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GEOLOGY AND GROUND-WATER RESOURCES OF WALKER COUNTY, GEORGIA

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U.S. Geological Survey

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GEOLOGY AND GROUND-WATER RESOURCES OF WALKER COUNTY, GEORGIA

by Charles W. Cressler

ABSTRACT

Walker County is in the Cumberland Plateau and the Valley and Ridge physiographic provinces of Georgia. It is underlain by rocks ranging in age from Early Cambrian (Rome Formation) to Pennsylvanian (Rockcastle Sandstone). All the geologic formations except the Chattanooga Shale yield sufficient water to wells for domestic and farm use. Most wells in the county are between 50 and 200 feet deep, but a few are deeper than 300 feet.

The largest sustained pumpage from a well was 60 gpm (gallons per minute), but wells in the Knox Group, the Conasauga Formation, the Chickamauga Limestone and the Mississippian rocks probably would supply more. Some artesian wells in the Chickamauga Limestone and the Floyd Shale flow.

Hardness of ground water from wells sampled throughout the county ranges from 17 to 400 ppm (parts per million). The mineral constituents vary considerably with each formation, but the iron content generally is less than 0.02 ppm.

Springs in the Knox Group and the Mississippian rocks discharged more than 21 mgd (million gallons per day) during 1960. Of this amount, at least 15 mgd was unused. Much of this spring flow could be used as a source of industrial supply in Walker County.

Hardness of the spring water ranges from 86 to 157 ppm. The iron content generally is less than 0.09 ppm.

INTRODUCTION

Walker County includes an area of 448 square miles in northwestern Georgia (fig. 1). It is bounded on the east and south by Catoosa, Whitfield, Gordon, and Chattooga Counties, Ga., on the west by DeKalb County, Ala. and Dade County, Ga., and on the north by Hamilton County, Tenn. LaFayette, the county seat, is on U.S. Highway 27 about 25 miles south of Chattanooga, Tenn.

Walker County has a mild climate with an average January temperature of 41°F and an average July temperature of 78°F. The frost-free season averages about 190 days. The average yearly precipitation is about 55 inches and includes a small amount of snow. Precipitation in the county is heaviest in the winter and midsummer. Autumn is the driest season of the year.

The county is in the drainage basins of the Tennessee and the Coosa Rivers. Areas north of LaFayette, including McLemore Cove, drain to the Tennessee. The remainder of the county drains southward into the Coosa River.

The principal industries of Walker County are textile and furniture manufacturing, dairying and milk processing, poultry and egg raising, and farming. Agriculture is mainly part-time and residential farming. A major part of the agricultural income is derived from poultry and poultry products. The soils of the county are of medium productivity. The valleys are used for growing cotton, corn, small grains, and pasture crops. The lower ridges are used for truck, hog, and pasture crops, and the rougher terrane is used for growing timber.

A good network of all-weather roads make all sections of Walker County easily accessible. The main roads serving the county are U.S. Highway 27 that connects LaFayette, the largest city, with Chattanooga, Tenn. to the north and Rome, Ga. to the south. Georgia Highway 151 links LaFayette with U.S. Highway 41 and Atlanta. The Central of Georgia Railroad and the Tennessee, Alabama, and Georgia Railroad serve the county.

The writer wishes to express his sincere appreciation to the well and spring owners of Walker County for their cooperation in supplying data on their water supplies.

Dr. A. T. Allen and Mr. R. J. Martin, of Emory University Geology Department, were very helpful on problems concerning geology.

The U.S. Park Service permitted the installation of a recording gage on a well in the Chickamauga and Chattanooga National Military Park.

The writer was assisted by Harry E. Blanchard, hydrologic engineering technician, U.S. Geological Survey, in making the well and spring inventory.

This investigation was made under the supervision of J. T. Callahan, former district geologist, Ground Water Branch, U.S. Geological Survey.

PURPOSE AND SCOPE

This investigation was made by the U.S. Geological Survey in cooperation with the Georgia Department of Mines, Mining, and Geology to evaluate the ground-water resources of Walker County. The investigation is part of a statewide program of reconnaissance designed to appraise Georgia's ground-water resources, the amount of ground water being used, and the quantity, quality, and availability of ground water in each county. Walker County is one of ten counties that will be studied in the Paleozoic rock area of

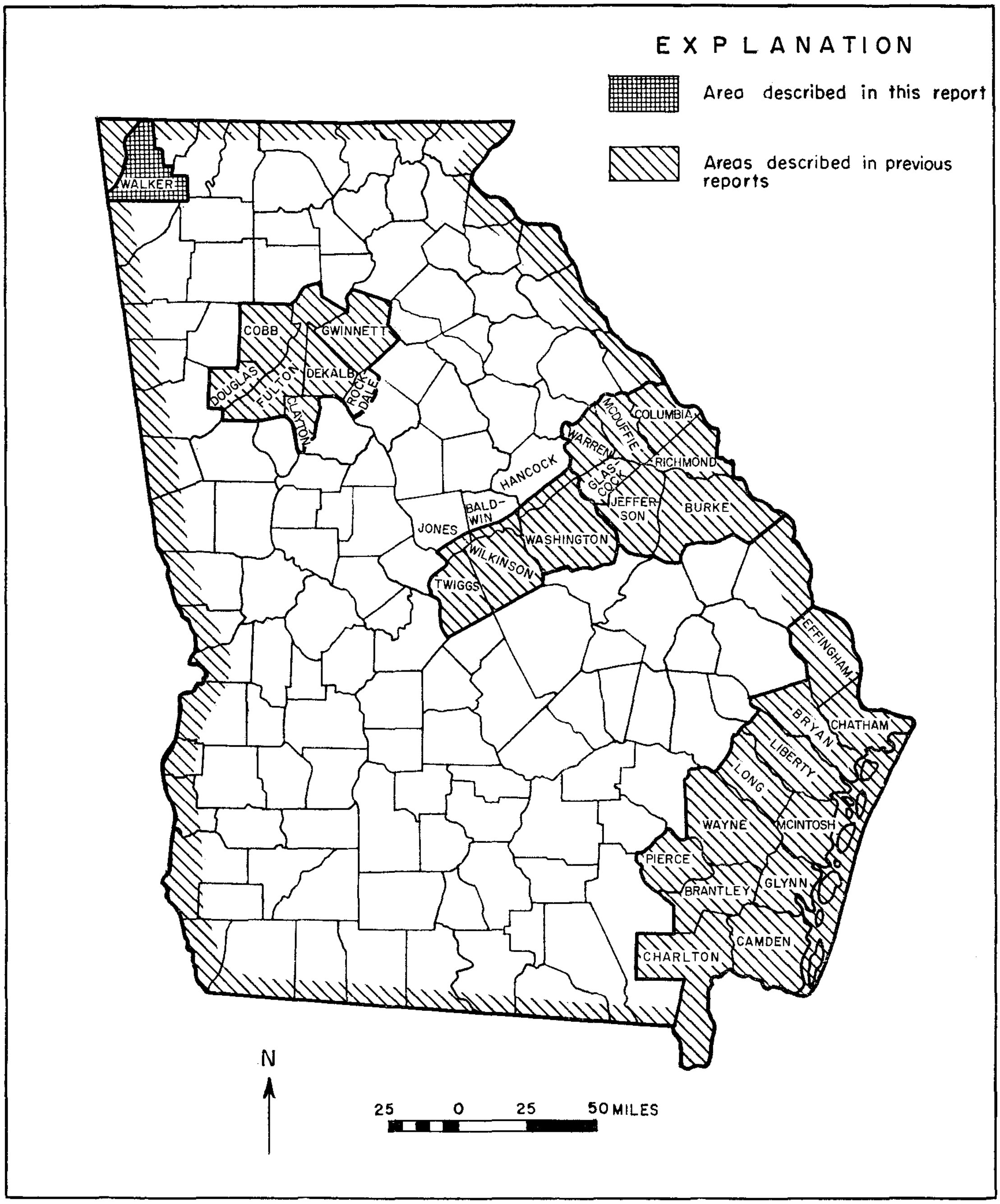

Figure 1.—Map of Georgia showing Walker County and areas described in previous reports.

Georgia. Field work was done from July 1959 to September 1960.

The investigation included an inventory of more than 300 dug and drilled wells to obtain information about the range in depth of wells in the county and to determine the quantity and quality of the well water.

Springs of significant size were inventoried and their rate of flow measured or estimated. Water temperature was measured, and the reliability, fluctuation, and water quality were determined where possible.

Water samples from 6 wells and 7 springs were analyzed by the U.S. Geological Survey. Other analyses data were obtained from the Georgia Department of Mines, Mining, and Geology.

A recording gage was installed on one well to obtain a continuous water-level record.

The geology of the county was mapped in sufficient detail to determine the limits of the aquifers.

PREVIOUS INVESTIGATIONS

The earliest geologic investigations in the area were made in 1891 by C. W. Hayes of the U.S. Geological Survey. Hayes (1894) mapped and described the formations in some detail. Butts (1948) made the most comprehensive study of the region. Allen and Lester (1957) studied the Middle and Upper Ordovician limestones in detail. Several other reports dealing with the geology of the county have been published as Georgia Geological Survey Bulletins and are listed in Butts (1948).

GEOLOGY

Physiography

Walker County is partly in the Valley and Ridge physiographic province and partly in the Cumberland Plateau.

The Valley and Ridge province is part of the Appalachian Valley (Butts, 1948, p. 3), which is a comparatively narrow belt of low-lying country extending from Canada to northern Alabama. The terrane consists of parallel valleys, separated by steep or by well-rounded ridges. Lowland areas are about 800 to 900 feet above sea level. The highest ridges reach an altitude of 1,600 feet.

The Cumberland Plateau is a large tableland of relatively undeformed rocks that includes Lookout and Pigeon Mountains in Walker County. Lookout and Pigeon Mountains have terrane of rolling hills and shallow valleys except where downcutting streams have formed canyons. The mountains rise about 1,200 feet above the adjacent valleys.

Geologic History

The rocks exposed in Walker County (table 1) originated as sediments on the floor of a shallow inland sea. The oldest sediments were washed from nearby land areas about 450 million years ago and gradually were compacted into rock. Material that formed the youngest rocks in the county was deposited about 225 million years ago, mostly in fresh water or in shallow lagoons. Changing conditions of deposition are indicated by the animal and plant remains preserved in the rocks. Shells of salt-water animals constitute the bulk of fossils in the older rocks, whereas plant remains are abundant in the younger rocks.

After many thousands of feet of sediments were deposited on the sea floor, they were uplifted, and the sea retreated. At about the same time forces from within the earth began to compress the sediments from the southeast. The pressure was so great that it consolidated them into rock and folded and broke them in many places. Next, the rocks were eroded to sea level.

Similar cycles of uplift and erosion were repeated several times. The present-day topography of Walker County is the result of an incomplete cycle in which the area has been partially eroded to sea level. Lookout and Pigeon Mountains remain high in comparison with the surrounding country because they are capped by resistant sandstone. Other rocks in the county are less resistant and have been worn away more readily.

STRATIGRAPHY

CAMBRIAN SYSTEM

Rome Formation

The Rome Formation was named from Rome, Floyd County, Ga. where it is well exposed. The Rome is the oldest formation exposed in Walker County.

Exposures of the Rome Formation are limited to a belt northwest of Villanow in the eastern part of the county (fig. 2). The Rome consists of sandstone, siltstone, and claystone. The siltstone and claystone are green, yellow, brown, and red. For the most part they are fissile. The sandstone is fine grained and green, brown, red, dark gray, or nearly white. Most of the sandstone beds are less than 4 inches thick.

Tight folding is a striking feature of the formation. In nearly all exposures the beds are steeply tilted or vertical. Because of the folding, and because the base of the formation is not exposed, the thickness of the Rome is unknown.

Conasauga Formation

The Conasauga Formation was named by Hayes (1891, p. 143) from exposures along the Conasauga River in Whitfield and Murray Counties, Ga.

The largest exposure of Conasauga in Walker County is in the valley which passes through LaFayette. The Conasauga also underlies a narrow valley in Peavine Ridge south of LaFayette and is exposed in a strip west of Villanow.

In Walker County the Conasauga is composed of siltstone, claystone, shale, and limestone. The siltstone and claystone dominate the lower part of the formation, which contains only a few scattered beds of limestone. At the top of the formation is about 300 feet of thick-bedded limestone that apparently is correlative with the Maynardville Limestone of the Conasauga Group of Tennessee.

Table 1. *Geologic formations and their water-bearing properties, Walker County, Ga.*

System	*Group or formation*	*Thickness (feet)*	*Lithology*	*Water-bearing characteristics*
Pennsylvanian	Pennsylvanian rocks, undifferentiated	1,200±	Shale and massively bedded conglomeratic sandstone at base; coarse-grained sandstone and sandstone interbedded with shale; commercial deposits of coal.	Wells less than 100 feet deep; adequate for domestic and farm needs; iron content high in many areas.
Mississippian	Mississippian rocks, undifferentiated	1,500±	Western facies: Bedded chert at base; thick-bedded cherty and noncherty, fine- to coarse-grained limestone; thin sandstone and shale beds; shale and little sandstone interbedded at top.	Chert and limestone; good aquifer; may yield several hundred gpm from solution openings and joints; wells less than 200 feet deep; several springs in limestone; mostly small.
		1,500±	Eastern facies: Gray to black fossiliferous shale; many places includes limestone and sandstone members similar to those of western facies; bedded chert at base.	Wells less than 100 feet deep; some yield more than 30 gpm, but most less than 10 gpm; best yields from limestone members, poorest from shale.
Devonian and Mississippian	Chattanooga Shale	15	Black hard shale, high cleaved; top 1 to 3 feet is greenish phosphatic clay.	Not an aquifer; locally may be a confining layer; contains iron and hydrogen sulfide and should be cased off from well.
Silurian	Red Mountain Formation	1,000±	Sandstone, shale and limestone; more sandstone on east side of county.	Wells less than 100 feet deep; supplies domestic and farm needs; water high in iron in some areas; yields as much as 30 gpm from sandstone.
Ordovician	Chickamauga Limestone	1,400-2,300	Thin and thick-bedded limestone, clayey limestone, and siltstone in western outcrops; siltstone and claystone in eastern outcrops.	Good aquifer; wells generally less than 100 feet deep; yields 10 to 20 gpm common; higher yields probable; some hydrogen sulfide; yields poor in siltstone areas.
	Knox Group	3,550±	Thin and thick-bedded dolomite; limestone and dolomite at top; weathers deeply and has thick chert and clay mantle.	Very good aquifer; wells and springs of good yield; wells between 150 and 200 feet deep and supply 20 to 60 gpm; larger yields from solution openings and joints; springs discharge 25 to 40 mgd, depending on precipitation.
Cambrian	Conasauga Formation	2,000±	Limestone, limy siltstone, claystone, shale.	Good aquifer, wells 50 to 150 feet deep; yields adequate for domestic and farm needs, and many are 20 to 60 gpm; much larger yields from solution openings in limestone part of formation.
	Rome Formation	2,000±	Sandstone, siltstone, claystone; highly cleaved and folded.	Poor aquifer in Walker County; may supply farm or home, but many wells unreliable; iron is problem in places.

The siltstone and claystone contain enough lime to give them the appearance of limestone. For this reason, on fresh exposures the formation resembles a limestone. When weathering removes their lime content the siltstone and claystone are reduced to a brownish or greenish shale-like rock. The green shale units seem to have a higher clay content than the brown shale.

The limestone at the top of the formation is thick bedded (1 to 6 feet), light to dark gray, and has a ribboned appearance caused by bands of silty and clayey material that stand in relief on weathered surfaces.

CAMBRIAN AND ORDOVICIAN SYSTEMS

Knox Group

The name Knox Group is used in this report for a sequence of rocks that corresponds nearly to the Knox Group of the type locality in Knox County, Tenn. However, in this report the Newala Limestone is not included in the Knox Group as it is in Tennessee, but is placed in the Chickamauga Limestone because it is more like the Chickamauga.

The largest outcrop areas of the Knox Group in Walker County are on Missionary Ridge and Peavine Ridge. It is exposed also in the ridge that passes through LaFayette and in the ridge complex in the eastern part of the county between Dick Ridge and Mill Creek Mountain.

In Georgia the Knox Group includes the following formations listed in ascending order: Copper Ridge Dolomite, Chepultepec Dolomite, and the Longview Limestone. These formations were not mapped separately.

The following general descriptions of the formations of the Knox Group in adjacent Catoosa County are considered to be applicable to Walker County.

Copper Ridge Dolomite

The lower half of the Copper Ridge Dolomite is a thickly to massively bedded dolomite containing no limestone except one or two beds near the base. Much of the dolomite is brownish gray and has an asphaltic odor that is noticeable when the rock is broken. The upper half of the Copper Ridge is mainly light gray dolomite and some light brownish gray dolomite, in thin to thick beds. Chert layers are more abundant in the upper half. The Copper Ridge is about 2,500 feet thick.

Chepultepec Dolomite

The Chepultepec Dolomite includes all the rock between the Copper Ridge Dolomite and the Longview Limestone. It is mainly dolomite but contains several beds of limestone. The dolomite is mostly light gray, but may also be brownish gray or light red. The bedding is thin to thick, and some layers are thinly laminated. A few layers of chert 10 feet thick occur, but most chert is in thin layers and nodules. Thin sandstone beds cemented with chert are present near the top of the formation. The total thickness of the Chepultepec is about 700 feet.

Longview Limestone

The Longview Limestone is composed of about 350 feet of light gray and light olive gray cherty limestone and dolomite. Limestone and some dolomite make up the middle and upper parts, whereas the lower part is mostly limestone. Layers and nodules of reddish chert are characteristic of the Longview.

ORDOVICIAN SYSTEM

Chickamauga Limestone

The Chickamauga Limestone was described in 1890 by C. W. Hayes from exposures along Chickamauga Creek, east of Chattanooga, Tenn., and branches of that creek in Ringgold quadrangle, northwestern Georgia. Detailed studies of the Chickamauga Limestone have been made by Allen and Lester (1957) in which the formation was divided into a series of zones based on lithologic and faunal characteristics.

The Chickamauga Limestone is a complex of silty and clayey limestone and limy siltstone. The composition and texture of the rock vary with the location of the outcrop and its position along the strike. Most of the formation is thin bedded, but some limestone beds are 3 or 4 feet thick. A high degree of fracturing and jointing is characteristic.

The Chickamauga, which crops out on the eastern side of the county around Johns and Mill Creek Mountains, is mostly siltstone and claystone and is designated the near-shore facies by Allen and Lester (1957, p. 5). This facies is about 2,300 feet thick and is composed of sediments laid down relatively near the source of sedimentation.

The remainder of the Chickamauga in the county is largely a flaggy limestone and is designated the off-shore facies. The off-shore facies is 1,400 to 2,100 feet thick.

SILURIAN SYSTEM

Red Mountain Formation

The Red Mountain Formation was named from Red Mountain, near Birmingham and Bessemer, Ala. The formation has the same character in Georgia as it does in Alabama.

The Red Mountain Formation crops out along the flanks of Lookout and Pigeon Mountains, and it forms the northern extension of Pigeon Mountain. It is exposed in the valley south of Rossville, and it makes up Taylor Ridge, Dick Ridge, Johns Mountain, Horn Mountain, and Mill Creek Mountain.

The Red Mountain Formation is about 1,000 feet thick and consists of sandstone and shale and a minor amount of limestone. In the eastern part of the county, the formation contains large quantities of sandstone and forms high ridges. The western outcrops are mostly shale and form low ridges and rolling hills.

The sandstone ranges in grain size from very fine to coarse and in places contains quartz pebbles 0.5-inch or more in diameter. The beds range from less than 1 inch to more than 10 feet thick, and many are interfingered with beds of shale. Unweathered sandstone is gray to cream colored, but where weathered it is red or buff. A few beds of hematite occur.

The shale of the Red Mountain is in beds 0.1 inch to more than 10 inches thick. On fresh exposures it is gray but weathers rapidly to brown or maroon. Much of the shale contains layers and lenses of coarse sand or pebbles, particularly in eastern outcrops.

DEVONIAN AND MISSISSIPPIAN SYSTEM

Chattanooga Shale

The Chattanooga Shale was named for Chattanooga, Tenn., which is situated on a belt of the shale. The Chattanooga is a highly fissile shale, generally black, but brown where weathered. It is about 15 feet thick. The upper part of the Chattanooga is a layer of greenish clay, 1 foot to 2.5 feet thick, that contains phosphatic nodules ranging from 0.5 inch to 2 inches in diameter. This clay probably is the same as the Maury Formation of Tennessee.

The Chattanooga is folded and cleaved, whereas the Red Mountain Formation below and the Fort Payne Chert above are relatively undeformed. The shale is present everywhere between these two formations and is a useful geologic datum.

MISSISSIPPIAN SYSTEM

The Mississippian System of Georgia is composed of two diverse facies of rock of equivalent age. In Lookout and Pigeon Mountains, the Mississippian is almost entirely limestone and chert, except for the Pennington Shale at the top. East of Taylor Ridge all the Mississippian above the Fort Payne Chert is predominantly a shale that has limestone and sandstone members developed to various degrees at different localities. This facies was named the Floyd Shale from exposures in Floyd County, Ga. where it is fully developed.

Western Facies

The western facies of the Mississippian System includes the following members described in ascending order (descriptions taken largely from Butts, 1948).

Fort Payne Chert

The name Fort Payne is taken from Fort Payne, DeKalb County, Ala.

The Fort Payne is 390 feet thick. It is composed mainly of stratified chert and dark compact calcareous shale or argillaceous limestone, named the Lavender Shale Member (Butts, 1948, p. 44). The beds range in thickness from 2 inches to 1 foot and are irregularly furrowed along the bedding faces, causing an uneven contact. Small quartz geodes, 0.25 inch to 2.5 inches in diameter are common, but are more abundant in the lower part of the formation.

St. Louis Limestone

The St. Louis Limestone, named for St. Louis, Mo., is a thick-bedded dark fine-grained cherty limestone. The St. Louis generally is non-oolitic and is 100 feet thick.

Ste. Genevieve Limestone

The Ste. Genevieve Limestone, named from Ste. Genevieve, Mo., is easily distinguished from the St. Louis below by its oolitic and non-cherty character. It is gray to bluish gray, rather thick bedded, and coarsely crystalline and is probably nearly pure calcium carbonate. Its thickness is 100 to 200 feet.

Gasper Limestone

The Gasper Limestone is very similar lithologically to the Ste. Genevieve Limestone and would not be separated except for the fact that in western Kentucky and southern Illinois the two are separated by the Bethel Sandstone. The Gasper is a thick bedded gray rather coarsely crystalline noncherty limestone and is about 150 feet thick.

Golconda Formation

The Golconda consists of shale and interbedded thin platy limestone. Fossil evidence links this zone with limestone named from Golconda, Hardin County, Ill. It is less than 20 feet thick.

Hartselle Sandstone

Five to ten feet of sandstone or sandy limestone that weathers to sandstone, exposed in the northern end of Lookout Mountain, and probably represents the Hartselle Sandstone of Alabama (Butts, 1948, p. 48).

Bangor Limestone (restricted)

The Bangor is a thick bedded bluish gray coarsely crystalline limestone extending up to the Pennington Shale. It is about 500 feet thick.

Pennington Shale

The Pennington, named from Pennington Gap, Va., is predominantly a gray shale, which weathers yellow and red. The beds of red shale are a distinguishing characteristic. Some beds of sandstone and limestone occur in the formation. The Pennington contains an abundance of marine fossils, mainly bryozoa and brachipoda, which do not occur in the overlying Pennsylvanian rocks. The thickness is about 200 feet.

Eastern Facies

The eastern facies of the Mississippian System includes only the Fort Payne Chert and the Floyd Shale. The Fort Payne Chert is similar in both the eastern and western facies. The Floyd Shale is predominantly a gray to black fossiliferous shale and in many places includes limestone and sandstone units similar to those of the western facies. The eastern facies of the Mississippian System is about 1,500 feet thick.

Pennsylvanian System

The Pennsylvanian rocks of Georgia include several formations which are described below. The nomenclature and much of the descriptive material are from Johnson (1946).

Lookout Sandstone

The oldest formation of the Pennsylvanian System is the Lookout Sandstone, which includes the Gizzard Member below and the Sewanee Member above. The Gizzard Member is about 150 feet thick and consists of fine-grained sandstone and gray shale. Four coal beds occur in the Gizzard. The Sewanee Member consists of about 175 feet of coarse grained generally massively bedded white to buff conglomeratic sandstone. The Sewanee forms much of the prominent rim around Lookout Mountain.

Whitwell Shale

The Whitwell Shale is a thin bedded light to dark gray shale about 50 feet thick at a maximum. The shale thins to the south, where at many outcrops it is only 5 to 10 feet thick.

Bonair Sandstone

The Bonair Sandstone is a crossbedded fine to coarse grained light colored sandstone about 200 feet thick that weathers to reddish brown. It is similar to the Sewanee Member of the Lookout Sandstone except that it generally does not contain pebbles. In some areas the Bonair forms a line of cliffs above those of the Lookout Sandstone and is separated from it by the Whitwell Shale.

Vandever Shale

The Vandever Shale is 150 to 200 feet thick and consists of coal, gray shale, and sandy shale. Considerable amounts of coal have been mined in the Vandever.

Rockcastle Sandstone

The lower 150 feet of the Rockcastle Sandstone is coarse grained, thick bedded, and crossbedded and is resistant to weathering. The upper 300 feet of the Rockcastle consist of interbedded sandstone and shale that contains three seams of coal.

STRUCTURE

Lookout and Pigeon Mountains are relatively flat-topped ridges that have shallow synclinal structural features that plunge gently to the south (fig. 2). The mountains are the eastern front of the Cumberland Plateau in Georgia and form the west boundary of the Valley and Ridge province.

Between Pigeon Mountain and Lookout Mountain is an anticline that underlies McLemore Cove, Chattanooga Valley, Missionary Ridge, and Hawkins Ridge.

About 3 miles south of the Tennessee line, the valley between Hawkins Ridge and Missionary Ridge is underlain by an anticline composed of rocks younger than the rocks on either side. Faulting has brought the Knox Group of Missionary Ridge and Hawkins Ridge stratigraphically up in contact with the Red Mountain Formation of the valley. Later faulting uplifted the rocks so that the Knox Group is against Mississippian limestones on Hawkins Ridge.

Outcrops in the area are few and scattered, making it impossible to determine the structure in greater detail without more mapping. The locations of the faults on the geologic map (fig. 2) are based partly on field evidence and partly on extrapolation from geologic maps of Tennessee (Rodgers, 1953).

East of Pigeon Mountain are two thrust faults. One fault brings the Knox Group over the Newala Limestone; the other displaces the Conasauga Formation over the Knox Group and locally removes part of the Knox and part of the Conasauga.

The valley in which LaFayette is situated is underlain by an asymmetric anticline — being steeper on the west side.

The Knox Group of Peavine Ridge dips eastward except for local variations. At one place on the ridge the Chickamauga Limestone remains uneroded in a syncline in the Knox; at another the Conasauga Formation is exposed through an eroded anticline in the Knox.

The Red Mountain Formation that underlies Taylor Ridge dips eastward beneath West Armuchee Valley and reappears as Dick Ridge, forming the opposite limb of an asymmetric syncline.

East of Dick Ridge a major thrust fault has brought the Rome Formation up into contact with the Knox Group and placed the Knox in contact with Ordovician and Silurian rocks.

Johns Mountain is synclinal. Mill Creek Mountain is the eastward-dipping limb of an asymmetric syncline.

GROUND WATER

The natural underground reservoirs contain the largest stored supply of fresh water in the nation —far more than the capacity of all surface reservoirs and lakes including the Great Lakes. Ground water is of particular importance because it is available at nearly every location where it is needed and generally is a more reliable source than unregulated streams.

SOURCE AND OCCURRENCE

Ground water of Walker County is derived from precipitation. Precipitation either runs off the surface to a stream, evaporates back to the atmosphere, or soaks into the ground. Of the water that soaks into the ground, some remains near the surface, clinging to soil particles, or is used by plants, and some passes downward into the zone of saturation. The zone of saturation is that part of the earth in which all the pore space and other openings are filled with water under pressure equal to or greater than atmospheric; this water is called ground water. The upper surface of the body of ground water is called the water table. Most wells in Walker County probably are water-table wells, but many are nonflowing artesian wells.

The quantity of ground water stored in the zone of saturation depends on the amount of open space in the rocks. Openings in the rocks of Walker County consist mainly of joints and fractures. Joints and fractures in shale and sandstone are narrow and have small storage capacity. Joints in limestone, on the other hand, commonly are enlarged by solution and have large capacity. For this reason, limestone is the most important ground-water reservoir in Walker County.

The degree to which rock openings are interconnected affects the productivity of an aquifer. Joints in limestone and dolomite are highly interconnected; a well penetrating a single joint of small storage capacity may have a large yield, because the joint is part of an extensive system which supplies water to the well.

Ground water moves in response to gravity just as surface water does, though more slowly, because it loses energy by friction as it passes through openings in rocks.

CHEMICAL QUALITY

Ground water dissolves material from the soil and rocks with which it comes in contact. The kind and amount of material dissolved in water is important because it largely determines how the water can be used. The U.S. Public Health Service (1946) recommends that water for domestic and municipal supplies contain no more than 250 ppm (parts per million) chloride, 250 ppm sulfate, 125 ppm magnesium, 1.5 ppm fluoride, 0.3 ppm iron and manganese together, and 500 ppm dissolved solids.

Water containing too much iron tends to stain laundry and enameled ware. Iron in concentrations greater than about 0.5 to 1.0 ppm can be tasted. Livestock are sensitive to the taste of iron and may not drink water with a high iron content.

Hardness of water is caused almost entirely by calcium and magnesium, though other constituents, such as iron, aluminum, and free acid also cause hardness. Hard water is objectionable in the home because of its soap-consuming capacity. For satisfactory operation commercial laundries require water that is practically of zero hardness. The processing water for textile mills is required to be very soft. Water with a calcium, magnesium hardness of 1 to 60 ppm is considered soft; 61 to 120 ppm, moderately hard; 121 to 200 ppm, hard; and 201 ppm and above, hard to very hard (Lamar, 1940, p. 25).

Water for industrial use can have a wide range of chemical quality; almost every industrial application has different standards. Many industries require water with an iron content less than 0.2 ppm. Hardness as calcium and magnesium generally should be less than 100 ppm, though it may be as high as 250 ppm for carbonated beverages. Textiles and general dyeing require a dissolved solids content of 200 ppm or less (Moore, 1940, p. 271).

UTILIZATION

During 1960 the amount of ground water used in Walker County was about 6.8 mgd (million gallons per day). This included about 1.7 mgd distributed by Chickamauga and LaFayette, which is mainly spring water. Industry used about 4 mgd directly from springs. The remainder, or 1.1 mgd, is derived from wells throughout the county.

WATER-LEVEL FLUCTUATIONS

A continuous water-level record was obtained for well 237. The well, in the lower part of the Chickamauga Limestone, is 72 feet deep. It is similar in depth and construction to many wells in the county.

The record shows that the water table rises very rapidly after a heavy rain (fig. 3). This rise may be less than an inch or several feet, depending on the duration, intensity, and amount of rain. Shortly after the rain stops, the water table begins a slow decline, which continues at a progressively slower rate until it is reversed by another rain. The hydraulic gradient decreases as the water table declines, and ground water travels more slowly to discharge points. During dry periods, the water table recedes below the channels of most small streams, causing them to go dry.

Water-level records obtained during the investigation show that the water table is highest during the wet months of January, February, and March and lowest during July, August, and September, when precipitation is very light and water loss through evaporation and transpiration is greatest.

Long-term records of water levels are not available for Walker County; therefore, it is impossible to determine whether the water table has declined, as many residents report. However, judging by the small number of old dug wells that have gone dry permanently or that have required deepening, any decline has been slight.

WATER-BEARING CHARACTER OF THE GEOLOGIC FORMATIONS

A geologic formation that yields water in useful quantities is an aquifer. All the geologic formations exposed in Walker County are aquifers except the Chattanooga Shale. The formations are discussed separately beginning with the oldest.

Rome Formation

The outcrop area of the Rome Formation in Walker County is sparsely populated, and the formation is practically unused as an aquifer. In Catoosa County to the north, however, the Rome yields enough water to wells for most domestic and farm needs, and, on the flanks of sandstone ridges, yields of 20 gpm (gallons per minute) are reported. Most wells in the Rome in Catoosa County are less than 100 feet deep, but some are deeper than 200 feet.

In areas where sandstone is lacking, wells tend to go dry after several minutes of continuous pumping, but they usually recover overnight.

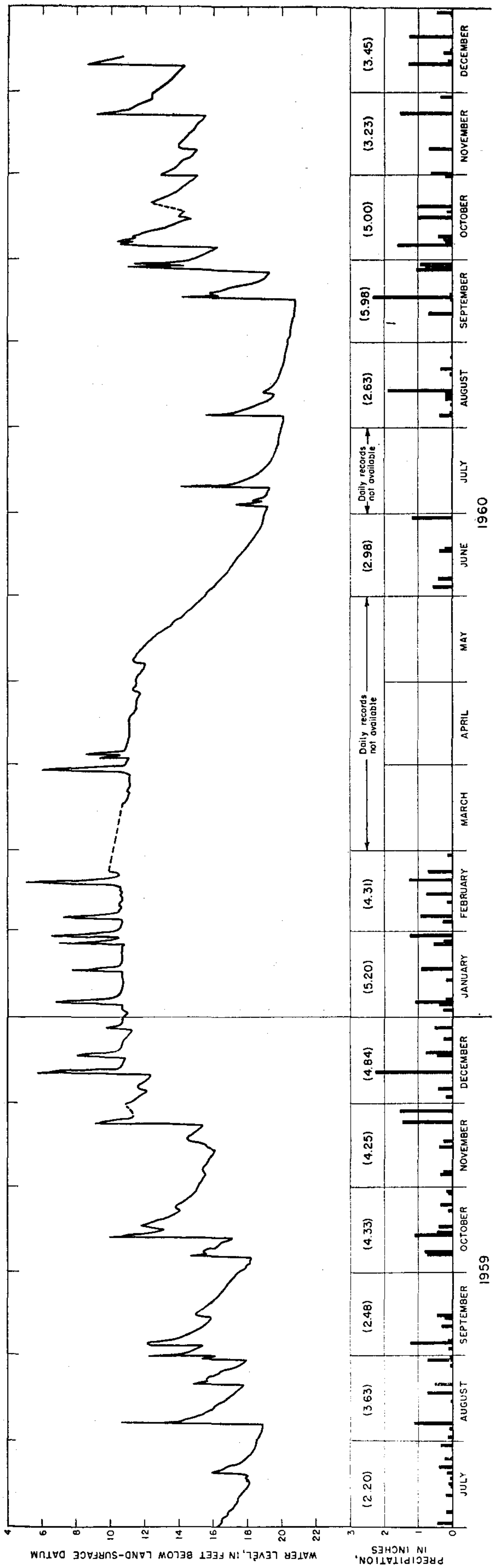

Figure 3.—Water-level fluctuations in well 237 and daily precipitation at Chickamauga and Chattanooga National Military Park, 1959–60.

Water from the Rome commonly is hard and contains iron in excess of 0.3 ppm. Analyses of water from two wells in this formation in Catoosa County showed a total hardness of 108 and 207 ppm and an iron content of 0.02 and 0.63 ppm.

Conasauga Formation

Most wells in the Conasauga Formation yield sufficient water for domestic and farm use. Wells generally are between 50 and 150 feet deep, though some are deeper than 200 feet. Yields of 20 to 60 gpm are reported.

Solution openings are well developed in the formation, particularly in the limestone. During the drilling of well 90, water was struck at a depth of 40 feet and could be heard flowing through the well. During the remainder of the drilling—to 78 feet—all the drill cuttings were flushed from the well and none could be recovered by bailing. Several buckets full of mud were poured into the well, and the mud was flushed away before it could be bailed out. The well was pumped at 10 gpm for a day without any measurable drawdown.

Because of the prevalence of shale and siltstone in some areas and limestone in other areas of the Conasauga, the water-bearing character of the formation varies considerably. Drilling is difficult in places underlain by tilted siltstone strata, but yields of wells generally are good. On the average, the best yields are obtained from wells in the thick limestone at the top of the formation. Where the formation is mostly clay shale, the yield of wells is relatively low, but a completely dry hole is unusual.

Dug wells in the Conasauga are fairly common, probably because they are easy to dig in the residual material. Dug wells are dependable and some supply a relatively large quantity of water. Well 89, only 24 feet deep, supplied water for a family of 6, with bath and automatic washer, and for 2,600 chickens.

Wells in the limestone areas of the Conasauga and in many of the siltstone areas yield hard water. Water from wells in areas of clay shale and from shallow wells in residuum generally is soft. Water from well 90 had a total hardness of 87 ppm (table 2).

Knox Group

The Knox Group is one of the best aquifers in Walker County. It yields large quantities of water to wells and discharges millions of gallons per day from springs, including Crawfish Spring (S-1), one of the largest springs in northwestern Georgia.

Wells in the Knox average between 150 and 200 feet in depth, which is somewhat deeper than wells in other formations of the county. This is because the Knox weathers deeply and is covered by a thick layer of chert and clay residuum. To reach bedrock, wells must penetrate from 100 to 200 feet of residuum. Generally, it is necessary to drill into rock to obtain a large yield. Some wells in residuum, however, supply several gallons per minute, and many people prefer them because they are shallower and cheaper to drill. As a rule,

Table 2. Chemical analyses of ground water, Walker County, Ga.

(Analyses by U.S. Geological Survey and Georgia Department of Mines, Mining, and Geology)
Water-bearing formations: Pu, Pennsylvanian rocks undifferentiated; Mu, Mississippian rocks undifferentiated; Srm, Red Mountain Formation; Oc, Chickamauga Limestone; OꞒK, Knox Group; Ꞓc, Conasauga Formation.

	Name or owner	Date of collection	Water-bearing formation	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chlorida (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (at 180° C)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25° C)	pH	Color	Temperature (°F)	Remarks
217	G. K. Grigsby[1]	7-27-60	Oc	8.9	0.07	7.4	2.3	0.7	0.4	66	0.4	0.5	0.1	0.0	80	28	0	97	6.8	5	...	Water turns light blue and tastes soapy when boiled. Reason unknown.
74	Mountain Cove Farms[1]	7-25-60	Pu	24	.71	15	3.0	6.5	.5	76	4.0	.5	.2	.1	106	50	0	128	6.7	16	...	Domestic and stock well.
73	do[1]	7-25-60	Srm? Mu?	13	.03	102	28	9.1	.4	189	215	1.5	.4	.1	517	370	214	668	7.4	8	62	Well 440 feet deep.
64	Eugene Patterson[1]	7-25-60	Pu	6.3	.00	4.8	1.2	3.0	1.8	24	17	6.5	.1	.0	80	17	0	97	6.2	12	...	Domestic well.
129	Levoy Stephenson[1]	8-14-60	Oc	9.2	.16	53	2.2	1.1	.3	180	.8	1.5	.2	.6	173	141	0	272	7.4	3	...	Do
90	L. H. Bowers[1]	8-14-60	Ꞓc	12	.01	33	.4	2.2	.7	99	.4	2.0	.1	2.3	117	84	3	166	7.2	7	...	Domestic and stock well.
S-1	Crawfish Spring[1]	11-26-57	OꞒk	8.6	.04	26	10	1.4	.5	124	1.0	1.0	.1	3.5	114	106	4	199	7.2	4	59	Municipal supply.
S-10	Big Spring[1]	2-20-59	OꞒk	9.2	.01	27	9.6	1.0	.2	125	2.4	1.5	.0	3.8	117	107	4	188	7.4	3	57	LaFayette water supply.
S-4	Mountain View Farms[1]	8- 4-60	Mu	8.0	.11	53	3.9	1.8	.6	172	4.8	2.5	.2	2.9	175	148	7	272	7.3	4	56	Stock well.
S-5	Dickson Spring[1]	2-13-61	Mu	5.5	.05	13	.6	.4	.2	41	1.2	.8	.0	.0	43	35	2	72	7.2	0	...	Under lake.
S-9	Buzzard Roost Spring[1]	7-18-60	OꞒk	8.6	.09	41	9.6	1.4	.7	168	2.4	1.5	.1	2.9	167	142	4	257	7.5	7	60	LaFayette water supply.
S-12	Williams Spring[1]	7-18-60	OꞒk	8.2	.01	24	12	.9	.4	127	2.4	1.0	.1	.8	124	110	6	191	7.3	3	59	Industrial supply.
	Cave Spring[1]	5- 5-58	Oc	7.1	.02	24	5.8	1.8	.4	101	5.0	2.5	.1	3.1	106	84	1	174	7.1	1	60	Seasonal spring.
	Not given[2]	4-21-55	OꞒk	3.5	2.0	35	28	66	...	348	45	12	tr.	...	557	201	...	...	9.9	pink	...	
	Mrs. Sidney Wilson[2]		?	9.0	.03	117	27	tr.	tr.	376	tr.	12	...	...	415	400	...	...	8.0	opaque	74	
S-2	Blue Hole[2]	9-22-52	OꞒk	8.0	.00	30	19	tr.	tr.	140	tr.	2	...	.05	150	150	...	...	7.5	none	...	May be S-1, some doubt.
S-2	do[2]	11-24-53	OꞒk	8.0	.15	40	1	tr.	tr.	132	1	1	tr.	...	200	105	...	...	7.5	none	...	
S-9	Buzzard Roost Spring[2]	10-21-55	OꞒk	6.0	.40	40	14	tr.	tr.	158	5	7	...	...	236	157	...	...	8.0	none	...	
S-10	Big Spring[2]	4-20-38	OꞒk	6.9	.18	22	7.5	1.1	.5	99	2.4	1.6	.0	3.1	94	86	...	...	...	...	...	
	Horseshoe Cave[2]	5-15-56	Oc	2.0	.15	31	8	tr.	tr.	135	.8	5	...	2	196	110	...	...	8.0	...	...	
	W. E. McWhorter[2] LaFayette	5-11-40	?	5.0	...	8.5	tr.	tr.	20.7	12.2	.0	...	...	...	...	...	...	...	...	...	...	
	Mrs. Maud T. Daniel	1-12-50	Oc?	10	tr.	36	1	tr.	tr.	195	4	3	...	...	145	144	...	...	8.5	none	...	

[1]Analysis by U.S. Geological Survey
[2]Analysis by Georgia Department of Mines, Mining, and Geology

Table 3. Spring flows in Walker County, Ga.

Number	Name or owner	Geologic formation	Date measured or estimated	Flow (gallons per day)	Remarks
S-1	Crawfish Spring	Knox Group	10-27-54	23,000,000	Developed. Used by Chickamauga.
			10-26-60	8,900,000	
S-2	Blue Hole	do	10-26-60	5,700,000	Developed. Bleachery.
			8-23-50	270,400	Undeveloped.
S-3	Mathis Spring	Mississippian rocks undifferentiated	10-26-60	100,000[a]	
			8- 4-60	500,000	Undeveloped. Stock water.
S-4	Mountain View Farms	do	9-15-49	1,440,000	Under lake.
			12-17-56	7,200,000	
S-5	Big Spring or Dickson Spring	do	2-13-61	7,500,000	
			8-22-50	96,000	Undeveloped.
S-6	Baker Spring	Knox Group	8-17-60	100,000[a]	Do
			9- 9-49	304,000	Do
S-7	Waterville Spring	do	9-16-59	511,000	Do
			10-26-60	200,000[a]	
S-8	Hoffman Springs	do	9-16-49	1,376,000	Undeveloped. Water used by LaFayette.
			10-28-54	1,250,000	
S-9	Buzzard Roost Spring	do	12-17-56	1,540,000	
			7-18-60	700,000	
S-10	Big Spring	do	11- 2-60	1,600,000	
			9-16-60	1,000,000	Used by LaFayette.
S-11	Howard Lake	Conasauga Formation	8-23-50	200,000	Under lake.
S-12	Williams Spring	Knox Group	9-14-60	1,200,000	Developed. Bleachery.
S-13	Anderson Cave Spring	Mississippian rocks undifferentiated	8- 4-60	150,000[a]	Developed. Domestic supply.

[a]Estimated.

wells in residuum yield softer water than wells in bedrock.

The thick permeable layer of chert and clay that overlies the Knox acts as a huge sponge to absorb precipitation that otherwise would run off. The water slowly filters down through the residuum and fills joints and other openings in the rocks below. The slow release of ground water from the residuum to the rock openings enables springs in the Knox to continue discharging large volumes of water during extended drought. Water from the residuum also keeps the joint systems filled, thereby making wells in the Knox less susceptible to drought.

The dolomite, of the Knox Group, though less soluble than limestone, has an extensive development of solution openings. At a depth of 86 feet, well 128 struck an opening that was 78 feet deep. Numerous wells in the Knox penetrate solution openings and obtain large volumes of water from them. The yield of these wells is not known, but many were bailed by the driller at rates of 20 to 60 gpm as he cleaned the wells after drilling. Unfortunately the bailing usually was for a short period and no records of drawdown were kept, so it is impossible to estimate the maximum yield of the wells.

Springs in the Knox Group discharge from 17 to 40 mgd depending on the amount of precipitation during the previous months or years (table 3). Crawfish Spring (S-1) discharged 23 mgd in October 1954. In October 1960 its flow was only 8.9 mgd. No other flow measurements of this spring are available to establish a trend, but it might be assumed that the drought of 1954 had finally affected the discharge in 1960, or the spring flow may have been low for some other reason. At any rate, it will be necessary to gather more information before trends can be established.

In 1960 Crawfish Spring and the Blue Hole, both in the town of Chickamauga, discharged about 15 mgd. Of this amount, the town of Chickamauga and the local industry (bleachery) used only about 3 mgd. The remaining 12 mgd flowed into the creek, unused except to carry waste and to maintain streamflow.

Nearly all ground water used for industrial supply or commercial distribution in Walker County is obtained from springs discharging from the Knox Group. The city of LaFayette distributes as much as 1.7 mgd, the greatest part of which is from springs in the Knox. The town of Chickamauga uses about 0.2 mgd from Crawfish Spring; Crystal Springs Bleachery uses nearly 3 mgd from the Blue Hole. The Flintstone Bleachery Co. uses as much as 1 mgd from Williams Spring. Barwick Carpet Mills buys about 0.4 mgd from the LaFayette water system.

Well water from the Knox generally is relatively free of iron and hydrogen sulfide.

Hardness of spring water sampled from the Knox ranges from 86 to 157 ppm. The iron content of the water ranges from 0.01 to 0.4 ppm.

Chickamauga Limestone

The Chickamauga Limestone is a productive aquifer. Nearly every well inventoried yielded more than enough water to meet the requirements of a modern home or farm. Of 62 wells, 31 were less than 100 feet deep; 27 were between 100 and 200 feet deep; and 4 were deeper than 200 feet. Yields of 10 to 20 gpm are common. The maximum potential yield of some wells may be much higher. Water can be heard running through well 49. A few wells struck cavities in the limestone and their water levels are not lowered significantly when pumped 10 to 12 gpm for long periods.

In the Chickamauga Limestone of Walker County it apparently is possible to get water by drilling at almost any location. No dry areas were discovered.

About one-third of the well owners questioned reported that their wells yielded soft water. The rest reported hard or moderately hard water. Water from well 129 had a total hardness of 141 ppm. Hydrogen sulfide is fairly bothersome in scattered areas, but only a few wells have water with an odor strong enough to make it unsuitable for drinking. Water from well 217 turns milky blue when boiled.

Well 181 flows a few gallons per minute all year. Well 18 flows during the winter when ground-water levels are high. Flowing wells are rather unusual in the Chickamauga, and, so far, it has been a matter of luck to drill one. Predicting where to drill to find water under enough pressure to flow is uncertain. The limestone is so highly jointed that ground water probably is not confined in many places.

Red Mountain Formation

All the wells inventoried in the Red Mountain Formation supply ample water for domestic and farm needs. Most of the wells are less than 100 feet deep. All were in the vicinity of Lookout and Pigeon Mountains, where the Red Mountain is largely shale and partly sandstone.

Most of the well water was reported to be soft, indicating that the shale and thin sandstone in the area are not calcareous. Generally, water from the Red Mountain has a good taste, but some wells yield water with objectionable quantities of iron; this not only is unpleasant to drink but also stains porcelain and clothing.

The sandstone beds of the Red Mountain are highly jointed, so wells that penetrate sandstone tend to have the best yields. The downdip side of sandstone ridges probably is the best location to drill if a large yield is required. One well (67) is reported to yield at least 30 gpm. Well 7 supplies water for five families during the summer.

Shale beds of the formation are of different types, some friable when wet, others very hard. The harder shale beds tend to fracture and act as water-bearing layers confined between beds of soft, unjointed shale. In a fresh road cut, the writer observed water flowing out of jointed shale that was confined above and below by unjointed shale. The water was under sufficient pressure to spurt from the joint and to flow about 1 gpm.

The Red Mountain Formation is one in which wells drilled at nearly any locality can be expected to yield at least 1 gpm. Much larger yields are common, but it usually requires luck to drill a well of large yield. Because of the residuum it is difficult, if not impossible, to tell where a large water-filled joint may occur.

Chattanooga Shale

The Chattanooga Shale is not an aquifer in Walker County. It is thin (15 feet) and generally impervious. The small amount of water that does come from the Chattanooga generally has a high iron and hydrogen sulfide content. For this reason, the shale should be cased from wells that penetrate it.

Because of its relative impermeability, the Chattanooga may act as a confining layer, but no wells that flowed because of the presence of the Chattanooga were found during this investigation.

The blackness of the shale makes it easily recognized during drilling. The driller commonly will case down through the shale to keep out its iron- and hydrogen sulfide-bearing water. The shale may be slightly radioactive in places.

Mississippian System—Western Facies

Excluding the Fort Payne Chert, the western facies of the Mississippian system consists of about 900 feet of limestone overlain by 200 feet of shale. On Lookout and Pigeon Mountains, Mississippian rocks are exposed only on the mountain sides below the rim rocks, and because they form such steep slopes, they are little used as aquifers. In the northern end of Chattanooga Valley where Mississippian rocks underlie large areas of relatively flat land, the formation is an important aquifer.

Wells started in the overlying rocks atop Lookout or Pigeon Mountains seldom are deep enough to derive water from the Mississippian rocks. Lateral drilling may prove to be a practical method for obtaining water from these rocks.

Several springs discharge from the Mississippian limestone. Spring S-4 flows 0.5 mgd during low flow. Anderson Cave Spring (S-13) discharges about 0.2 mgd. Several springs southwest of Roland Ridge have a combined flow of about 0.5 mgd. Numerous small springs in McLemore Cove and along the outcrop line of the Mississippian limestones are important locally for stock watering and domestic supply. Dickson Spring (S-5), southwest of LaFayette, discharged 7.5 mgd on February 13, 1961.

Most of the spring water is hard but good tasting and seems to be free of troublesome amounts of hydrogen sulfide and iron. Water sampled from S-4 had a hardness of 155 ppm.

On the west side of the county, the Fort Payne Chert makes up such steep ridges that few people use it as a source of water and no information about it was available. For this reason the Fort Payne Chert is discussed under the eastern facies of the Mississippian System.

Mississippian System—Eastern Facies

In synclinal West Armuchee Valley, the Fort Payne Chert underlies the Floyd Shale, and it is difficult to be sure that wells starting in the Floyd Shale do not get water from the Fort Payne Chert. Therefore, the Floyd Shale and the Fort Payne Chert are discussed together.

Most wells in West Armuchee Valley are about 100 feet deep, but some are deeper than 200 feet. The wells generally yield ample water for domestic and farm use. Drillers report that some wells cannot be bailed dry at a rate of 30 gpm. A few wells, however, will go dry after about an hour of continuous pumping and may require several hours to refill. Probably the better wells get water from the Fort Payne Chert or from the limestone units of the Floyd Shale. The wells of low yield probably are in shale.

The diversity of rock types in the Floyd Shale results in a considerable variation in the yield of wells and the quality of well water. Both soft and hard water are common in the formation. Water from the Fort Payne Chert generally is hard if from a deep well, but water from the residuum or from a spring usually is soft.

One well (214) in the northern part of West Armuchee Valley flows about 4 gpm. The well is 206 feet deep and probably penetrates the upper part of the Fort Payne Chert. The water tastes good and is moderately hard, according to the owner. Other wells penetrating the Fort Payne Chert may flow. The Fort Payne is permeable where it crops out, so it may be a very good aquifer.

Pennsylvanian System

The Pennsylvanian sandstone and shale generally yield 1 to 5 gpm to wells at nearly any locality except near deep canyons or mountain rims. Some wells in sandstone yield 10 gpm or more and supply water to large herds of cattle. Most wells are less than 100 feet deep.

Water contaminated by iron is a widespread nuisance in the Pennsylvanian rocks, but much of the water is soft. Wells in some areas of sandstone are reported to yield hard water. Hardness of water from two wells that were sampled was 17 and 50 ppm.

SUMMARY OF GROUND WATER

Wells drilled at virtually any location in Walker County can be expected to yield from 1 to 60 gpm, or more. Dry wells are not common. This is important because many homes are being constructed in areas away from public water supplies. Nearly every home site can have its own water supply. Wells capable of supplying a modern home or farm commonly need not be deeper than 200 feet, though a few have been drilled deeper than 300 feet. The hardness of water ranges from soft to very hard.

During 1960 more than 21 mgd discharged from springs in the Knox Group and the Mississippian rocks. More than 70 per cent of this water was unused. Most of the spring water is hard, but is low in iron content and suitable for many industrial uses.

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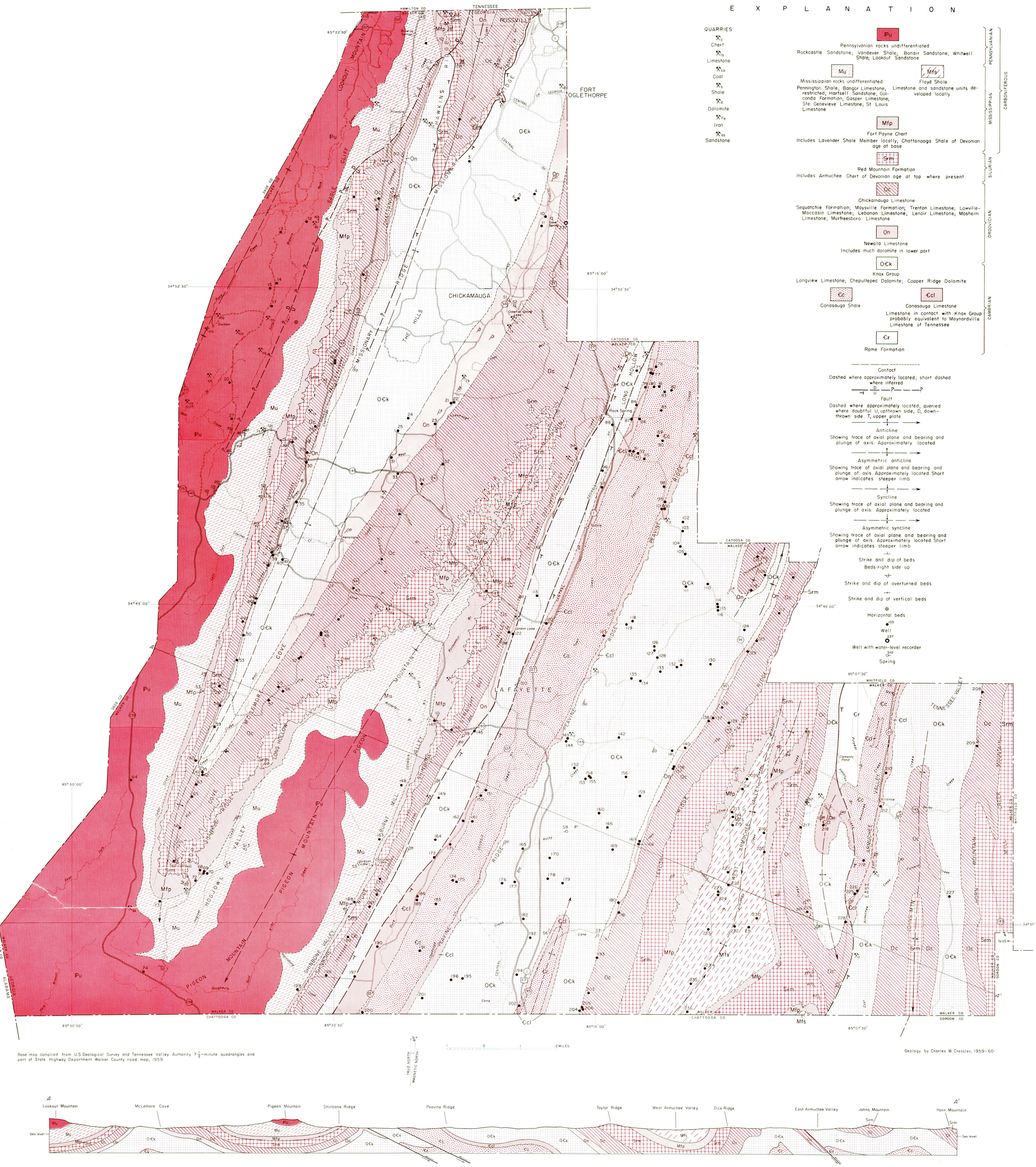

Figure 2.—Geology, and well and spring locations, Walker County, Georgia.