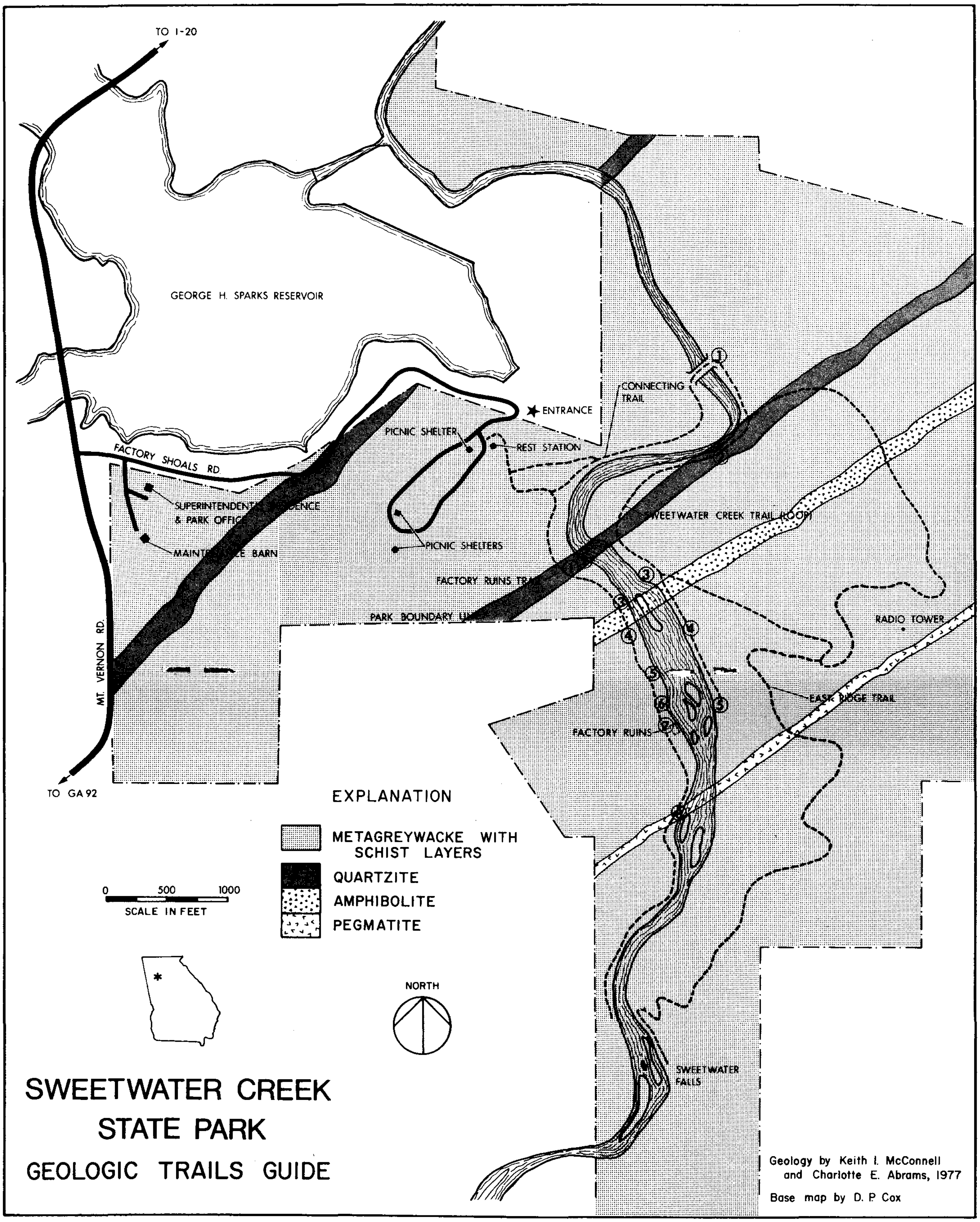


Figure 6. Geologic trails map.

Geologic Guide to the Factory Ruins Trail of Sweetwater Creek State Park

Distance Between Stops	Total	
00′	00′	Leave the rest station and follow the trail that leads to the mill ruins. Upon reaching Sweetwater Creek, turn right on the Factory Ruins Trail. Take the first trail on the left. This trail leads to stop 1.
1363′	1363′	

Stop 1: Garnet - mica schist

The rock outcrop on your left before reaching the creek is a garnet - mica schist. The most interesting feature of this rock is the garnets. Garnet is a common rock-forming mineral in the Georgia Piedmont. Most of the garnets here are small, reddish-brown and "wart-like." On closer examination of the rock, a second, flattened type of garnet can also be seen.

In some parts of the United States, garnets are mined for use as gemstones or abrasives. However, garnets found here have little or no commercial value because they lack the size, form, and quality necessary for such uses.

3′	1366′	From Stop 1 walk toward the creek along the same trail to Stop 2.

Stop 2: Joint control of stream flow.

At this stop the creek turns almost 90° and begins to flow nearly perpendicular to the *strike*. Until this point, stream flow was moving in the direction of the *foliation* (see page 6 of general geology). Here, most *joints* have the same orientation and control stream flow by providing natural channels for the water to cross the strike of the rocks. Several joints can be seen in the rocks present at this stop.

524′	1890′	Return to the main trail and continue downstream to the marked trail on your left. Follow this side trail to the Creek.

Stop 3: Natural Dam

The rock spanning the creek at this point was a major factor in the site selection of the millway entrance. This rock provides a natural base for a dam to divert water into the millway. It also marks the beginning of a major increase in the slope of the stream. This change in stream level, or *gradient,* allowed the mill, located downstream, to be at a lower level than the entrance to the millway. This difference in the level of the millway entrance and the mill provided the slope necessary to generate the water energy to turn the mill wheel.

858′	2748′	Return to the main trail and proceed to stop 4. Note the presence of amphibolite along the trail. A short distance along the trail on the right is a spring which is fed by underground water passing through joints in the rock beneath the ground surface.

Stop 4: Foliation

The rock exposed at this stop shows weathering along foliation planes in a metagreywacke. The almost horizontal ridges in the rock are formed by erosion along the foliation. While all rock in Sweetwater Creek State Park, except the pegmatites, shows a foliation, this rock is one of the better examples of foliation.

Another structural feature visible at this stop is the small joint in the middle of the rock.

89′	2837′	Stops 5 and 6 are off the main trail on the path that leads through the millway to the left. From stop 4 proceed to the left into the millway towards the mill.

Stop 5: Millway Wall

This stop shows the millway wall which was partially constructed from rock quarried from the surrounding rock units. The marks made by quarrying equipment can be seen on some of the rocks in the wall. These marks are the cylindrical holes on the rock sides.

Foliation played an important part in the quarrying operation. By splitting along the foliation quarrying was made easier, enabling the builders to provide rocks that had at least two regular smooth, flat surfaces.

Joints, although not as common as foliation, were also used as an aid in quarrying. In the construction of the wall, the builders used a combination of joints and foliation to form rectangular blocks.

Joints also played another role in the millway wall. As you continue through the millway, observe how the builders used the joint surfaces of the large rock outcrops to your right as part of the millway wall. This portion of the wall is formed by natural joint surfaces.

176′	3016′	Continue along the millway to the second opening in the wall on the left. The features of stop 6 are visible from the top of the wall.

Stop 6: Pothole and joints

In the stream directly in front of you there are examples of 1) a well-developed pothole and 2) well-developed joints.

Potholes are erosional features usually found in the rock in fast moving streams. These circular depressions in rocks are formed by the grinding action of trapped sand and gravel being swirled around by the strong currents within the creek (Fig. 8). Starting points for potholes are usually niches or breaks in the rock, such as poorly developed joints or along foliation planes, where the water flow becomes disturbed and begins to swirl and erode. The pothole shown at this stop was initiated along a poorly developed joint.

As you look toward the opposite bank of the stream, you can see many joints and their influence on the creek. The water finds the open joints much easier to flow along and to erode down through than the less open foliation.

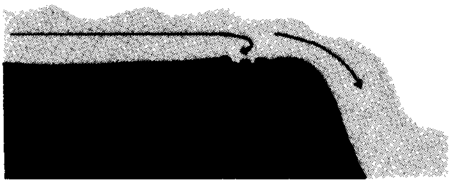
54′	3067′	Continue along the millway until you reach the main trail. Stop at the first corner of the mill ruins near the archway. This is stop 7.

Stop 7: Augen

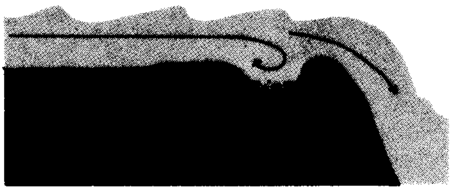
Rocks used for the mill base are primarily metagreywacke, and amphibolite. Both of these rocks are found locally, but no abandoned quarry, necessary for the large amount of rock used, has been found as a source for these rocks. An interesting feature in the rocks used for the base is the presence of large elliptically shaped *feldspars* (white). The distinctive appearance given by these elliptical feldspars within the rock is termed "augen" (German for "eyes"). A good example of the augen is found in the bottom cornerstone of the mill. There, a series of augen is visible within a band of feldspar in the rock.

693′	3760′	Continue along the main trail behind the mill. As you pass behind the mill note the well-developed joints in the rock on your right. As you near the creek you can observe two large blocks of rock on the opposite bank that have fallen down the hill side. These blocks are an indication that the stream is widening its channel, and therefore is undercutting the rocks along the banks.

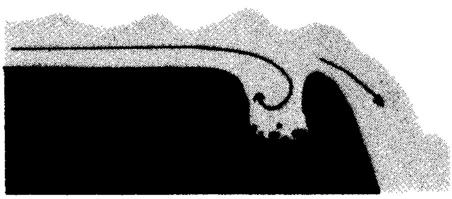
Figure 7. Open pothole.



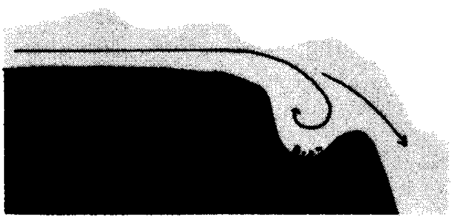
Pebbles transported by the water are caught in a depression in the rock. This depression can be at the intersection of two joints, in the nose of a fold, or where less resistant material has been eroded from the rock unit.



Pebbles are circulated in the depression by the force of the water. Abrasion resulting from the grinding of the pebbles deepens the depression.



With the passage of time abrasion continues and the pothole deepens even more. As the pebbles become abraded to smaller grains of sand new pebbles are constantly being introduced.



Finally, the downstream side of the pothole may become eroded away, leaving an open pothole as seen in the photograph on page 17.

Figure 8. Development of the pothole shown in figure 7.

Stop 8: Pegmatite

The lighter colored rock near the bank of the creek is called pegmatite. As you look diagonally across the creek in an upstream direction, you can see that the pegmatite extends across the width of the creek. The darker rock on either side of the pegmatite is metagreywacke. Joints are poorly developed or are not present in the pegmatite. The pegmatite was injected as a hot liquid into the metagreywacke after *metamorphism,* and therefore, lacks the foliation present in the metagreywackes. It also has much larger crystals than the metagreywacke because it cooled slowly. The lack of uniformity with the surrounding rocks caused the pegmatites to react differently than the metagreywackes to the joint forming stresses, resulting in a lack of joints in the pegmatites.

Sweetwater Creek begins to bend at this point due to the influence of the pegmatites within the stream. As the creek bends, it once more flows at near right angles to the joints and parallel to the foliation. Further south, the creek bends again to flow through the joint openings.

Figure 9. Scenic overlook.

Geologic Guide to the Sweetwater Creek Trail

Leave the rest station area and follow the Factory Ruins Trail downhill to the Creek. Turn left at the creek and follow the trail to the bridge.

As you cross the bridge notice the flat, sandy areas on either side of the creek. These areas are part of the creek's floodplain. A floodplain is a relatively flat area adjacent to a stream (creek or river) that is frequently covered by water during periods of flooding. A stream in flood has the capacity to carry more and larger sediment within its channel due to a higher water velocity. As the stream overflows its banks the velocity of the overflow water decreases and some of the stream's sediment load is deposited adjacent to the stream. The flat sandy areas on either side of the bridge are examples of deposition on the flood plain.

Length from the bridge		
Between points	Total	
00′	00′	Continue across the bridge to stop 1.
68′	68′	

Stop 1: Kyanite

The rock outcropping in the road is mica schist. This schist contains kyanite, a mineral that is commercially important to Georgia. On close examination of the rock at this stop, kyanite is visible as the bluish-grey, bladed mineral. It is characterized by its ability to be scratched with a knife in a direction parallel to its long axis, and it's resistance to scratching along its short axis. Kyanite is formed under high temperatures and pressures. Its presence is used by geologists as an indication of the intensity of *metamorphism* that has occurred in an area.

Kyanite is mined at Graves Mountain in Lincoln County, Georgia. Its stability at high temperatures allows it to be used as a refractory (a material that resists the action of heat and chemical agents). Kyanite is also altered to a synthetic mineral termed mullite which is used in ceramics, in particular as the ceramic insulator on spark plugs.

732′	800′	Continue along the trail to stop 2. As you walk along the trail you may notice debris left in the branches of trees and shrubs by high water. This material was left from one of Sweetwater Creek's periodic floods.

Stop 2: Quartzite

The rock at the water's edge near the trail is quartzite. Because of its high quartz content the quartzite is more resistant to erosion by the creek than the surrounding metagreywackes and mica schists. Here the quartzite deflects the water flow causing the creek to bend and flow parallel to the *foliation* of the rocks (see page 6 of general geology). The creek continues in this new direction until the water reaches a point where it has been able to erode through the quartzite; there the creek returns to its earlier direction. The quartzite is the first evidence within the park that the rock units control or influence the direction of Sweetwater Creek. This control of the creek by the rocks is called *lithologic* control.

1567′	2447′	Continue on the main trail to the first trail on your right. Follow this side trail to the creek.

Stop 3: Natural Dam

At this stop the park visitor gets a better view of the natural dam and millway entrance described in stop 3 of the Factory Ruins trail. As you can see very little additional construction was needed for the natural dam to divert some of the creek's flow into the millway.

Downstream from this point the slope of the creek channel begins to steepen. Another term for this slope is *gradient*. The increased gradient of Sweetwater Creek results in an increase in the water velocity of the creek. Turbulence also increases as the creek channel becomes more rocky and full of obstacles which disturb the water flow. The water no longer flows smoothly but becomes disrupted and forms eddies within the creek. The churning water is more erosive than the quiet, uninterrupted stream flow, enabling the creek to gradually cut through and remove rock lying within its channel.

321′	2768′	Return to the main trail and proceed to the second side trail to your right. Follow
441′	3209′	this trail to stop 4.

Figure 10. Rock "benches".

Stop 4: Rock "benches"

Visible downstream from this stop are a series of rock "benches" extending across the creek. These "benches" are formed by differential erosion of the rock by the creek. By *differential erosion* we mean some rock becomes eroded and carried away faster than other rock due to a difference in rock composition. Some of the rock has been removed leaving ridges or benches of resistant rock in the creek.

The rock benches form shoals within the creek inhibiting the water flow and causing turbulence. As the water flow becomes more interrupted by these barriers, churning currents (as discussed in stop 3) increase the rate of erosion within the creek.

171′	3380′	Continue along the side trail to stop 5. On the hill to your left are several large outcrops of metagreywacke. Over a period of millions of years, Sweetwater Creek has eroded down to its present level exposing the outcrops on your left. The trail becomes more difficult from this point on and should be taken with caution.

Stop 5: Falls and Cave

Located in the stream directly below you is a large block of rock that has been dislodged by the water flow. The strong force of the water flipped the block over during a period of high water when the stream had the large amount of energy necessary for such movements. Separation from the surrounding rock occurred along *joints* at both ends of the block and along the rock's foliation on its underside.

The cave-like opening in the outcrop of metagreywacke behind you results from a process called undercutting. Through time Sweetwater Creek has been gradually eroding and cutting down to this level to form the present stream valley. This rock has been undercut by the creek, and material the rock once rested on has been removed. Gravity has caused the exposed underside of the rock to break off along planes of weakness (foliation) forming the opening.

A scenic overlook is on the hill above you, and provides the best view of the creek. Across the creek from the overlook are the Factory Ruins. Upstream you can see the benches of rock described in stop 4 and the beginning of the creek's gradient change (stop 3). Below you, the creek drops sharply (approx. 6′) at the falls where it flows parallel to the joints. Further downstream, observe how the creek bends to flow at a right angle to the joints and parallel to the foliation.

Numrous folds are visible in the rocks of Sweetwater Creek State Park. The best examples of these are located at Sweetwater Falls on the East Ridge Trail. Figures 11 and 12 show two types of folds found there.

The East Ridge Trail is rougher than most in the park, but the scenery at its end makes the trip worthwhile for the more adventurous park visitor.

Figure 11. Refolded fold in a metagreywacke. The rocks of Sweetwater Creek State Park exhibit two separate periods of folding. In the photo the limbs of the first fold have been folded by a second episode of folding (see Fig. 4C).

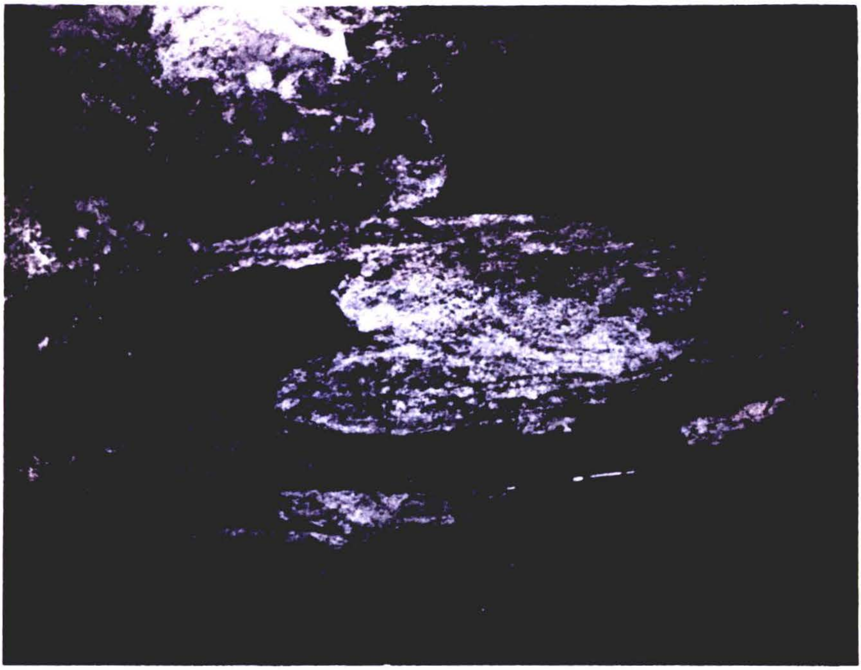


Figure 12. Folded pegmatite in a metagreywacke. The pegmatite was injected into the meta-greywacke before folding and was folded along with the surrounding rock.

Glossary

These definitions are paraphrased from the following sources:

(1) Gary, Margaret, et al (eds.): *Glossary of Geology*, Washington: American Geological Institute, 1974.

(2) Fairbridge, Rhodes W., (ed.); *The Encyclopedia of Geomorphology;* Encyclopedia of Earth Sciences Series, Volume III, New York: Rheinhold Book Corporation, 1968.

(3) Gilluly, James, et al; *Principles of Geology,* San Francisco: W. H. Freeman and Company, 1968.

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anticlinorium — a convex upward fold of regional extent composed of smaller folds. (1)

Brevard Fault Zone — a zone of intense faulting that extends from northwestern North Carolina to the Fall Line in Alabama.

crust — the outer shell of the earth (1)

differential erosion — erosion that occurs at irregular or varying rates, caused by the differences in the resistance and hardness of rocks. Softer and weaker rocks are rapidly worn away while harder and more resistant rocks remain to form ridges, hills, or mountains. (1)

discharge — the amount of water passing a given point in a specific amount of time.

drainage basin — region (or area) drained by a particular stream or river and its tributaries.(2)

fault — a fracture in the rock along which movement has occurred. (3)

feldspar — a closely related group of minerals which owe their importance to the fact that they are the most abundant of all minerals. (3)

foliation — thin layering in metamorphic rocks which is due to the parallel orientation of its minerals. (3)

gradient — ...(b) a part of a surface feature that slopes upward or downward; a slope, as of a stream channel.... (1)

joint — a fracture or break in a rock along which no movement has taken place. (1)

lithology — (a) the description of rocks.... (b) the physical character of a rock.... (1)

metamorphism — the transformation of rocks by heat, pressure and chemically active fluids to which they were subjected after deep burial. (3)

organic acids — acids derived from organic material.

recrystallization — the formation of new minerals in a rock.... under the influence of metamorphism.... (1)

relief — ...(b) the vertical difference in elevation between the hilltops... and the lowlands... of a given region.... (1)

runoff — that portion of rainfall which makes its way into a stream.... (1)

strike — the direction or trend of a rock unit. (1)

tributary — (a) a stream... joining or flowing into a larger stream (at any point along its course).... (1)

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