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GEORGIA

STATE DIVISION OF CONSERVATION

DEPARTMENT OF MINES,MINING AND GEOLOGY
GARLAND PEYTON, Director

THE GEOLOGICAL SURVEY
Information Circular 30

GEOLOGY AND GROUND-WATER RESOURCES OF CRYSTALLINE ROCKS DAWSON COUNTY, GEORGIA

By

Charles W. Sever
U.S. Geological Survey

1776

Prepared in cooperation with the U.S. Geological Survey

ATLANTA
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GEOLOGY AND GROUND-WATER RESOURCES OF CRYSTALLINE ROCKS, DAWSON COUNTY, GEORGIA

by Charles W. Sever

ABSTRACT

Dawson County, in the central part of northern Georgia 58 miles north of Atlanta, has a mean annual precipitation of 52 inches, an average annual temperature of 58°F., and an average growing season of about 195 days.

Rocks in Dawson County are grouped in five distinct geologic divisions; they are designated zones A, B, and C, Great Smoky Group, and alluvium. The age and regional stratigraphic position of zones A, B, and C are uncertain.

A thick schist sequence makes up the rocks of zone A and is divisible into five mappable lithologic units. From the oldest to the youngest, the units are mica schist and interbedded sillimanite-mica schist; mica schist and interbedded amphibolite; garnet-mica schist; quartzite and garnet amphibolite; and mica schist.

The rocks of zone B lie along a fault between the rocks of zone A and zone C and consist of mixed igneous and metamorphic rocks referred to as migmatite.

The rocks of zone C lie along the northeast-southwest belt and consist of three units — biotite schist, amphibolite, and metagraywacke.

The rocks of the Great Smoky Group are metasedimentary and are divided into zones D, E, and F.

Alluvial deposits composed of poorly sorted silt, sand, and gravel occur along the major streams.

The average yield per foot of drilled wells, based on the total footage, was 0.08 gpm (gallons per minute) in mica schist, 0.23 gpm in quartzite, 0.06 gpm in migmatite, 0.09 gpm in amphibolite, 0.04 gpm in metagraywacke, 0.13 gpm in zone F, and 0.08 gpm in zone E. Also, the average yield per foot of drilled wells was 0.08 gpm on hilltops, 0.10 gpm on slopes, and 0.15 gpm in valleys and draws.

The yield per foot of drilled wells decreased with well depth. It averaged 0.24 gpm between the land surface and 100 feet, 0.09 gpm for 300 feet, 0.03 gpm for 400 feet, and 0.02 gpm for wells deeper than 400 feet.

Studies indicate that the greatest volume of ground water moves along cleavage, schistosity, and (or) bedding planes, which in Dawson County generally are parallel except on the nose of folds.

Ground water from the metamorphic rock of Dawson County is soft and of good chemical quality, but carbonic acid dissolved in the water makes it corrosive. Water from alluvial deposits is soft and contains a small amount of acid. The pH of ground water ranged from 4.9 to 6.8. The carbon dioxide content ranged from 5 to 135 ppm (parts per million). Water from 39 percent of the wells and springs contained more than 0.3 ppm iron. Water from 95 percent of the wells and springs had a ratio of alkalinity to carbon dioxide of less than 3:1, and 92 per cent had a ratio of less than 1.1. The lowest ratio was 1:8.

The seasonal changes in ground-water temperature in wells where the water table was more than 40 feet below the land surface averaged about 1.5°F., but in wells where the water table was less than 15 feet below the land surface it averaged about 15.2°F. The seasonal change in the temperature of ground water at springs was about 2°F. The temperature of the shallow ground water decreased the higher the land-surface altitude. Also, both Lake Sidney Lanier and geologic structure affect the temperature of ground water.

Topography, lithology, and strike of the rocks are the three most important geologic factors to consider when selecting a well site.

INTRODUCTION

Purpose, Scope, and Methods of Investigation

In October 1958, the U.S. Geological Survey in cooperation with the Georgia Department of Mines, Mining, and Geology, began an investigation of the geology and ground-water resources of Dawson County, Ga., as part of the statewide study of ground-water resources. The purpose of the investigation was to determine the occurrence and chemical quality of ground water and the relation of yields of wells and springs to geology and topography. A study was made of ground-water development in the county.

Field work was started in November 1958 and completed in February 1960. It consisted of inventorying wells and springs; gathering information from well drillers; estimating the discharge of water at wells, springs, and road cuts; mapping geologically and measuring a network of observation wells to determine seasonal water-level fluctuations and changes in ground-water temperature. Water-level measurements were made in wells at about one-third of the rural residences in Dawson County. The discharges of the springs were estimated. Chemical analyses were made by the U.S. Geological Survey Laboratory, Ocala, Fla. Determination of water pH as a part of the study of the distribution of carbon dioxide was made in the field. Geophysical data, furnished by the Geophysics Branch, U.S. Geological Survey, and aerial photographs were used as aids in geologic mapping.

Location and Extent of Area

Dawson County includes 213 square miles in north-central Georgia (fig. 1). It is bordered on the east by Hall and Lumpkin Counties, on the north by Gilmer County, on the west by Pickens and Cherokee Counties, and on the south by Forsyth County. Long 84°00′E. and lat 34°30′N. intersect in southeastern Dawson County. Dawsonville, the county seat, is 58 miles north of Atlanta and is accessible by U.S. Highway 19. Other highways in the county are Georgia Highways 9E, 52, 53, 136, 226, 183, and 318.

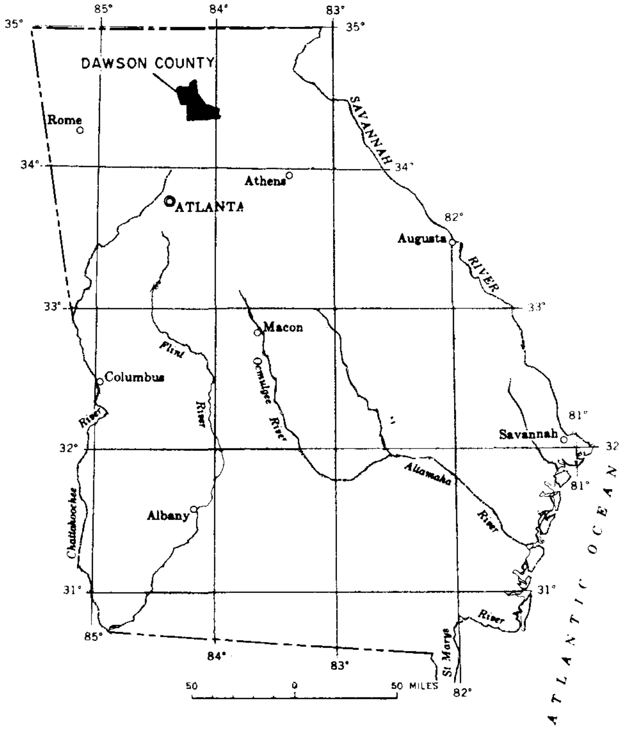

Figure 1.—Map of Georgia showing Dawson County.

The 1960 census listed 3,590 people in the county. Dawsonville is the only incorporated town and has a population of about 200.

Well-, Spring-, and Outcrop-numbering System

To facilitate the location of wells, springs, outcrops, and other features, a numbering system based on the transverse Mercator projection by the U.S. Coast and Geodetic Survey is used in this report. (See fig. 2.) In previous Georgia reports, wells and springs were numbered either serially within each quadrangle or county, or numbered by geographic coordinates based on longitude and latitude grids. In this report each location is given a three and a four digit number separated by a dash, which represents the east-west and north-south coordinates, respectively, of the square in which the well, spring, or outcrop is located. Each three and four digit number represents a Mercator-projection coordinate measured in thousands of feet. The designation 500-1600-1 represents a well or spring within the square bounded on the east by the 500,000-foot and on the south by the 1,600,000-foot coordinates. The number after the second dash indicates that the well or spring was the first to be located in that square. The designation 500-1600-A represents an outcrop within the same square as above.

Well records and other basic data not included in this report are on file at the district office, U.S. Geological Survey, Ground Water Branch, 19 Hunter Street, S.W., Atlanta, Georgia.

Previous Investigations

General information concerning the geology of Dawson County is included in a report by Crickmay (1952). Bayley (1928) and LaForge and Phalen (1913) mapped the western and northern parts of the county, respectively, as Carolina Gneiss (of former usage). Furcron and Teague (1945) mapped the kyanite deposits of the county and divided the Carolina Gneiss into two units, the Oglethorpe Formation and the Amicalola Gneiss. Detailed geologic and hydrologic studies were begun at the GNL (Georgia Nuclear Laboratory) site in 1956 by Stewart, Callahan, and others and were continued to 1962 (written communication).

Related studies have been made in nearby areas by Hurst (1955 and 1956), Mundorff (1950), and Herrick and LeGrand (1949). Additional references relating to the geology and ground-water resources of the area are given as citations and references in this report.

Acknowledgments

The assistance of well owners who provided data on their wells is greatly appreciated. Special acknowledgment is due the Gainesville Well Drilling Co., City Ice Co., Murphy Well Drilling Co. Oasis Well Drillers, Inc., Virginia Supply and Well Co., All Purpose Boring Co., and Mr. Gordon Graham for their cooperation in furnishing records of wells. Mr. Glynn Wallace, Dawson County Sheriff, is especially thanked for furnishing office space to the author. The Geophysics Branch, U.S. Geological Survey, furnished aerial radioactivity and geomagnetic data, which aided in delineating lithologic units and geologic structure. The author acknowledges the interest and assistance of the staff of the Georgia Department of Mines, Mining, and Geology.

GEOGRAPHY

Surface Features

Dawson County lies within the Blue Ridge and Piedmont physiographic provinces (Fenneman, 1938). (See fig. 3.) The Blue Ridge is a series of prominent round-crested mountains in the northwestern part of the county, and the Piedmont is a series of prominent hills near the base of the mountains but changes to flat-topped undulating hills toward the south. Scarps of 500 to 700 feet separate the two provinces.

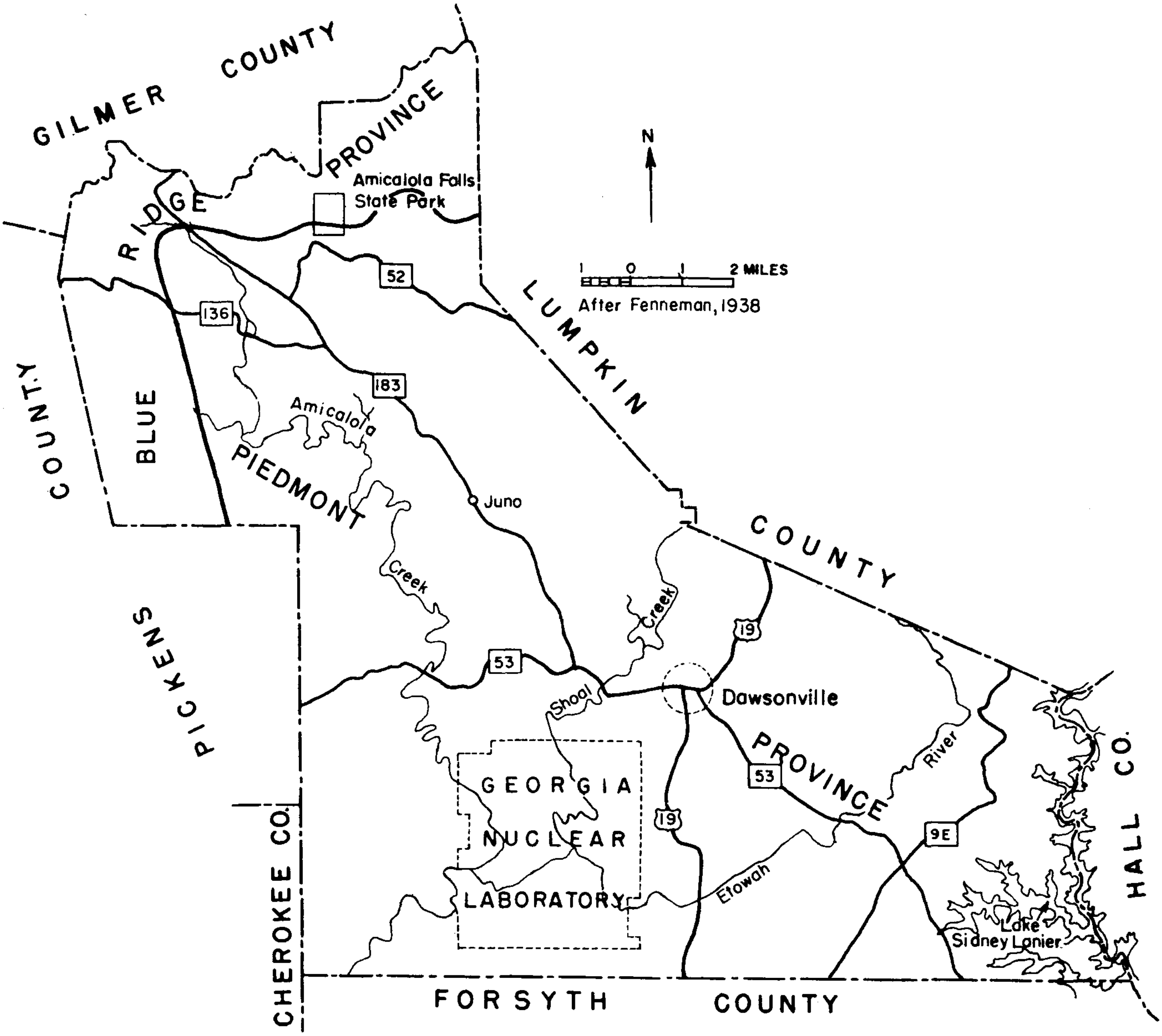

Figure 3.—Physical geographic divisions of Dawson County.

The physiographic history of the county is only partly understood because geomorphic studies and detailed geologic mapping in the region have not been made. However, the general physiographic evolution of the southern Appalachians has been partly explained by LaForge (1925, p. 91). The deformations resulted in the general withdrawal of the sea from the region and the upheaval of a great mountain system. During the deformation the main streams remained in their courses and incised their valleys across the rising land but the tributary drainage was controlled by the topography. The larger tributaries flowed in the northeast-trending valleys between the rising ridges and joined the rivers nearly at right angles, as some still do. The smaller tributaries flowed down the slopes and ridges with increasing velocity and erosive power as the uplift of the surface continued. Since the latest uplift the streams have not had time to become adjusted to the present base level. They flow for the most part over rock beds that cause numerous rapids and small falls.

Climate

The mild, humid climate of Dawson County is typical of the southern Appalachians. Winter is characterized by alternating cloudy, rainy periods and clear, dry periods and moderately low temperatures. Spring is stormy with occasional late cold snaps. Summer is characterized by scattered heavy rains and thundershowers, high daytime temperatures, and mild nighttime temperatures. Fall generally is a dry period with clear skies, mild daytime temperatures, and cool nights. Prevailing winds are from the west-southwest, whereas storm winds generally are from the east-northeast.

The average annual precipitation is about 52 inches. The wettest month is August with an average rainfall of 7.00 inches, and the driest is

October with an average rainfall of 2.59 inches. Average monthly precipitation and temperature for the period September 1956 to August 1959 in Dawson County is as follows: (From records of the Atmospheric Physics Group at the Georgia Nuclear Laboratory.)

Month	Precipitation (inches)	Temperature (°F.)
January	4.64	39
February	4.83	43
March	3.83	49
April	4.27	58
May	5.17	66
June	3.64	72
July	3.29	76
August	7.00	75
September	3.48	68
October	2.59	57
November	3.59	48
December	3.72	43

The mean annual temperature at GNL is about 60°F. The hottest months of the year are July and August with average temperatures of 76°F. and 75°F., respectively. The coldest month is January with an average temperature of 39°F.

Dawson County lies within the mountain horticulture area of Georgia, where the main crops are corn and timber. The average length of the growing season is 195 days. The first killing frost occurs about October 27, and the last killing frost occurs about April 15 in the mountains and about April 10 in other parts of the county. About 30 inches, or 58 percent of the total precipitation, generally occurs during the growing season.

Agriculture and Industrial Development

Dawson County is predominantly agricultural and has little industry. In 1950, 82 percent of the population were farm workers. Total area in Dawson County is 136,200 acres. In 1955, there were 605 farms averaging 135 acres per farm for a total of 81,679 acres of farmland (U.S. Dept. Agriculture, 1956). Poultry and poultry products accounted for about 93 percent of the total farm income in 1955, whereas only 3.3 percent came from crops.

The county has two industries, the Sweet-Orr Manufacturing Co., in Dawsonville, which employs about 150 people, mostly women seamstresses, in the manufacturing of Boy Scout clothing, and the Georgia Nuclear Laboratory. At one time several gold mines were operated. At present, however, no mining operations are active other than parttime operations for road metal and flagstone. Other minerals that have been found or reported to occur in the county include arsenopyrite, pyrite, graphite, ochre, iron, kyanite, magnetite, and manganese.

THE GEOLOGIC FORMATIONS AND THEIR WATER-BEARING CHARACTERISTICS

The Carolina Gneiss (of former usage) was defined by Keith (1903, p. 2) to include "* * * an immense series of interbedded mica schists, mica gneiss, and fine granitoid layers * * * [which] contains some thin interbedded layers of hornblende schist and hornblende gneiss [in the upper part]: * * * named for its great extent [in the Piedmont Plateau] in North Carolina and South Carolina." LaForge and Phalen (1913) mapped the rocks in the northern part of Dawson County, and Bayley (1928) mapped the rocks along the western edge of Dawson County as Carolina Gneiss. The Carolina Gneiss was renamed Carolina Series by Crickmay (1952, p. 7). Crickmay (1952, p. 50) concluded that the gneiss facies of the Carolina Series is probably equivalent to the Great Smoky Group. Crickmay's conclusion is borne out in Dawson County, for rocks mapped in Dawson County by LaForge and Phalen, and by Bayley, as Carolina Gneiss are part of the Great Smoky Group.

Crickmay (1950, p. 50) also concluded that the upper schistose part of the Carolina Series is equivalent to the Ashland Mica Schist mapped in Alabama by Adams (1926), and Crickmay projected the Ashland Mica Schist across Dawson County (Cook and others, 1939). More than 100 miles separates Dawson County from Ashland, Ala., and detailed geologic mapping has not been done between the two places. Because this distance is too great for accurate correlation, the rocks mapped by Crickmay as Ashland Mica Schist are mapped as zone C in this report, and the names Ashland Mica Schist and Carolina Series are not retained in this report.

Based on major breaks in geologic structure and (or) differences in genetics, the rocks are grouped in five distinct geologic divisions; they are designated zones, A, B, C, Great Smoky Group, and alluvium (fig. 2). The divisions are discussed consecutively from the southeastern part of the county toward the northwest — with the exception of alluvium, which is discussed last. The Great Smoky Group is subdivided into zones D, E, and F.

The age and regional stratigraphic position of all rocks other than alluvium and the Great Smoky Group are uncertain.

Zone A

A thick sequence of mica schist which contains quartzite, amphibolite, and sillimanite-bearing rocks makes up most of zone A. These rocks are equivalent to the metasediments mapped about 30 miles to the southwest in Cobb County by Hurst (1956). The lithologic divisions of the sequence are nearly the same as those in Cobb County, except that sillimanite is present in the lowermost part instead of kyanite. The stratigraphic interpretation worked out in Cobb County by Hurst was used to determine the top of the sequence. The rocks in Dawson County are in the same stratigraphic order as in Cobb County, and the younger units usually overlie the older units.

Zone A is divisible into five mappable lithologic units (fig. 2). The sequence probably will be of group rank and each unit probably will be of formational rank when the regional stratigraphy is known. From oldest to youngest, the mapped units in the sequence are mica schist with interbedded sillimanite-mica schist and sillimanite-biotite-amphibole gneiss; mica schist with interbedded amphibolite; garnet-mica schist; quartzite and garnet amphibolite; and mica schist.

The lithologies are gradational both along the strike and normal to it, except that of the quartzite. The stratigraphic boundaries of the quartzite are fairly sharp. Small amber-colored garnets are scattered sporadically throughout the unit and are abundant in the schist immediately below the quartzite.

The aquifer properties of the four main lithologies in this sequence — mica schist, sillimanite gneiss and schist, amphibolite, and quartzite — vary considerably (table 1-A). For this reason these lithologies are discussed separately.

MICA SCHIST

Description of the rocks

Muscovite-biotite schist, biotite schist, amphibolite-biotite schist, and garnet-mica schist constitute the bulk of the schist sequences. Lithologies are gradational particularly along strikes. Small brown aureoles around opaque minerals in the muscovite are common. Small amber-colored garnets are scarce to abundant, and epidote is rare. Garnets as much as half an inch in diameter are common below the quartzite. Biotite is dark green to black. Hydrothermal quartz veins, pegmatities, and migmatites are common throughout the unit but increase in abundance northwestward. In the weathered rocks, openings along the foliation and bedding planes are more numerous and continuous for longer distances than openings along the joints. The rocks, however, are well jointed. The schist weathers to a yellow soil. No fresh outcrop of mica schist was observed, but good exposures of the saprolite occur along Georgia Highway 318.

Water-bearing characteristics

The yield of drilled wells in mica schist averages about 16 gpm and is influenced by topography (table 2).

Hilltop wells in zone A average 234 feet in depth and 15 gpm in yield; slope wells average 171 feet in depth and 19 gpm in yield. No information is available for wells in valleys or draws, but the yield of these wells should be greater and their depths shallower than those on slope and hilltops. (See table 16.) Hilltop wells average only 0.06 gpm per foot of well whereas slope wells average 0.11 gpm per foot of well.

Dug-well construction also is influenced by topography. Dug wells in mica schist average 34 feet to the water table on hilltops, 26 feet on slopes, and 16 feet in valleys and draws (table 1-B). According to owners and tenants familiar with the construction of their wells, 57 percent of the wells on hilltops and 17 percent of those on slopes required blasting to reach the saturated

Table 1.—*Dug wells in zone A*

(Numbers represent wells reported unless otherwise shown)

Location	Number of wells inventoried	Water level below land-surface datum (feet)		[1]Well has adequate yield			[1]Users reported water quality as shown			[1]Mud accumulates in well			[1]Well caves			[1]Well required dynamiting			
		Average depth	Range in depth	No	Yes	Unknown	Good	Poor	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	Range in footage blasted (feet)
A. Wells in zone A analyzed with respect to lithology																			
Quartzite	1	36	—	0	1	0	1	0	0	1	0	0	1	0	0	0	1	0	30
Amphibolite	10	29	15-50	3	5	2	8	1	1	2	1	7	3	0	7	2	0	8	0
Sillimanite gneiss and schist	21	36	7-51	2	16	3	12	4	5	8	4	9	8	4	9	9	3	9	0-30
Mica schist	35	29	4-56	4	29	2	15	5	15	10	10	15	14	4	17	10	5	20	0-18
All rocks	67	30	4-56	9	51	7	36	10	21	21	15	31	27	8	33	21	9	37	0-30
B. Wells in mica schist analyzed with respect to topography																			
Hilltop	17	34	18-56	2	15	0	2	[2]5	10	7	6	4	9	2	6	3	4	10	12-39
Slope	13	26	16-35	2	9	2	8	0	5	3	4	6	4	1	8	5	1	7	0-?
Valley and draw	5	16	4-27	0	5	0	5	0	0	0	0	5	1	1	3	2	0	3	0
All locations	35	29	4-56	4	29	2	15	[2]5	15	10	10	15	14	4	17	10	5	20	0-39
C. Wells in sillimanite gneiss and schist analyzed with respect to topography																			
Hilltop	10	42	31-51	1	8	1	7	1	2	4	1	5	4	1	5	5	0	5	0
Slope	10	29	19-43	1	7	2	5	[2]2	3	4	2	4	3	3	4	4	2	4	0-30
Valley and draw	1	7	7	0	1	0	0	1	0	0	1	0	1	0	0	0	1	0	4
All locations	21	36	7-51	2	16	3	12	4	5	8	4	9	8	4	9	9	3	9	0-30

[1] Information reported by well owners or tenants.

[2] Hard water.

Table 2.—*Analyses of data on drilled wells*

					Reported yield (gpm)		
			Number of wells	Average depth (feet)	Range	Average	Per foot of well
ZONE A	According to rock type	Quartzite	1	150	35	35	0.23
		Sillimanite gneiss and schist	3	323	5-25	15	.05
		Mica schist	16	194	0-80	16	.08
		All wells	20	213	0-80	17	.08
	According to topographic location	Hilltop	8	234	0-20	15	.06
		Slope	12	171	4-80	19	.11
		Valley and draw	None	----	----	----	----
	According to depth of wells (feet)	0 — 99	None	----	----	----	----
		100 — 199	11	139	4-30	15	.11
		200 — 299	5	215	0-80	21	.10
		300 — 399	2	300	6-14	10	.03
		400+	2	478	6	6	.01
ZONE B	According to topographic location	Hilltop	3	248	4-13	9	.04
		Slope	4	127	7-17	13	.10
		Valley and draw	3	163	7-20	14	.09
		All wells	10	174	4-20	11	.06
	According to depth of wells (feet)	0 — 99	2	71	7-17	12	.17
		100 — 199	7	154	4-20	11	.07
		200 — 299	0	----	----	----	----
		300 — 399	0	----	----	----	----
		400+	1	423	13	13	.03
ZONE C	According to rock type	Metagraywacke	2	400	2-30	16	.04
		Amphibolite	2	78	3-11	7	.09
		Biotite schist	0	----	----	----	----
		All wells	4	239	2-30	12	.05
	According to topographic location	Hilltop	4	239	2-30	12	.05
		Slope	0	----	----	----	----
		Valley and draw	0	----	----	----	----
GREAT SMOKY GROUP	According to rock type	Zone D	5	236	11-40	30	.13
		Zone E	8	146	3-27	13	.09
		Zone F	0	----	----	----	----
		All wells	16	166	3-40	18	.11
	According to topographic location	Hilltop	11	176	6-40	19	.11
		Slope	5	159	15-30	23	.11
		Valley and draw	0	----	----	----	----
	According to depth of wells (feet)	0 — 99	2	78	27-43	35	.45
		100 — 199	10	153	3-21	11	.08
		200 — 299	3	222	9-30	16	.08
		300 — 399	1	300	11	11	.04
		400+	0	----	----	----	----

zone. Water from wells in valleys, draws, and slopes usually is reported to be soft, but that from wells on hills usually is reported to be hard. Valleys, draws, and lower slopes are considered better sites for dug wells than the tops and upper slopes of hills.

Two chemical analyses of water from this rock are given in table 7; neither analysis is from a hilltop well.

SILLIMANITE GNEISS AND SCHIST

Description of the rocks

Beds of sillimanite-amphibole gneiss and sillimanite-mica schist are common in the lower part of the sequence. (See fig. 2.) The texture is variable and ranges from schist with paper-thin laminations to gneiss with 6-inch laminations. Sillimanite usually occurs on the periphery of small eye-shaped feldspar-quartz pods. Good exposures of sillimanite schist were not found, but the saprolite can be observed on Georgia Highway 53, about half a mile west of Georgia Highway 9E.

Water-bearing characteristics

The permeability of these rocks is low. Although the wells yield about 15 gpm, well depths average 323 feet, or an average of only 0.05 gpm per foot of well. (See table 2.)

The water table in dug wells averages 36 feet in depth (table 1-C). About 10 percent of the wells visited yield inadequate quantities of water for domestic and farm uses. Hard water is reported in the gneisses containing amphiboles. Free carbon dioxide also is present. Water from both drilled and dug wells in this rock is higher in carbon dioxide than water from other rocks in zone A.

Hilltop wells average 42 feet to water, slope wells average 29 feet, and valley and draw wells average only 7 feet (table 1-C). Of special interest is the fact that in this unit many of the valley, draw, and slope wells required blasting, but the hilltop wells did not.

AMPHIBOLITE

Description of the rocks

Beds of garnet-biotite amphibolite and biotite amphibolite are abundant in the middle part of this sequence. In some areas the texture is that of a granular "salt and pepper" rock with diversely oriented minerals, but usually the amphibole is linearly oriented, giving the rock a gneissic appearance. The rock varies from black and white to solid black. An ochre to dark-red soil develops upon weathering and is rather characteristic. However, the color varies with the amphibole and biotite content of the rocks and the iron content of the minerals. The darker soils usually develop from rocks containing amphibole and have a high clay content.

Fresh outcrops of biotite-amphibolite were observed at locations 560-1570-C and D (fig. 2).

Garnet-biotite schist is interlayered at some places with garnet amphibolite. This rock is moderately jointed; most joint planes are coated near the surface with manganese oxide.

Water-bearing characteristics

A few wells have been dug in the saprolite of these amphibolites, but none have been drilled. They average 29 feet in depth (table 1-A). Their yields are inadequate, the water is hard, and accumulation of mud is common. Although it was reported that blasting was not necessary in those recorded for this study, the author believes that most hilltop wells in this rock will require blasting to get adequate water supplies.

QUARTZITE

Description of the rocks

The quartzite is a coarse-grained muscovite bearing feldspathic quartzite of sedimentary origin. Bedding is fairly uniform. Features resembling crossbedding and truncation of minor structures were observed at a few places but were too indistinct to reveal the tops and bottoms of beds. Feldspar is more abundant within the stratigraphically lower part. The rocks at some places contain needles of sillimanite. Muscovite flakes are oriented parallel to bedding, as is the foliation of adjacent rocks. The thickness of the quartzite varies along the strike but is usually about 80 feet. A light-yellow to orange coarse sandy soil, which contains abundant small fragments of the quartzite, is formed upon weathering. The rock resists erosion and is frequently used for road metal. Along the crest of folds it is highly fractured by joints oriented at high angles to the bedding. Outcrops are fairly common. The best outcrop observed is at 560-1570-A (fig. 2). The quartzite is underlain by an amphibolite schist from 80 to 100 feet thick, and at a few places it is overlain by a thin amphibolite schist.

Water-bearing characteristics

The quartzite is a good aquifer. Drilled wells yield about 35 gpm, and dug wells yield sufficient water for domestic and farm uses. Dug wells on hilltops underlain by quartzite always require blasting to reach the saturated zone, but the lower feldspathic part probably will cave when penetrated at shallow depth. The upper few feet of rock underlying the quartzite has been leached by water moving from the quartzite. This zone probably is water bearing and should be penetrated for maximum yield. Wells probably can be drilled in this quartzite that will yield 50 to 60 gpm if they are properly located. The water is soft but is slightly corrosive. A chemical analysis of water from a drilled well in quartzite is given in table 7.

The general structural and topographic occurrence of this rock has important influences on the proper selection of well sites, as shown in figure 4. Wells penetrating the quartzite between A and B would have the greatest yield. Those near A would be deeper than those near B. Wells between B and C would have successively lower yields toward C because of the decrease in thickness of the saturated part of the aquifer. Wells between C and D would encounter no water in the quartzite and would derive their supplies from the adjacent poorer yielding rocks. Wells on the slope near E would not penetrate the quartzite.

Dug wells generally would require blasting to reach saturated rock except in valleys as at B.

Well-boring machines usually cannot penetrate the quartzite.

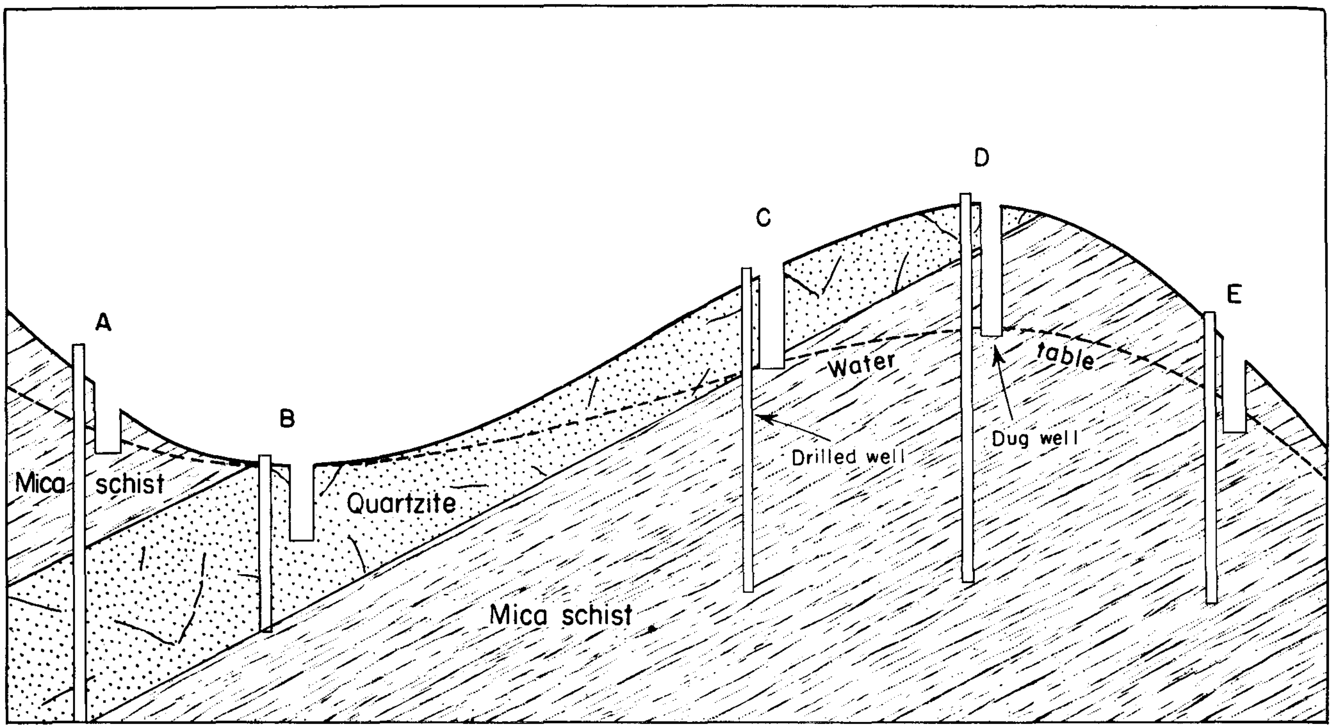

Figure 4.—The effects of structure and topography on the yield of wells in quartzite.

ZONE B

Description of the rocks

The rocks of zone B are a composite of biotite, granite, granitic gneiss, amphibolite, and mica schist herein called migmatite. The mica schist and amphibolite appear to occur in folds in the gneiss. The gneiss is locally intruded and cut by coarse-grained biotite granite which may be a product of local mobilization of the gneiss. Contacts between zone B and adjacent zones are gradational. The mica schist of zone A is interlayered with migmatite and intruded by granite pegmatites and quartz veins. The schist of zone C also is interlayered with migmatite and intruded by pegmatite and quartz veins, but it is structurally more complex and has been intruded by biotite granite. Along this contact the schist is intensely crushed and deformed suggesting that movement has recurred several times. The intrusion folding and major faulting occurred contemporaneously with orogeny. Local high-angle faulting has occurred later.

The best exposure of the migmatite is at location 530-1570-B (Black's Quarry). Additional good exposures occur at locations 560-1600-A and 560-1570-B.

Water-bearing characteristics

Drilled wells in zone B average 174 feet in depth and about 11 gpm in yield (table 2). Based on the total footage drilled, average yield is about 0.06 gpm per foot of well. Valley and draw wells average about 0.09 gpm per foot of well; slope wells average about 0.10 gpm; and hilltop wells average about 0.04 gpm. Wells in valleys and

Table 3.—*Dug wells in migmatite of zone B (analyzed with respect to topography.)*
(Numbers represent wells reported unless otherwise shown.)

Topographic location	Number of wells inventoried	Watel level below land-surface datum (feet)		Well has[1] adequate yield			Users[1] reported water quality as shown			Mud[1] accumulates in well			Well caves[1]			Wells required dynamiting[1]			
		Average depth	Range in depth	No	Yes	Unknown	Good	Poor	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	Range in footage blasted (feet)
Hilltop	5	50	34-58	2	3	0	5	0	0	5	0	0	4	1	0	4	1	0	0-12
Slope	5	35	16-50	1	4	0	4	0	1	4	0	1	3	1	1	4	0	1	0
Valley and draw	2	7	7-7	0	2	0	2	0	0	2	0	0	0	2	0	2	0	0	0
All locations	[1]14	40	7-58	3	9	2	11	0	3	11	0	3	7	4	3	10	1	3	0-12

[1] Information reported by well owners or tenants.

[2] The topography was not recorded at two well locations.

draws yield twice as much per foot as those on hilltops.

The depth to water below the land surface in dug wells averages 7 feet in valleys and draws, 35 feet on slopes, and 50 feet on hilltops (table 3). About 25 percent of the wells are inadequate, which probably is due to insufficient well depth.

Dug wells in valleys and draws, and some on hilltops and slopes, require casing because of caving. About 20 percent of the hilltop wells reportedly required blasting. The water is generally of good quality. Two chemical analyses of water from migmatite are given in table 7.

ZONE C

The rocks mapped as zone C in this report were mapped by Crickmay (Cook and others, 1939) as Ashland Mica Schist. The name Ashland Mica Schist is not retained in this report and zone C is divided into three lithologic units; biotite schist, amphibolite, and metagraywacke.

BIOTITE SCHIST

Description of the rocks

The biotite schist unit consists of interbedded biotite schist, biotite gneiss, garnet-biotite schist, garnet-biotite gneiss, and thin discontinuous layers of amphibolite. The rocks show evidence of shearing and the occasional development of mylonite. Fair exposures of this rock were observed along the Etowah River at the GNL site. The rocks generally are coarsely crystalline, strongly foliated, and moderately jointed. Foliation and cleavage are generally parallel. The rocks have been intruded by granite near zone B.

Water-bearing characteristics

No drilled wells have penetrated this rock, but at least six wells are dug in the saprolite. The dug wells averaged 36 feet in depth to the water table (table 4-A), and their yields are adequate for domestic and farm uses. Some dug wells were reported to cave. Blasting was required in others to reach saturated rock. The water is reported to be soft but corrosive.

AMPHIBOLITE

Description of the rocks

Overlying the biotite schist is 500 to 800 feet of dark-green to black amphibolite and thin interbedded lenses of pale orange-colored schist. The amphibolite is composed mainly of quartz, plagioclase, and hornblende, but minor amounts of magnetite, mica, and epidote occur in a few places. This rock is well jointed and at least three sets of joints were recognized in most outcrops. Secondary manganese oxide coats most of the joint surfaces. This amphibolite is a prominent ridge former and can be traced easily. A dark yellowish-orange to dusty-red soil develops on the amphibolite, and in most road cuts it has a cellular appearance.

Table 4.—*Dug wells in zone C*
(Numbers represent wells reported unless otherwise shown)

Location	Number of wells inventoried	Water level below land-surface datum (feet)		[1]Well has adequate yield			[1]Users reported water qual'ty as shown			[1]Mud accumulates in well			[1]Well caves			[1]Well required dynamiting			
		Average depth	Range in depth	No	Yes	Unknown	Good	Poor	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	Range in footage blasted (feet)
A. Wells in zone C analyzed with respect to lithology																			
Metagraywacke	29	41	3-64	3	11	15	13	0	16	12	1	16	13	0	16	2	2	25	4-12
Amphibolite	4	28	20-33	0	2	2	2	0	2	1	0	3	0	1	3	1	0	3	0
Biotite schist	6	36	25-60	0	4	2	4	1	1	2	0	4	2	1	3	1	1	4	0-4
All rock types	39	39	3-64	3	17	19	19	1	19	15	1	23	15	2	22	4	3	32	0-12
B. Wells in metagraywacke analyzed with respect to topography																			
Hilltop	16	45	28-64	1	7	8	7	0	9	7	0	9	7	0	9	0	[2]1	15	4
Slope	8	35	20-44	2	3	3	5	0	3	4	1	3	5	0	3	0	1	7	12
Valley and draw	5	12	3-30	0	1	4	1	0	4	1	0	4	1	2	2	2	0	3	0
All locations	29	41	3-64	3	11	15	13	0	16	12	1	16	13	2	14	2	2	25	4-12

---

[1] Information reported by well owners or tenants.

[2] This well reportedly failed in 1954 and contained only 1.2 feet of water on 11-05-57. It needs to be deepened.

Water-bearing characteristics

Only two wells have been drilled into the amphibolite. One well is 80 feet deep, but its yield is unknown. The other well is 74 feet deep and has a yield of about 7 gpm. The average yield per foot of well is about 0.09 gpm (table 2).

Four dug wells were inventoried. They averaged 28 feet in depth. The yields of dug wells are adequate for most domestic and farm uses. Well owners reported that blasting was not necessary to get water from the amphibolite and that they had no problems with mud accumulating in wells.

The water is reported to be soft. Two chemical analyses of water from the amphibolite are given in table 7.

METAGRAYWACKE

Description of the rocks

The rocks mapped as metagraywacke generally are metamorphosed sediments. Lithologic variations along the strike are common. The individual beds consist of garnet-biotite schist, garnet-biotite gneiss, biotite gneiss, and quartz-biotite schist. Thin discontinuous bodies of amphibolite and epidote-hornblende gneiss also are present throughout the metagraywacke. Rocks of this unit are similar in mineralogy to the biotite gneiss but are well bedded in contrast to the massive appearance of the biotite gneiss. Thickness of the beds ranges from a fraction of an inch to several feet. Bed thickness and composition vary along the strike. The lowermost 20 to 40 feet of this unit is a biotite schist which contains conglomeratic pebbles of quartz; the individual beds are 2 to 8 inches thick and are graded. Bedding in the metagraywacke is shown in figure 5.

Hydrothermal quartz veins are common and are usually subconcordant with the foliation. A good exposure of metagraywacke is at location 530-1570-A; graded beds occur at this location.

Generally the quartz-biotite schist forms prominent ridges, and the more feldspathic gneisses form lowlands.

Shearing formed openings in which gold and pyrite were deposited. Eye-shaped pyrite-bearing quartz-feldspar pods 1 to 6 inches across are present in many places; these can be seen at location 530-1570-A. Copper is present sporadically.

The amount and type of jointing vary considerably with lithology (fig. 5). Gneisses are more jointed than schists.

Water-bearing characteristics

The metagraywacke yields only small amounts of water to drilled wells. The average yield is about 0.04 gpm per foot of drilled well. Drilled wells inventoried averaged 400 feet in depth (table 2).

Data on dug wells in the metagraywacke were analyzed with respect to topographic location of the well (table 4-B). The average depth to the water table below the land surface on hilltops is 45 feet, on slopes it is 35 feet, and in valleys and draws it is only 12 feet. The probability of having to blast in order to reach saturated rock is greatest on hilltops. Valley and draw wells frequently cave unless cased.

Figure 5.—Jointing and bedding in the metagraywacke of zone C.

GREAT SMOKY GROUP

The name Great Smoky conglomerate was used by Keith (1904, p. 6) for a thick sequence of interbedded conglomerate, graywacke, quartzite, schist, and slate in North Carolina. The Great Smoky conglomerate was renamed the Great Smoky Formation by LaForge and Phalen (1913). Detailed mapping by Hurst (1955) showed the sequence of rocks to be divisible into four distinct lithologic units, each of sufficient stratigraphic importance to warrant formational rank. Therefore, Hurst reclassified the Great Smoky Formation as the Great Smoky Group and divided it into the Copperhill, Hughes Gap, Hothouse, and Dean Formations. Based upon lithology the Great Smoky Group in Dawson County is divided into three zones — zone D, zone E, and zone F. These zones are lithologically similar and possibly equivalent respectively to the Copperhill, Hughes Gap, and Hothouse Formations of Hurst (1955).

Criteria for the determination of the age of the Great Smoky Group were not observed in Dawson County, but the Great Smoky Group is considered to be Precambrian.

In the extreme northern part of the county, lithologic changes along the strike, similarity in lithology between the upper part of zone F and zone D, and uncertain structure, create a complex that can be described only by mapping in great detail. For this reason the northern part of Dawson County was mapped as Great Smoky Group undifferentiated. Within this undifferentiated area kyanite schist similar to that within zone E was observed as well as conglomerate, metagraywacke, and quartzite that could be either zone D or zone F. In the remainder of the county the lithologic zones were mapped.

ZONE D

Description of the rocks

About half of zone D is metagraywacke, and the remainder consists of biotite schist, biotite conglomerate, irregularly banded biotite gneiss, quartzite, metasiltstone, kyanite-sillimanite-mica schist, and meta-arkose. Pseudodiorite occurs as eye-shaped pods in some areas. A thick coarse-grained amphibolite occurs within this zone. The amphibolite is mineralogically and stratigraphically similar to the Newtown sill described by Hurst (1955, p. 59) near Ducktown, Tenn. The best exposure of the amphibolite is at location 470-1630-B, but a more easily accessible outcrop occurs at location 470-1630-C. Graded bedding is well preserved and is abundant in some areas. The conglomerate and schist occur as thick, massive nonpersistent beds. The metasiltstone is thinly bedded; beds range from one-twentieth to one-half inch in thickness. The metagraywacke usually occurs as alternating beds of biotite schist and biotite gneiss. The best exposures of zone D are along Georgia Highway 136 near the Dawson-Pickens County line.

Water-bearing characteristics

Springs are the only developed source of water in zone D in Dawson County. Four springs were inventoried; their yields ranged from 5 to 12 gpm. The water is reported to be soft and of good chemical quality. Because of the rugged topography, hillside springs are numerous and springs probably will continue to be the principal source of water from this zone.

ZONE E

Description of the rocks

Most of zone E consists of amphibolite, amphibole-biotite schist, biotite-amphibole gneiss, garnet-biotite-amphibole gneiss, quartzite, kyanite-biotite schist and gneiss, sillimanite-kyanite schist, and quartz-garnet-muscovite schist. The abundance of garnet, kyanite, sillimanite, dark-red biotite, and amphibole indicate a high iron and aluminum content in these rocks. The sillimanite occurs as thin, barely discernible crystals in the schist beds of the central part of the county. The sillimanite crystals increase in size and abundance northward, and in the vicinity of Faucetts Lake the coarse fibrous sillimanite called fibrolite occurs sporadically. Sillimanite was not observed in these rocks south of Georgia Highway 53. A characteristic of zone E in the central and southwestern part of the county is the interlocking to radiating clusters of kyanite which megascopically resemble conglomeratic pebbles of milky quartz. In the schistose beds kyanite occurs as elliptically-shaped porphyroblasts about half an inch in diameter, but the amount of kyanite decreases toward the northwest, where it appears to have been partially replaced by sillimanite. Schistosity generally is wavy owing to the porphyroblastic growth of crystals of kyanite, sillimanite, and garnet. Weathered out garnet-mica-quartz buttons about 1 inch in diameter and 0.3-inch thick are common; buttons more than 2 inches in diameter and 0.5-inch thick are scarce.

The rocks of this zone are well jointed but do not weather deeply. A shallow-dark-red soil develops, which contains abundant pebbles of garnet and kyanite.

Water-bearing characteristics

Drilled wells in zone E average 146 feet in depth and 13 gpm in yield; this is about 0.09 gpm per foot of well (table 2).

Dug wells average 37 feet to the water table (table 5). Wells on hilltops average 49 feet to the water table, wells on slopes 37 feet, and wells in valleys or draws 14 feet. Of the owners interviewed who had knowledge of the construction of their wells, 6 of 28 reported inadequate yields, 6 of 37 reported corrosive water, 4 of 31 reported mud accumulation, 2 of 31 reported occasional caving, and 8 of 12 reported that their wells had to be blasted to obtain water. One well was reported blasted at least 53 feet before reaching saturated rock. Wells that fail during dry weather, contain corrosive waters, accumulate mud, or require blasting to reach saturated rock are more numerous on hilltops than on slopes or in valleys and draws. Caving wells are most numerous in valleys and draws.

Water in zone E generally is corrosive and high in iron. Four chemical analyses of water from this zone are given in table 7.

Table 5.—*Dug wells in zones E and F (analysed with respect to topography)*
(Numbers represent wells reported unless otherwise shown)

Topographic location	Number of wells scheduled	Water level below land-surface datum (feet)		[1]Well has adequate yield			[1]Users reported water quality as shown			[1]Mud accumulates in well			[1]Well caves			[1]Well required dynamiting			
		Average depth	Range in depth	No	Yes	Unknown	Good	Poor	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	Range in footage blasted (feet)
								Zone E											
Hilltop	23	49	34-68	4	9	10	15	[2]4	4	16	3	4	19	0	4	2	4	17	25-53
Slope	11	37	19-55	1	5	5	8	[2]1	2	3	0	8	3	0	8	0	2	9	?-15
Valley and draw	10	14	5-30	1	8	1	8	[2]1	1	8	1	1	7	2	1	2	2	6	?
All locations	44	37	5-68	6	22	16	31	[2]6	7	27	4	13	29	2	13	4	8	32	?-53
								Zone F											
Hilltop	27	44	24-67	4	3	20	8	2	17	8	2	17	10	0	17	2	1	24	21
Slope	13	34	16-65	0	11	2	11	0	2	11	0	2	11	0	2	3	1	9	?
Valley and draw	6	11	5-15	2	0	4	2	0	4	4	0	2	2	1	3	0	0	6	0
All locations	46	35	5-67	6	14	26	21	2	23	23	2	21	23	1	22	5	2	39	21

[1] Information reported by well owners or tenants.

[2] Water reported to contain excessive iron.

ZONE F

Description of the rocks

The amount of schist decreases and the amount of metagraywacke increases stratigraphically from the bottom to the top of this zone. The lower part of zone F is mainly muscovite schist containing numerous thin metagraywacke beds. Graded bedding is common. Much of the muscovite contains small prismatic iron-bearing minerals resembling tourmaline. Thin beds of tourmaline-mica schist, kyanite-mica schist, and quartzite also are present. The kyanite occurs as distinct bladed crystals in contrast to the clusters of kyanite in zone E. The biotite content of the rocks increases near the contact with zone E. Unweathered exposures of schist are rare but were observed along the banks of Shoal Creek northwest of Dawsonville and along the banks of the Etowah River in Lumpkin County, east of U.S. Highway 19. A thick bed of feldspathic quartzite occurs near the base of the Hothouse Formation — which is a good stratigraphic marker — but it is not always present. The best exposure of this quartzite is at location 500-1570-A.

The middle part of zone F consists of interbedded metagraywacke, quartzite, and mica schist. The beds range in thickness from 4 inches to more than 20 feet. Metagraywacke beds usually are the thickest.

The upper part of zone F consists of thick beds of metaconglomerate and metagraywacke. Occasional beds of quartzite, biotite gneiss, and biotite schist, and rare beds of kyanite schist also are present. The lithology changes rapidly along the strike. The upper part of zone F is exposed in Lumpkin County along Gab Creek and along Georgia Highway 52.

Water-bearing characteristics

Drilled wells in the schist of the lower part of zone F average 112 feet in depth and yield about 30 gpm (table 2). The drilled wells yield an average of 0.13 gpm per foot of well. Drilled wells have not been developed in the metaconglomerate and metagraywacke of the upper part of zone F in Dawson County. Springs constitute the major source of water from the upper part of the zone, as they do from similar beds of zone D.

The flow of springs in zone F ranges from 1 to 90 gpm. The average is about 18 gpm. (See table 12.) Spring 530-1600-19, the largest spring observed in Dawson County, flows about 90 gpm from the lower part of zone F.

In dug wells the depth to water below the land surface averaged 44 feet on hilltops, 34 feet on slopes, and 11 feet in valleys and draws (table 5). Of the people familiar with the construction of their dug wells, 6 of 20 reported inadequate yields, 2 of 23 reported water of poor quality, 2 of 25 reported mud problems, 1 of 24 reported caving, and 2 of 7 reported that blasting was required to reach saturated rock.

Three chemical analyses are given in table 7. The water from this zone is soft and of good quality.

ALLUVIUM

Description

Alluvial deposits occur along the flood plains of all major rivers and streams. The deposits consist of poorly-sorted gravel, sand, and micaceous silt, and the gravel content usually is greatest in the lower part of the deposit. The larger rivers have broader flood plains and thicker deposits than the smaller streams. In some parts of Dawson County the flood plain of the Etowah River is more than a mile wide (fig. 2), and the alluvium is as much as 23 feet thick. Along the smaller streams the alluvival deposits are thin or may be completely absent.

Water-bearing characteristics

Ground water from the alluvial deposits is of good chemical quality. It is soft and noncorrosive. The water is well suited for domestic and industrial use. However, some wells immediately adjacent to streams may yield water which is muddy after rains and which contains coliform bacteria or other objectionable matter. An example is well 560-1570-21, which is 14 feet deep and is about 10 feet from a polluted stream. Mundorff (1950, p. 13), after studying alluvial deposits in North Carolina, found that wells 100 to 200 feet from polluted streams yielded water of good quality.

The deposits of sand and gravel that fill many stream valleys are potential sources of large quantities of water. Information concerning the flood-plain deposits of Dawson County are listed in table 6. Based on the above data, the known yields of wells in alluvial sand and gravel in other similar areas, and the large yield reported from a dug well (570-1570-20) in alluvium in Dawson County, wells and infiltration galleries having yields of several hundred gpm can be developed in alluvial deposits along the Etowah River in Dawson County. Such wells and galleries would be from 20 to 30 feet deep.

STRUCTURE

The rocks of zone A are folded and generally overturned toward the northwest (fig. 6) Fold axes trend N.45°E. to N.75°E.

Zone B is a fault zone, and slickensides are numerous. The hanging wall (zone A) moved northwest over the footwall (zone C).

The rocks of zone C are folded into tight overturned isoclinal folds whose axial planes strike N.40°E. to N.60°E. and dip about 60° SE. This zone is bounded on both sides by faults. Neither of the faults was observed, but several criteria indicate their occurrence. A fault southeast of zone C was first mapped by Furcron and Teague (1945). Criteria observed by the author are: (1) the migmatite of zone B is tabular and has been injected into adjacent rocks, (2) radioactive and magnetic anomalies terminate abruptly, (3) slickensides are numerous in zone B, and (4) the topography changes abruptly along the southeast edge of zone C. This change was recognized by LaForge (1925) who used it to separate two of his physiographic divisions, the Fairburn and the Gainesville platforms.

Table 6.—*Thickness of alluvial deposits, Dawson County*

Location	Depth (feet) to table water	Depth (feet) to top of sand and gravel	Depth (feet) to bed-rock	Thickness of sand and gravel (feet)
Etowah River, about 2 mi. west of U. S. Highway 19	10	12.5	17	4.5
Etowah River, about 0.7 mi. below the mouth of Shoal Creek	9	6.3	17	11.7
Etowah River, about 0.9 mi. below the mouth of Shoal Creek	6	12	22	10
Etowah River, about 1.1 mi. below the mouth of Shoal Creek	---	18	23	5
Shoal Creek, about 1.5 mi. upstream from the Etowah River	---	1	4	3

A fault northwest of zone C was first mapped in Dawson County by Stose and Ljungstedt (1932). Criteria used by the author to establish this fault are: (1) zone F of the Great Smoky Group is thinned, and all younger beds are absent, (2) radioactive and magnetic anomalies terminate abruptly, (3) slickensides and shear zones occur locally, and (4) the topography changes abruptly along the northwest edge of zone C. This change was recognized by LaForge (1925) who used it to separate two more of his physiographic divisions, the Dahlonega and Atlanta Plateaus.

Most of the rocks of the Great Smoky Group occupy the upright east limb and the southern nose of a plunging anticline overturned toward the west. The overturned beds of the west limb are exposed along Georgia Highway 136 west of the county. The structural trends of the Great Smoky Group closely follow the configuration of the belt of Murphy Marble to the west, as shown on the Geologic Map of Georgia (Cook and others, 1939). Superimposed on this anticline are numerous minor folds whose axial trends are generally east-west.

The rocks of the Great Smoky Group are broken by numerous high-angle faults (fig. 6). Slickensides are common along the faults, as at location 470-1630-A (fig. 7). The dip of bedding is usually less than 40 degrees except near faults where it is erratic, and overturned beds are common. The fault between zone C and the Great Smoky Group caused steepening of dips and overturning of beds in the Great Smoky Group for several thousand feet northwest of the fault.

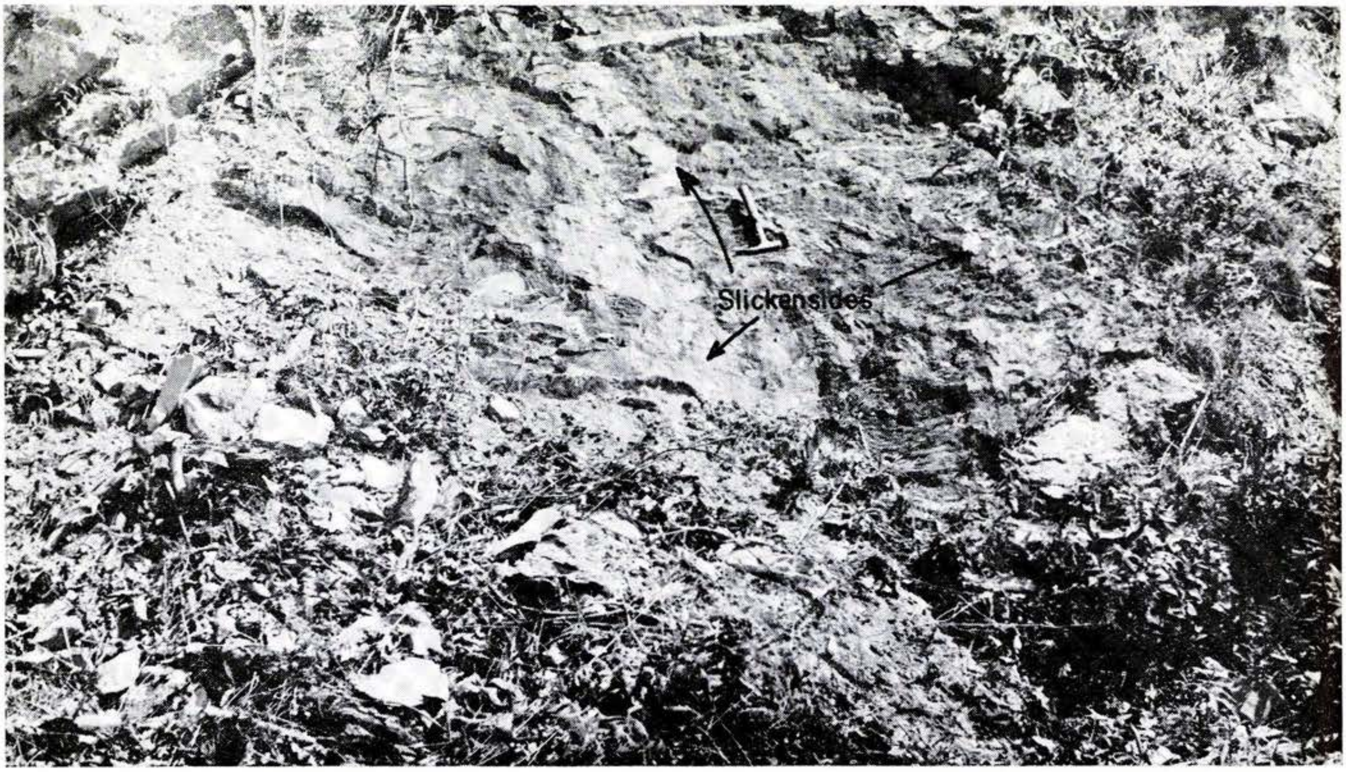

Figure 7.—Slickensides along fault at location 470-1630-A.

Figure 8 shows such an overturned fold in muscovite schist in the lower part of the Great Smoky Group, zone F. Schistosity and axial-plane cleavage are parallel to bedding except on the nose of folds (fig. 8b).

WEATHERING

The weathering of rocks may be divided into two principal categories, disintegration and decomposition. Weathering is caused by physical changes, the most important of which is rock expansion due to unloading, and chemical changes that are induced by ground water percolating downward through joints, schistosity planes, and other openings in the rock (Reiche, 1950). In the first stages of weathering certain mineral grains or groups of grains are broken apart by the expansion due to hydration of micaceous minerals. Rock during these first stages of weathering is referred to as disintegrated rock. The feldspars are particularly susceptible to breakage because of their cleavage and solubility. Only minor chemical weathering occurs at first, but, as particle size diminishes and more surface area is exposed, the chemical alteration of many of the minerals proceeds until clay minerals are formed. Alteration of the original minerals to clay is accompanied by hydration and expansion so that small cracks and joints formed in the first stages tend to become closed. The end product of this weathering is decomposed rock. All gradations occur between decomposed rock and fresh rock. In general the disintegrated rock is far more permeable than the decomposed rock and is the principal zone tapped by wells.

WATER RESOURCES

The Hydrologic Cycle

Precipitation is the source of all water in the county. Water vapor condenses and falls as snow or rain on the land surface where it either seeps into the soil, evaporates, or runs into lakes and streams. Part of the water that enters the soil returns to the atmosphere by transpiration and evaporation, and part is absorbed by various minerals. The remainder of the water seeps downward to the saturated zone. After water reaches the saturated zone, the top of which is called the water table, it may percolate through interstitial pores in the saprolite or along joints or other openings within hard rock. Ground water slowly moves downgradient to places where the water table is close to or intersects the land surface, where it is discharged either by springs and swamps or by evaporation and transpiration. It may seep directly from the saturated zone to stream beds.

SURFACE WATER

Streams

Two major river systems, the Coosa and the Chattahoochee, drain Dawson County. Drainage

a. Overall view of nose of fold.

b. Closeup of nose of fold showing departure of axial plane cleavage from bedding.
Figure 8.—Overturned recumbent fold in muscovite schist of zone F at location 530-1600-A.

on the northwestern slopes of the Highland is northwestward into the Coosawattee River in Gilmer County. Drainage on the southeastern slopes of the Highland is southward in the Amicalola Creek valley into the Etowah River. Shoal Creek, another tributary to the Etowah River, and the Etowah River, drain the central part of the county. The Etowah and Coosawattee Rivers are part of the Coosa River system. Drainage in the southeast corner of the county is into Lake Sidney Lanier on the Chattahoochee River system. These waters eventually reach the Gulf of Mexico.

The geographic arrangement of the streams is a result of geologic structure, differences in rock hardness, and the physiographic history of the region.

Streams in the county have relatively high rates of runoff per unit area owing to the hilly terrane. The average flow of the Etowah River at the gaging station near Dawsonville, 1 mile upstream from Georgia Highway 53, was 239 cfs (cubic feet per second) for the 19-year period between 1940 and 1959 (U.S. Geological Survey, 1960, p. 287). The average flow of Amicalola Creek at the gaging station near Dawsonville, at Georgia Highway 53, was 215 cfs for a 12-year period between 1939 and 1952 (U.S. Geological Survey, 1955, p. 226). The flow of Shoal Creek during October 1956 above its confluence with the Etowah River was about 30 cfs (Stewart and others, 1961, written communication).

Water from several small streams throughout the county is used by farmers to water chickens and livestock. About 150,000 gallons of water from the Etowah River are filtered and chlorinated daily for use at GNL. Other uses of streams in the area are for recreation and for cooling in the production of illicit white liquor called "moonshine."

Lakes

About 12 miles south of the Dawson-Pickens County line, the Chestatee and Chattahoochee Rivers are ponded by Buford Dam to form Lake Sidney Lanier. The lake floods about 2,600 acres of land in Dawson County at a lake elevation of 1,070 feet above mean sea level. Water surrounds an additional 200 acres of islands. The lake is used for the generation of electric power and is a major recreational area.

In 1954 the county contained 20 small artificial lakes which ranged in size from about 1 to 45 acres. One of the most popular is Lake Amicalola, a 7-acre lake in Amicalola Falls State Park. In addition, 12 small flood - retarding dams, under construction in 1960, will create lakes from 6 to 25 acres in area which also will be used for recreation.

Lakes help to raise the water table beneath adjacent hill slopes by reducing the ground-water gradient. This creates additional storage of ground water and helps reduce the number of well failures adjacent to the lakes during dry seasons.

GROUND WATER

Ground water is the water in the rocks below the water table. It is water that issues from, or may be pumped from, springs or wells. In the use of any spring or well, a continuing supply of ground water is as important as an adequate yield. All ground water supplied must be transported through openings in rock, but openings and kinds of rocks differ greatly. The character of both the openings and the rock are determined by the physical and chemical properties of the rock and geological processes. To gain knowledge about the water-bearing character of the rocks, geologic studies are necessary.

Recharge

The principal influences on recharge are precipitation, plantlife cover, season of the year, soil type, dip of planar features, and topography. Of these precipitation is obviously the most important for without it recharge would not be possible.

Precipitation, plant cover, and the season of the year are interrelated in their influences. During the growing season, infiltrated rainfall is used by plants or is evaporated directly from the soil because of high summer temperatures, and apparently little rainfall recharges the rocks except after exceptionally heavy or prolonged rains. Each large elm, oak, or similar tree can transpire as much as 500 gpd (gallons per day) or about as much as 10 people or 10,000 chickens will use in a day. Frequently during the growing season a wooded area will transpire all of a single rainfall without allowing recharge to the ground-water reservoir. In contrast, during the winter when most trees are dormant, even light rains recharge aquifers. Lower temperatures during the winter result in lower evaporation rates. Also, most rains during winter are slow and steady and have little runoff in contrast to the short hard summer thundershowers which inundate the streams. Snows also recharge aquifers during winter. Thus, the amount of annual recharge to the ground-water reservoir is controlled much more by precipitation during the winter, which averages about 17 inches, than by precipitation during the remainder of the year.

Rate of recharge also is controlled by the porosity and permeability of the soil. Sandy soils are more permeable, and water moves more rapidly into and through them than it does in clay soils. In Dawson County most soils are formed in place from the underlying rocks and vary in texture and composition with variations in the rocks; thus recharge varies from one rock unit to another.

The dip of bedding, cleavage, and schistosity affect recharge. Where these planar openings are horizontal, they aid lateral movement to discharging springs but inhibit the vertical movement of water and retard recharge. Where the planes dip at high angles, water moves readily down them to the water table.

Topography influences recharge because runoff is more rapid on steep slopes than on flat lands, and surface water has less time to infiltrate and recharge an aquifer.

Thus, the greatest recharge occurs during the winter and in areas of low relief, sandy soil, steeply dipping planar openings, and dormant plant life.

MOVEMENT

Field observations

Generally the movement of water downward through the soil is vertical (section a, fig. 9).

Figure 9.—Seeps show paths of water movement in saprolite. Road cut is near Doraville, DeKalb County. (See p. 20 for explanation.)

Small quantities of water were observed to move laterally (not shown in fig. 9) through the subsoil immediately above decomposed rock, indicating a smaller porosity and (or) permeability of the underlying saprolite.

Upon entering decomposed rock, movement of the water is influenced by relic rock textures and structural features, particularly bedding and schistosity. Note the abrupt change in direction of water movement at the top of decomposed rock (below point b, fig. 9). Some water moved along the joints (c and d, fig. 9), but most of the water moved parallel to the foliation through pores created by weathering (e, fig. 9). All the quartz veins examined in the saprolite were well fractured and more permeable than the surrounding material, as is the one discharging water at point f in figure 9.

Water that moves downward through the saprolite comes in contact with a tremendous decrease in porosity as it enters hard rock. Stewart and others (1961, written communication) found the average porosity of saprolite to be along sheeting or exfoliation joints, high-angle joints, bedding planes, and schistosity planes and through interstitial pores in the saprolite. Most water appears to move through interstitial pores in the saprolite immediately above hard rock.

Weathering as an indicator

To a degree the extent of weathering along each planar opening is indicative of its role as a conduit for water circulation. Using weathering as an indicator, the following observations and conclusions were made. Water movement is not uniformly distributed but tends to be concentrated in a few openings, such as the one shown in figure 10.

Although this opening appears to be wide in the photograph, it is thinner than a pencil lead. A zone of weathered rock has developed on each side of the plane, and, after exposure, is rapidly eroding away. Weathering along a few steeply dipping planes, as shown in figure 10, probably extends to great depth and accounts for the occasional well that taps large supplies of water below 500 feet. However, the number of joints about 46 percent and the average porosity of fresh rock to be about 4.5 percent at the GNL. The ratio of porosities is about 10:1. Inasmuch as all the water moving in the saprolite cannot flow into the few openings available in hard rock, most of it accumulates immediately above the hard rock. Accumulation of the water increases the hydraulic gradient, causing the water to be shunted laterally within the saprolite and amount of weathering along most joints decrease rapidly with depth.

The extensive joints are the most highly weathered ones. Decomposition is greatest along the uppermost sheeted zones and less great along the most prominent high-angle joints, indicating that these transport water. Where high-angle joints transect the alternating schist and gneiss beds of metagraywacke, decomposition is least adjacent to the gneiss beds, intermediate adjacent to the schist beds, and greatest adjacent to the

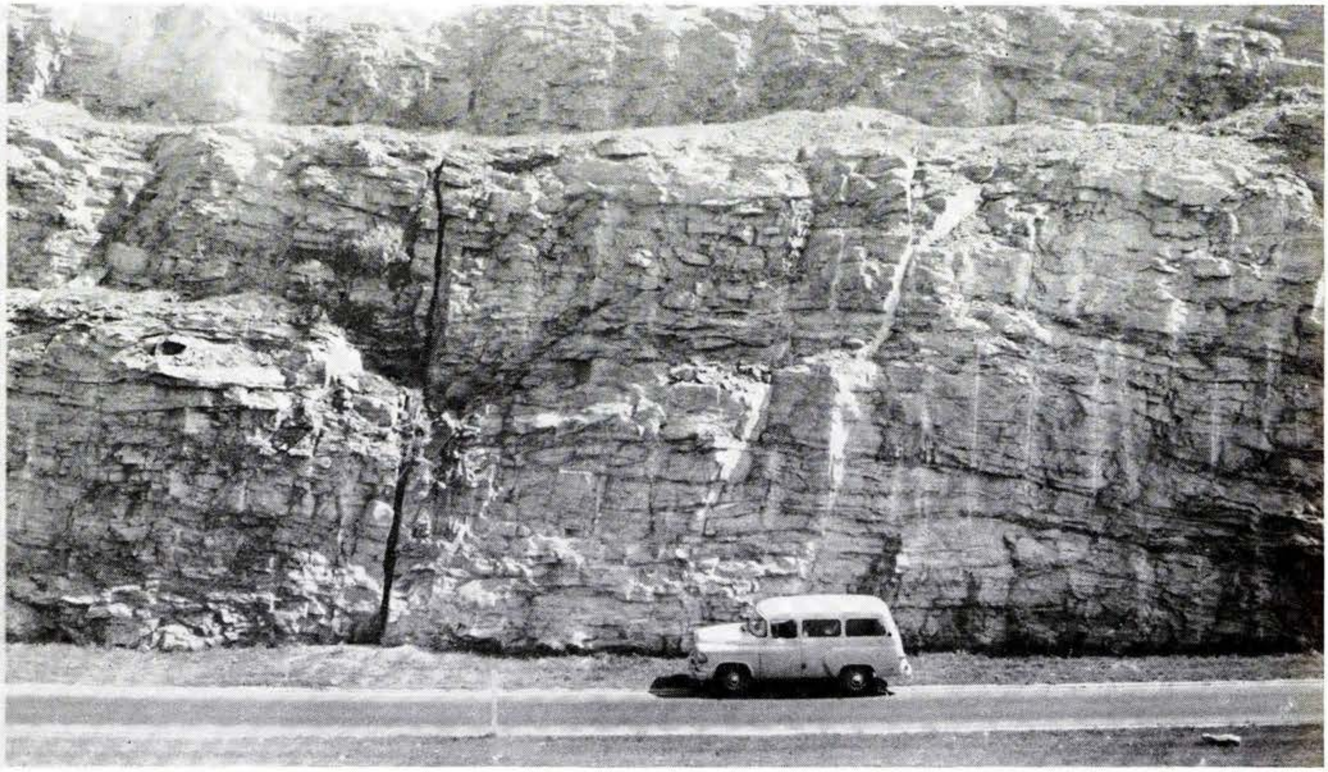

Figure 10.—Weathering along joints in biotite gneiss.

bedding planes — indicating that more water moves along the bedding planes.

The amount of weathering varies considerably with lithology. This is why the different lithologic units have different water yield. (See table 12) For example, as the feldspar content in schist increases, the weathered zone along joints, and along bedding and schistosity planes increases perceptibly in width.

Pumping test

A pumping test was made at GNL (Stewart and others, 1961, written communication) in saprolite of the migmatite of zone B. The cone of depression was elliptical with its major axis parallel to the direction of strike of the rocks.[1] The cone represents a dewatered area, and it is obvious from its shape that much more water moved toward the pumping well parallel to the strike of the rocks than normal to it.

Laboratory studies

Two samples of saprolite were collected at the same location (Stewart and others, 1961, written communication) to determine the differences in permeability parallel to and normal to the strike of the rocks. The permeability parallel to the strike was about 0.2 gpd per square foot, but the permeability normal to the strike was only about 0.009 gpd per square foot.

Variation in streamflow due to ground-water runoff

If the principal movement of ground water is along planes oriented parallel to the strike of the rocks, then streams flowing normal to the strike should transect a greater number of these planes and should receive a greater volume of ground-water runoff per unit length of stream than streams flowing in other directions (fig. 11).

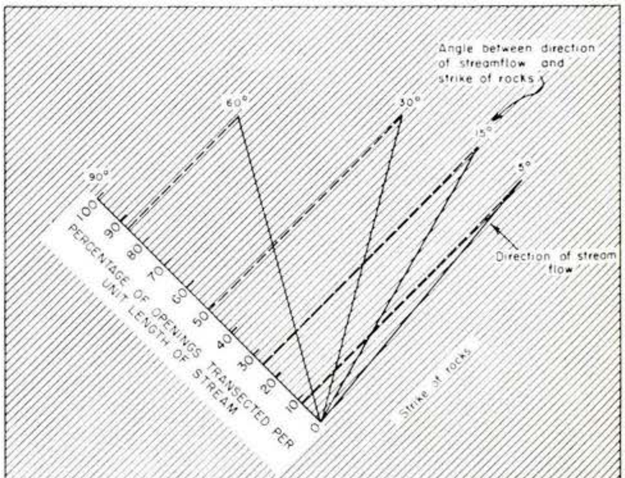

Figure 11.—Relationship between direction of streamflow and the number of planar openings transected per unit length of stream.

A study of the increase in streamflow due to the ground-water runoff made at GNL by R. F. Carter (Stewart and others, 1961, written communication) showed a variation in ground-water runoff with direction of streamflow. Ground-water runoff is plotted against strike and dip of the rocks in figure 12. The length of line represents runoff in cubic feet per second per square

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[1] Schistosity, axial-plane cleavage, and bedding are generally parallel in the area, and it is not known which of these actually control the direction of water movement. For convenience of discussion their orientation is given as the strike and dip of the rocks.

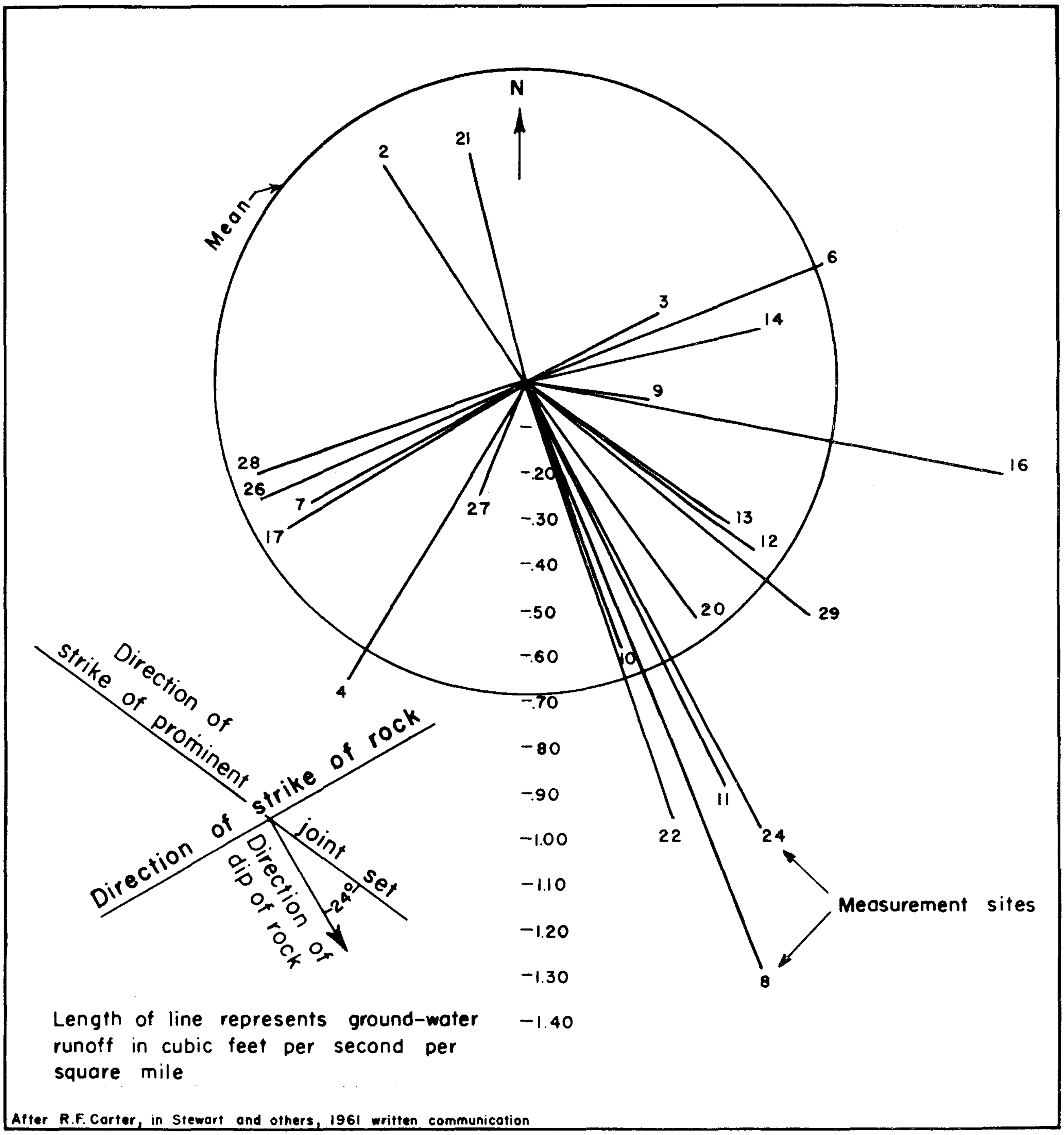
mile of drainage area. The greatest ground-water runoff is to streams flowing normal to the strike of the rocks. Also, 59 percent of the streams are on dip slopes while only 9 percent are on scarp slopes; 32 percent are on strike slopes.

Rate of movement

The rate of flow of ground water as determined by Stewart and others (1961, written communication) varied between 0.007 and 0.14 foot per day in hard rock, between 0.15 and 0.40 foot per day in weathered migmatite, and between 0.59 foot and 1.58 feet per day in weathered metagraywacke.

Storage

Storage capacity is an essential aspect of an aquifer. To understand where and how water is stored, the nature and distribution of openings must be studied. In crystalline rocks water is stored in the interstices and along various



Length of line represents ground-water runoff in cubic feet per second per square mile

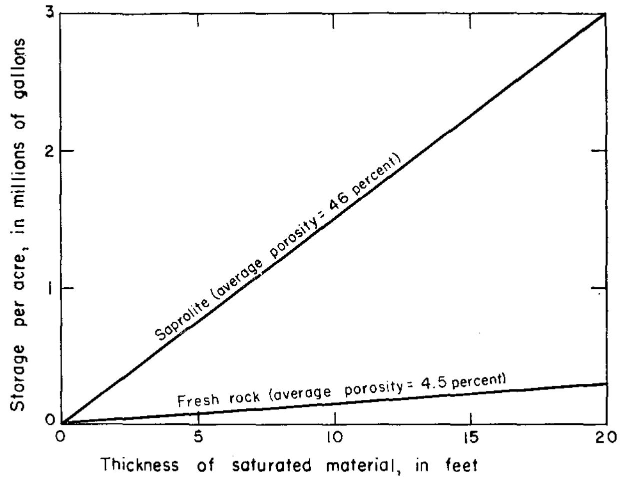
After R.F. Carter, in Stewart and others, 1961 written communication

Figure 12.—Relative ground-water runoff plotted in the direction of the major axis of stream basins at GNL, Dawson County.

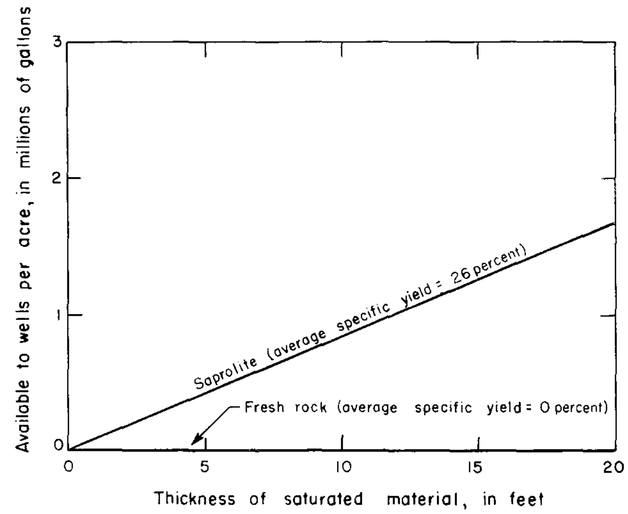
planar openings. Ground water also is stored in alluvial deposits.

The porosity of a rock — a unit measure of its storage capacity — is the ratio of the aggregate volume of interstices in the rocks to its total volume expressed as a percentage (Meinzer, 1923, p. 19).

Figure 13-A shows the difference in interstitial storage space in fresh rock and weathered rock. Completely saturated, a volume of saprolite 1 acre in area and 10 feet thick would contain about 1,500,000 gallons of water, whereas an equal volume of fresh rock would contain only about 150,000 gallons. This is a ratio of 10:1. But this is not as significant a difference as the specific yield.



A. Water stored in interstitial pores



B. Amount of stored interstitial water available to wells

Figure 13—Storage and availability of ground water in interstitial pores.

Specific yield is an expression of the amount of stored water that is available to wells and is defined as the ratio of the volume of water which a rock, after being saturated, will yield by gravity to its own volume, expressed as a percentage (Meinzer, 1923, p. 28). Figure 13-B shows the difference in specific yield of weathered rock and fresh rock. Completely saturated, a volume of saprolite 1 acre in area and 10 feet thick would contain about 850,000 gallons of water available to wells, or about 57 percent of the water stored. None of the water stored in interstitial pores in fresh rock is available to wells. The pores are so minute that capillary forces prohibit movement of the water. Because of the many difficulties involved, direct measurements have not been made to determine the porosity due to jointing and other open breaks within fresh rock. LeGrand and Mundorff (1952, p. 10), and numerous other investigators believe the porosity to be less than 1 percent. Ellis (1906, p. 21) believes the porosity to be less than one-half of one percent. Observations in quarries and cuts, as in figure 11, suggest that the porosity of fresh rock due to jointing alone is less than 1 percent.

Thus, practically all ground water available to wells is stored in weathered rock. Wells obtain some water from breaks in hard rock and from weathered rock adjacent to the breaks. As weathering generally decreases rapidly with depth porosity decreases correspondingly. The thickness of the saprolite, and hence the amount of water stored, varies with topography and with rock type.

No storage data are available for alluvial deposits in Dawson County, but on the basis of the known geology it is concluded that a large quantity of water is stored in the alluvium.

Discharge

Ground-water discharge is divided into two categories — natural and artificial. The principal natural discharge is by springs. Artificial discharge is restricted to wells and deep road cuts.

Most springs discharge from the saprolite immediately above hard rock, but the yield of these springs is usually less than 1 gpm. Springs that flow from joint, bedding, or foliation planes are less numerous but usually yield 1 to 5 gpm. Many of the larger springs are associated with faults and occur at intervals along fault traces. Yields of these springs are generally more than 5 gpm. The largest spring yields about 90 gpm and is the town supply for Dawsonville.

The total use of ground water in Dawson County, based on an estimated per capita use of 50 gpd per person and 5 gpd per 100 chickens, is about 220,000 gpd. No estimate of the discharge from road cuts has been attempted, but it is not much.

Chemical Quality

Natural water is not chemically pure, as it contains dissolved gasses and impurities from the air and many minerals dissolved from the rocks with which it comes in contact.

Chemical analyses of ground water in Dawson County were made to determine the amounts of dissolved constituents in the water. The amounts of silica, iron, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, and fluoride in the water were determined and are expressed in parts per million. The pH, hardness,

Table 7.—*Chemical analyses of ground water, Dawson County*
(Analyses by the U. S. Geological Survey except as indicated.)

Owner	Location	Aquifer	Type of supply[1]	Date of collection	Temperature (°F)	Parts per million																
																			Hardness as $CaCO_3$				
						Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Calcium, magnesium	Noncarbonate	Specific conductance (micromhos at 25°C)	pH
Sams, L. R.	560-1570-11	Quartzite	dr	12-11-59	----	21	0.13	4.4	1.7	3	1.5	28	0	2.4	0.8	0.1	0.0	----	18	0	52	6.4
Lumpkin School	[2]560-1570-54	Mica schist	dr	11-25-55	----	4	.2	20	2.6	present		---	--	2.4	10.5	----	----	96	42	--	----	7.4
Pugh, G.	560-1570-25	do	b	12-11-59	57	12	.00	8	.4	2.4	2.4	30	0	.4	2	.1	3.9	46	22	0	63	6.8
Bettys, Mrs.	560-1570-49	Amphibolite	du	12-11-59	----	15	.09	4	2.2	2.3	.6	23	0	.0	1	.1	3.7	43	19	0	51	6.6
U. S. Air Force	530-1570-51	Migmatite	dr	10-16-56	62	27	.11	4	.6	4.8	.7	22	0	2.6	.5	.1	1.2	53	12	0	42	6.9
Do	530-1570-52	do	du	7-13-56	60	7.9	.64	30	3.4	2.5	6.4	105	0	7	3.5	.1	2.9	116	89	3	199	7.4
Do	530-1570-48	Amphibolite	dr	10-18-56	69	21	.31	10	3.6	2.7	.6	56	0	.2	1.3	.1	.0	66	40	0	90	6.9
Do	530-1570-45	do	du	7-11-56	----	28	.01	19	20	8.7	.8	92	0	8.6	1	.2	.2	107	68	0	164	7.8
Do	500-1570-36	Metagraywacke	dr	7-31-58	----	12	.78	10	2.7	4.8	4.5	60	0	2	2.8	.1	.2	76	36	0	110	6.8
Do	530-1570-50	do	du	7-17-56	60	9.3	.03	3.6	2.4	14	2.6	4	0	6	16	.1	24	80	19	16	125	5.4
Do	500-1570-37	do	s	7-17-56	60	13	.03	2.8	.7	2	1.1	16	0	.5	1	.1	.2	29	10	0	26	6.8
Do	500-1570-31	Zone F	dr	10-31-56	66	22	1.3	23	3.8	5	4.2	97	0	10	.9	.2	.1	117	73	0	168	7.9
Do	500-1600-47	do	du	7-12-56	59	6.3	.38	3.2	1.2	3.6	1.6	22	0	.0	2	.0	.2	37	13	0	49	6.8
City of Dawsonville	530-1600-19	do	s	1- 7-57	58	.1	.04	4.5	1.3	3.7	.7	21	0	.4	3.5	.0	5.2	41	17	0	56	7.9
Harbin, G.	[2]500-1600- 9	Zone E	dr	2- 9-55	----	1	.8	1.8	.8	----	----	----	--	.2	5.4	----	----	26	5	--	----	6.7
Hill, S.	[3]500-1570-15	do	du	8-21-59	78	10	.6	3	1		2	13	0	1	2	.1	3.5	38	15	--	----	5.1
Harbin, M.	500-1600-31	do	du	12- 9-59	61	8	.00	.2	.4	.8	.7	4	0	.0	.0	.1	.5	----	2	0	13	5.5
Kent, J.	500-1600-49	do	du	11- 2-59	----	6.9	.10	.6	.2	1.3	.8	4	0	.0	2	.1	1.5	20	2	0	19	5.3
Burt, L. A.	500-1600-33	do	s	10-30-58	----	12	.00	6.6	2.1	.7	.3	29	0	.8	.2	.0	.3	37	25	1	49	6.8

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[1] Type of supply: b—bored well; dr—drilled well; du—dug well; s—spring.

[2] Analysis by Law and Co., Atlanta, Ga.

[3] Analysis by the Georgia Department of Mines, Mining and Geology.

and specific conductance of the water also were determined.

Chemical analysis data of ground water from wells and springs in Dawson County are given in table 7. The location of each source is shown by location number. (See fig. 2.)

The quality of the ground water in Dawson County generally is suitable for most municipal and domestic uses.

Table 8.—*Recommended limits of water quality for domestic use.*

(Based on U. S. Public Health Service Drinking Water Standards, 1962)

Chemical constituents	Recommended maximum limit (parts per million)
Iron (Fe)	0.3
Magnesium (Mg)	125
Sulfate (SO_4)	250
Chloride (Cl)	250
Nitrate (NO_3)	45
Fluoride (F)	[1]1.2

[1] Recommended maximum limit at annual average maximum daily air temperature of 63.9 — 70.6°F; recommended lower limit is 0.7 ppm and optimum is 0.9 ppm.

Table 9.—*Iron content of ground water, Dawson County*

Geologic division	Lithology[1]	Number of analyses	Iron content (ppm) Average	Iron content (ppm) Range	Number of analyses more than 0.5 ppm	Percent of analyses more than 0.5 ppm
Zone A	Quartzite	1	0.13	---	0	0
Do	Amphibole-mica schist	4	.30	0.0 -0.9	1	25
Do	Amphibolite	1	.09	---	0	0
Zone B	Migmatite	14	.64	.02-4.40	4	29
Zone C	Amphibolite	2	.16	.01- .31	1	50
Do	Metagraywacke	10	1.09	.03-4.9	5	50
Great Smoky Group	Zone F	10	.90	.00-5.9	4	40
Do	Zone E	6	.72	.00-2.0	4	67
Do	Great Smoky Group undifferentiated	1	.00	---	0	0
	All	49	.72	.00-5.9	19	39

[1] Water analysis not available for the garnet-amphibolite and sillimanite-bearing schist of zone A, biotite gneiss of zone C, or zone D of the Great Smoky Group.

Iron

Iron in small amounts is present in most water. The U.S. Public Health Department's recommended limit of iron for domestic use (table 8) is 0.3 ppm (parts per million). Water containing more than 0.3 ppm will stain fabrics, utensils, and fixtures, and 0.5 ppm is detectable by taste. Water having a high iron content favors the growth of the organism **Crenothrix.** This organism forms reddish-brown deposits in water pipes, partly or completely clogging them. The iron content in waters varies with lithology (table 9).

Table 10.—*Combined sodium and potassium content of ground water, Dawson County*

Geologic Divisions	Lithology[1]	Number of analyses	Combined sodium and potassium content (ppm) Average	Combined sodium and potassium content (ppm) Range	Number of analyses more than 5 ppm	Percent of analyses more than 5 ppm
Zone A	Quartzite	1	4.5	---	0	0
Do	Amphibole-mica schist	2	4.4	4.0- 4.8	0	0
Do	Amphibole orthogneiss	1	2.9	---	0	0
Zone B	Migmatite	14	13.2	1.2-91.0	7	50
Zone C	Amphibolite	2	6.4	3.3- 9.5	1	50
Do	Metagraywacke	10	7.4	3.0-13.9	6	60
Great Smoky Group	Zone F	10	4.9	2.0-11.8	3	30
Do	Zone E	4	4.0	1.5-10.9	1	25
Do	Great Smoky Group undifferentiated	1	1.0	---	0	0
	All	45	7.9	1.0-91.0	18	40

[1] Water analyses not available for the garnet-amphibolite and sillimanite-bearing schist of zone A, biotite gneiss of zone C, or zone D of the Great Smoky Group.

Calcium

Calcium carbonate forms a soft scale and calcium sulfate forms a hard scale in boilers and cooking utensils. Calcium also is a soap consumer. Water in some amphibolite of zone A is reported by well owners to contain enough calcium carbonate to form a scale in domestic cooking utensils.

Magnesium

Magnesium is generally present in small quantities in water that contains calcium. Magnesium carbonate, which is precipitated by heating, forms a soft friable scale. Calcium and magnesium sulfate when precipitated together form a dense porcelainlike scale. The highest magnesium content analyzed was 25 ppm. This is less than the recommended limit of 125 ppm shown in table 8.

Sodium and potassium

Water containing more than 5 ppm sodium and (or) potassium may cause foaming in boilers. More than 300 ppm sodium salts in water causes a saline taste. The sodium and potassium content of ground water varies between lithologies (table 10). More than 50 percent of the water from zones B and C contained more than 5 ppm sodium and potassium combined, but none of the water in zone A and only 25 percent of the water in the Great Smoky Group contained more than 5 ppm. The average content of all water analyzed is only 7.9 ppm.

Carbonate and bicarbonate

Calcium and magnesium bicarbonate are the most abundant dissolved mineral matter in ground water but have comparatively little effect on the utility of water unless present in very large amounts.

Carbonate is not present in the ground water of Dawson County.

Sulfate

Most sulfate is derived from oxidation of metallic sulfides, sulfur-bearing organic compounds, or fertilizers containing sulfate. Sulfate is purgative and causes a bitter taste in water if present in excess of 250 ppm. Sulfate in excess of 100 ppm causes hard scale in boilers if calcium and magnesium cations are present. Ground water in Dawson County contains little sulfate.

Chloride

Sodium chloride is a characteristic constituent of sewage, and any appreciable pollution of water by sewage is accompanied by a measurable increase in chloride. Small quantities of chloride also are dissolved from some rock materials. Chloride gives a salty taste to water if present in quantities greater than 250 ppm. Ground water in Dawson County is low in chloride.

Nitrate

Fertilizers contribute to the nitrate content in water supplies and some nitrogen is dissolved

Table 11.—*Carbon dioxide in ground water, Dawson County*

Sample No.	Date collected	Source	Location number	Field pH	Temperature (°F)	[1]Bicarbonate (HCO_3) (ppm)	[2]Carbon dioxide (CO_2) (ppm)	Ratio of HCO_3 to CO_2	Aquifer
1	01-19-60	drilled	500-1600-43	5.6	59.5	8	32	1:4	Zone E
2	01-19-60	spring	500-1600-11	5.7	57.0	11	35	1:3	Do
3	01-19-60	dug	500-1600-23	6.4	56.0	37	21	2:1	Migmatite
4	01-19-60	do	500-1600-39	6.0	58.0	8	13	1:2	Zone E
5	01-19-60	do	500-1600-49	5.3	57.0	6	48	1:8	Do
6	01-19-60	drilled	500-1600-50	5.7	59.0	15	48	1:3	Do
7	01-19-60	dug	500-1570-15	6.3	58.0	49	39	1:1	Do
8	01-20-60	do	530-1570-20	6.8	......	20	5	4:1	Alluvium
9	01-20-60	drilled	530-1570-14	6.1	......	43	54	1:1	Amphibole-mica schist
10	01-20-60	dug	530-1570-24	5.5	......	18	91	1:5	Metagraywacke
11	01-20-60	spring	530-1570-23	5.4	......	11	70	1:6	Do
12	01-20-60	drilled	500-1600-33	6.1	52.0	23	29	1:1	Zone E
13	01-20-60	spring	500-1600-32	5.6	56.0	12	48	1:4	Do
14	01-20-60	drilled	500-1630-13	6.2	55.0	56	56	1:1	Do
15	01-20-60	spring	500-1630-29	5.4	57.0	10	63	1:6	Great Smoky Group undifferentiated
16	01-20-60	dug	500-1630-34	6.0	51.0	63	100	1:1	Do
17	01-20-60	do	530-1600-24	6.1	56.0	11	14	1:1	Zone F
18	01-21-60	bored	560-1570-25	6.0	44.0	30	48	1:2	Sillimanite-amphibole-mica schist
19	01-21-60	drilled	560-1570-23	5.7	54.5	17	54	1:3	Amphibole-biotite gneiss
20	01-21-60	do	560-1570-11	6.2	54.5	30	30	1:1	Quartzite
21	01-21-60	dug	560-1570-3	5.8	59.5	17	43	1:3	Amphibole-biotite gneiss
22	01-21-60	do	560-1570-5	5.8	57.0	42	106	1:3	Quartzite
23	01-21-60	do	560-1570-49	5.6	57.0	24	96	1:4	Amphibolite
24	01-21-60	do	560-1570-91	5.6	56.0	8	32	1:4	Mica schist
25	01-21-60	spring	560-1570-92	5.3	58.0	17	135	1:8	Migmatite

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[1] Chemical analyses by Roger Landrum, Georgia Geological Survey, January 25, 1960.

[2] CO_2 content computed as follows: ppm CO_2 = 1.589 x 10^6 [H+] x ppm alkalinity as HCO_3.

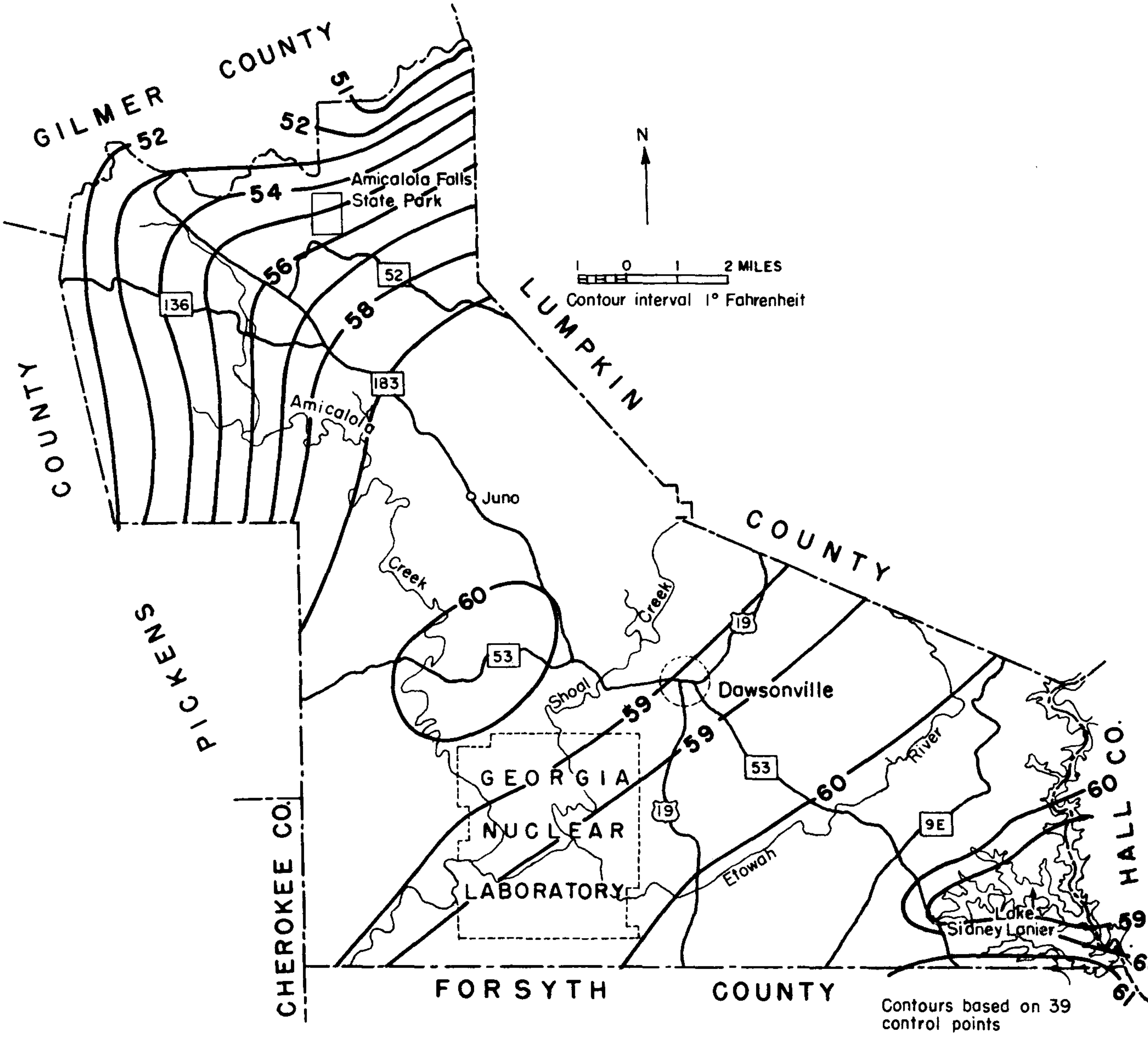
from rocks, but most of the nitrate in water is considered to be the oxidation product of nitrogenous organic material (usually sewage). The presence of abnormal quantities of nitrate may indicate poor sanitary conditions. The recommended limit is 44 ppm (table 8). Two dug wells were found to contain more than 44 ppm; both are polluted because of inadequate protection, and both wells are abandoned. Poor construction accounts for most of the pollution of well water.

pH

The pH is the negative logarithm of the hydrogen-ion concentration in water and is an expression of the acidity or alkalinity. A low pH is evidence of a high concentration of hydrogen ions, or acidity, and a high pH is evidence of a low concentration of hydrogen ions, or alkalinity. Neutral water has a pH of 7.0. Ground water in Dawson County is decidedly acid, and the pH of some water is as low as 4.9. A portable meter was used to determine the pH at 25 sites (table 11) immediately after collection of water samples; the determinations are considered to be nearer the natural pH than those in table 14 (laboratory determinations). The pH ranged from 5.3 to 6.8 in the field and averaged about 5.9. Water in alluvium has the highest pH, and water in metagraywacke has the lowest average pH of all waters examined — indicating that lithology influences the pH of ground water.

Carbon dioxide

The principal cause of corrosiveness of ground water in Dawson County is carbon dioxide. Carbon dioxide is absorbed from the atmosphere, from humus in the upper soil layer, and from soil air. The carbon dioxide content in soil air is 10 to 100 times greater than in the atmo-



Contours based on 39 control points

Figure 14.—Ground-water temperatures in degrees Fahrenheit, Dawson County (October 1959)

sphere (Hem, J. D., 1960, oral communication). Thus, percolating waters have access to and absorb large amounts of carbon dioxide. The carbon dioxide content of ground water in Dawson County is shown in table 11. If the ratio of alkalinity (bicarbonate) to carbon dioxide is less than 3:1, the water is corrosive. Of the 25 water samples tested, 23 were decidedly corrosive, one was slightly corrosive (No. 3, table 11), and one was noncorrosive (No 8, table 11). The noncorrosive water was from the alluvial deposit adjacent to the Etowah River. Corrosive waters cause reddish-brown or rust-colored stains on linen and porcelain fixtures where iron or steel plumbing is used and blue or blue-green stains where copper or brass plumbing is used. Corrosive water attacks and gradually destroys plumbing, appliances, pumps, and the like.

The corrosiveness of water can be neutralized by treatment with various commercial products. Water in dug wells and springs can be neutralized with crushed limestone or marble.

Hardness

Hardness is the property of water attributable to the presence of alkaline earths. Hardness is caused almost entirely by calcium and magnesium. Other constituents, such as iron, aluminum, strontium, barium, zinc, or free acid also cause hardness. Hardness that can be removed by boiling is referred to as carbonate hardness, and the remainder, if any, as noncarbonate hardness. Hardness causes scale in boilers, destroys soap to form soap curds, and destroys dyestuffs.

Water with a hardness of 0 to 60 ppm is classified "soft"; 61 to 120 ppm, "moderately hard"; 121 to 180 ppm, "hard"; and more than 181 ppm, "very hard." The hardness of water in Dawson County averages 28 ppm and ranges between 2 and 89 ppm (table 7.) Of the 19 analyses in table 7, 16 may be classified as soft and 3 as moderately hard.

Fluoride

Fluoride in excessive concentrations is undesirable in water used for drinking because it may cause spotting of the tooth enamel and may effect skeletal bone structure.

Fluoride is a natural constituent in much of the ground water in the study area and is dissolved from numerous complex fluoride-bearing minerals found in the rocks; the most important of these minerals are apatite, hornblende and mica. Fluoride content in water from the study area ranged from 0.0 to 0.2 ppm. The recommended maximum limit for fluoride content in water in this area is 1.2 ppm, according to the U.S. Public Health Service. (See table 8.)

Temperature

The temperature of ground water approximates the mean annual air temperature; but season of the year, and, locally, Lake Sidney Lanier also affect the ground-water temperature in Dawson County.

The altitude of the land surface in Dawson County ranges from about 1,000 feet in the southern part to 3,200 feet in the northern part. Ground-water temperature decreases with increasing altitude (fig. 14). This decrease is caused by a decrease of the mean annual air temperature and more snowmelt at higher altitudes.

The temperature of ground water decreases adjacent to Lake Sidney Lanier. The reason for the decrease is not understood, but the temperature of the water in Lake Lanier at a depth of 135 feet was about 47° F during October 1959 (Mr. William T. Alley, U.S. Army Corp of Engineers, oral communication, October, 1960).

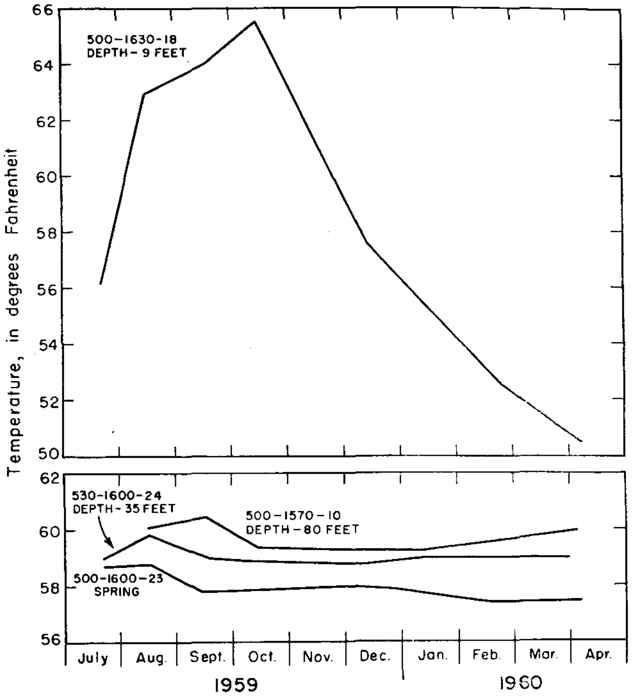


Figure 15.—Seasonal changes in the temperature of ground water.

The ground-water temperature decreases 1 degree along a northeast-trending belt passing through Dawsonville. This belt roughly corresponds to zone C and is attributed to increased altitude of land surface within the zone.

The temperature of water in 22 wells and springs were measured periodically between July 1959 and April 1960. The seasonal ground-water-temperature fluctuation is far greater in shallow wells than in deeper ones (fig. 15). This was consistent in all the wells measured. Changes in temperature of ground water lagged from 40 to 60 days behind changes in temperature of the air. The average seasonal temperature change was 15.2°F at shallow depths (less than 15 feet to the water table), 1.5°F in deeper wells (more than 40 feet to the water table), and 1.9°F in springs. During the summer water in shallow wells is warmer than that in deeper wells whereas during the winter water in shallow wells is considerably colder than that in deep wells.

Well Yield

The term yield, as used in this report, designates the maximum rate at which water can

Table 12.—*Yield of drilled wells and springs*

Location	Drilled wells				Springs		
	Wells	Reported yield (gpm)			Number of springs	Yield (gpm)	
		Range	Average	Per foot of well		Range	Average
		A. Analysed with respect to topography					
Hilltop	26	0-40	16	0.08	0	------	----
Slope	21	4-80	16	.10	[1]25	1-25	6
Valley and draw	3	7-40	21	.15	18	1-90	15
		B. Analysed with respect to lithology					
Zone A	20	0-80	17	.08	7	1-5	2
Quartzite	1	------	35	.23	0	------	----
Mica schist	16	0-80	16	.08	4	1-4	2
Amphibolite	0	------	----	------	0	------	----
Sillimanite-biotite gneiss and schist	3	5-25	15	.05	2	1-5	3
Amphibole orthogneiss	0	------	----	------	1	2	2
Zone B (migmatite)	10	4-20	11	.06	9	2-15	7
Zone C	4	2-30	12	.05	14	1-4	3
Biotite schist	0	------	----	------	2	2-2	2
Amphibolite	2	3-11	7	.09	0	------	----
Metagraywacke	2	2-30	16	.04	12	1-4	3
Great Smoky Group	16	3-40	18	.11	41	1-90	14
Zone F	5	11-40	30	.13	15	1-90	18
Zone E	11	3-27	13	.09	19	3-20	10
Zone D	0	------	----	------	4	5-12	9
Alluvium	0	------	----	------	0	------	----
All locations	50	0-80	16	.09	71	1-90	10

[1] The topographic location of 28 springs was not recorded.

be withdrawn from an aquifer by wells and is expressed in gallons per minute. Yield is influenced by porosity, permeability, jointing, storage, recharge, and other geologic and hydrologic factors. The topography in Dawson County is a result of differences in resistance of the rocks to erosion. The resistance of a rock to erosion is affected by its chemical and physical properties. The most resistant rocks form ridges, and the least resistant form valleys. Studies were made of the relationship between lithology, topography, and yield of wells.

Wells in valleys and draws have larger yields than wells on hilltops and slopes (table 12-A). For drilled wells the yield per foot of well in valleys and draws is almost twice that for wells on hilltops. Also, the average yield of springs in valleys is 2.5 times that of springs on slopes. Because dug wells seldom are tested, little is known about their yield, but the variation in yield should correspond to that of springs and drilled wells.

Yield also depends upon lithology. The variation in yield between lithologies is shown in table 12-B. The various lithologic units can be compared or rated best on the basis of yield per foot of drilled well. For example, in the quartzite of zone A the average yield is 0.23 gpm per foot of well, whereas in the metagraywacke of zone C the average yield is only 0.04 gpm per foot of well. Also, the average yield of springs in zone F is nine times as great as that of those in the mica schist and amphibolite of zone A and in the biotite schist of zone C.

SELECTING A WELL SITE

If the influences of topography, lithology, and the direction of ground-water movement were considered when selecting a well site, the cost would be less and the yield would be greater. Other factors influence the selection of a well site, but topography and lithology always should be considered. Table 13 summarizes the influences of topography on depth to the water table, necessity for blasting to reach saturated rock, need for well casing, yield of well, and the quality of water from dug wells. Although dug wells in

Table 13.—*Information to be considered in selecting sites for dug wells*

Topographic location	Average depth to water (feet)	Percent of wells inventoried[1]			
		Blasting required	Casing required	Yield inadequate	Water of poor quality
Hilltop	39	41	7	24	21
Slope	32	30	15	15	7
Valley and draw	12	25	50	15	10

[1] Based on information reported by well owners.

Table 14.—*Topographic control on the water table*

Topographic Location	Number of wells	Depth to water below land surface (feet)						
		0-10	11-20	21-30	31-40	41-50	51-60	below 60
		(Percent of wells inventoried)						
Hilltop	95	0	5	10	30	33	15	7
Slope	65	0	17	27	32	14	8	2
Valley and draw	24	55	33	4	8	0	0	0

Table 15.—*Topography versus blasting of dug wells*

Topographic location	Number of wells inventoried	Number of wells blasted	Number of wells blasted	Average footage blasted	Range in footage blasted
Hilltop	27	11	41	27	4-53
Slope	23	7	30	13	6-30
Valley and draw	12	3	25	4	2-6

Table 16.—*Topographic influences that should be considered in selecting the site for a drilled well*

Topography	Average yield per foot of well (gpm)	Average well depth (feet)	Average amount of casing required (feet)
Hilltop	0.08	202	73
Slope	.10	177	67
Valley and draw	.15	164	62

valleys and draws may require casing to prevent caving, they are shallower, require less blasting, have higher average yields, usually produce water of better quality, and usually cost less to construct than wells at other locations. Probably the most important topographic influences on the cost of dug wells are depth to water and the need for dynamiting to reach water. These two factors are analyzed more completely in tables 14 and 15. Note that the depth to water below the land surface in 55 percent of the hilltop wells is more than 40 feet, whereas in 55 percent of the valley and draw wells it is less than 10 feet. Also, as much as 53 feet in hilltop wells needed to be dynamited, whereas the most reported for valley or draw wells was 6 feet.

Table 16 summarizes the influences of topography on the construction and average yield of drilled wells. Drilled wells in valleys and draws have a much higher average yield per foot of wells, are shallower, and require less casing than those on either slopes or hilltops.

Part of the influence of lithology is incorporated in the discussion under topography because, other things being equal, rocks most resistant to erosion compose the hills, and the rocks least resistant underlie valleys and draws. Yield of the various rocks is summarized in table 12 and discussed in the chapter on well yield.

Dug wells in alluvium in Dawson County indicate that the alluvial deposits are very permeable and probably will yield large amounts of water to wells and infiltration galleries. Aquifer properties of the alluvium are discussed in the chapter on geology.

Recharge and discharge areas affect the yield of wells and should be considered in selecting a well site. If a pumping well induces recharge from a nearby stream or lake, the yield will be greater than that of a well not so favorably located, other factors being equal. A well near a spring, another pumping well, or a road cut reaching below the water table usually has a lower yield than one more favorably located.

The fact that ground-water movement in the area is principally parallel to the strike of the rocks is important in selecting a well site near another well. Wells several hundred feet apart along the strike could cause immediate interference and a decline in the yield of both wells, whereas those a short distance apart normal to the strike could be pumped for a long period of time without causing interference. The general strike in the southeastern part of Dawson County is northeast, and in the northwestern part of the county it is north.

The yield per foot of drilled well decreases with well depth (table 17). Yield per foot aver-

Table 17.—*Yield per foot versus depth of well*

Depth of well below land surface (feet)	Number of wells	Average depth (feet)	Yield (gpm)		
			Range	Average	Per foot of well
0- 99	6	76	3-43	18	0.24
100-199	28	148	3-30	13	.09
200-299	8	218	0-80	19	.09
300-399	3	300	6-14	10	.03
400+	5	436	2-30	11	.02

aged 0.24 gpm between the land surface and 100 feet, 0.09 gpm to 200 feet, 0.09 gpm to 300 feet, 0.03 gpm to 400 feet, and 0.02 gpm below 400 feet.

DEVELOPMENT

About 33 percent of the wells were inventoried. Type of development was distributed as follows: 64 percent dug wells, 20 percent springs, 15 percent drilled wells, and 1 percent bored wells. The type of development varied with topography and prosperity. Figure 2 shows the concentration of spring utilization in the northern and western areas of high relief and a higher than average percentage of drilled wells near Lake Lanier. The percentage of new homes having drilled wells is considerably higher than the county average. Of the inventoried wells constructed between 1949 and 1959, 45 percent are drilled wells. Many owners and tenants prefer drilled wells, and the trend toward drilled wells will probably continue as long as prosperity permits.

The water supply for the town of Dawsonville comes from a spring which flows about 90 gpm. Only 30 to 50 percent of the flow is used.

The ground-water resources of Dawson County have not been fully developed as shown by the large volume of ground water which annually flows from undeveloped springs.

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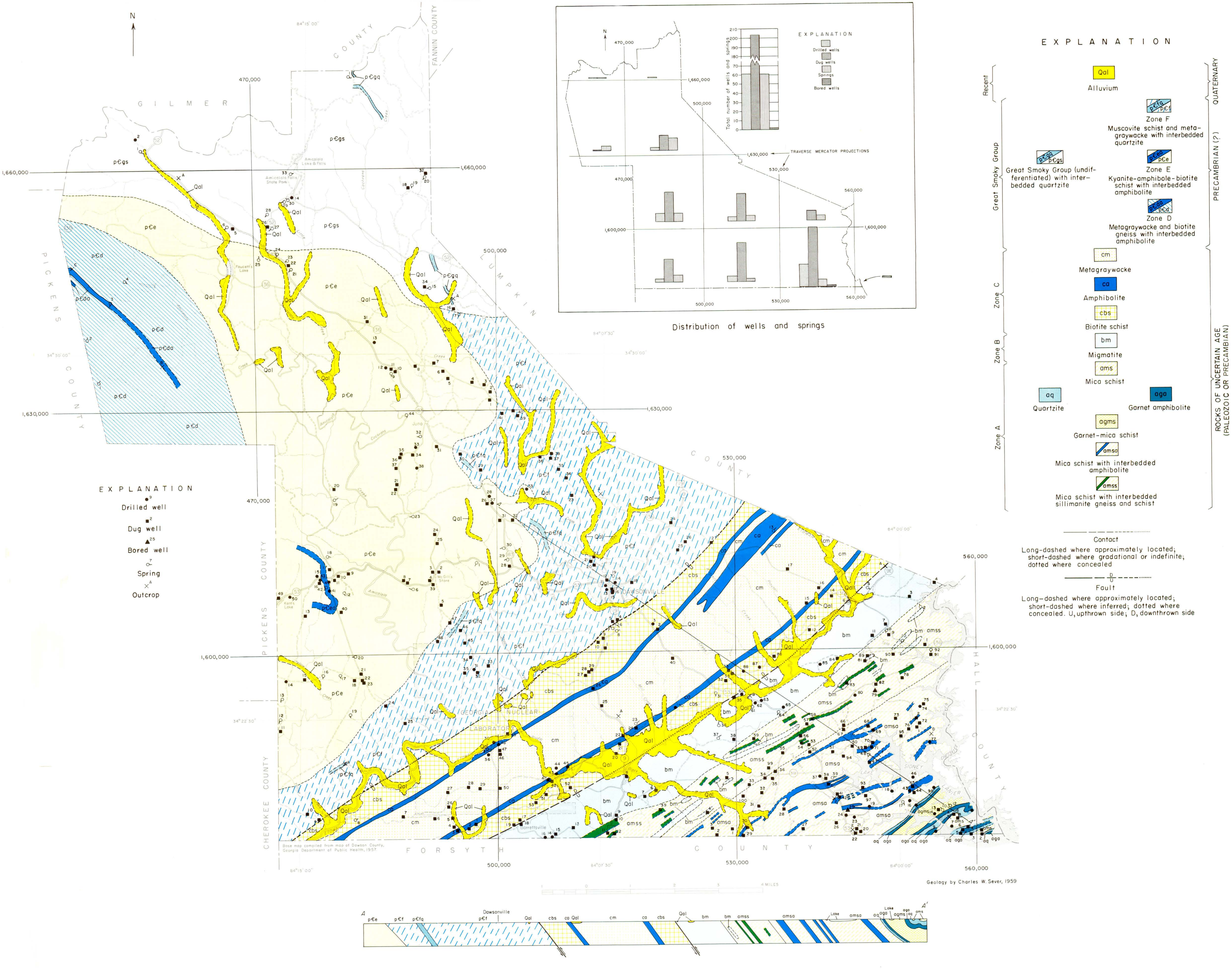

Figure 2.—Map showing geology, and location of wells, springs, and outcrops, Dawson County, Georgia.

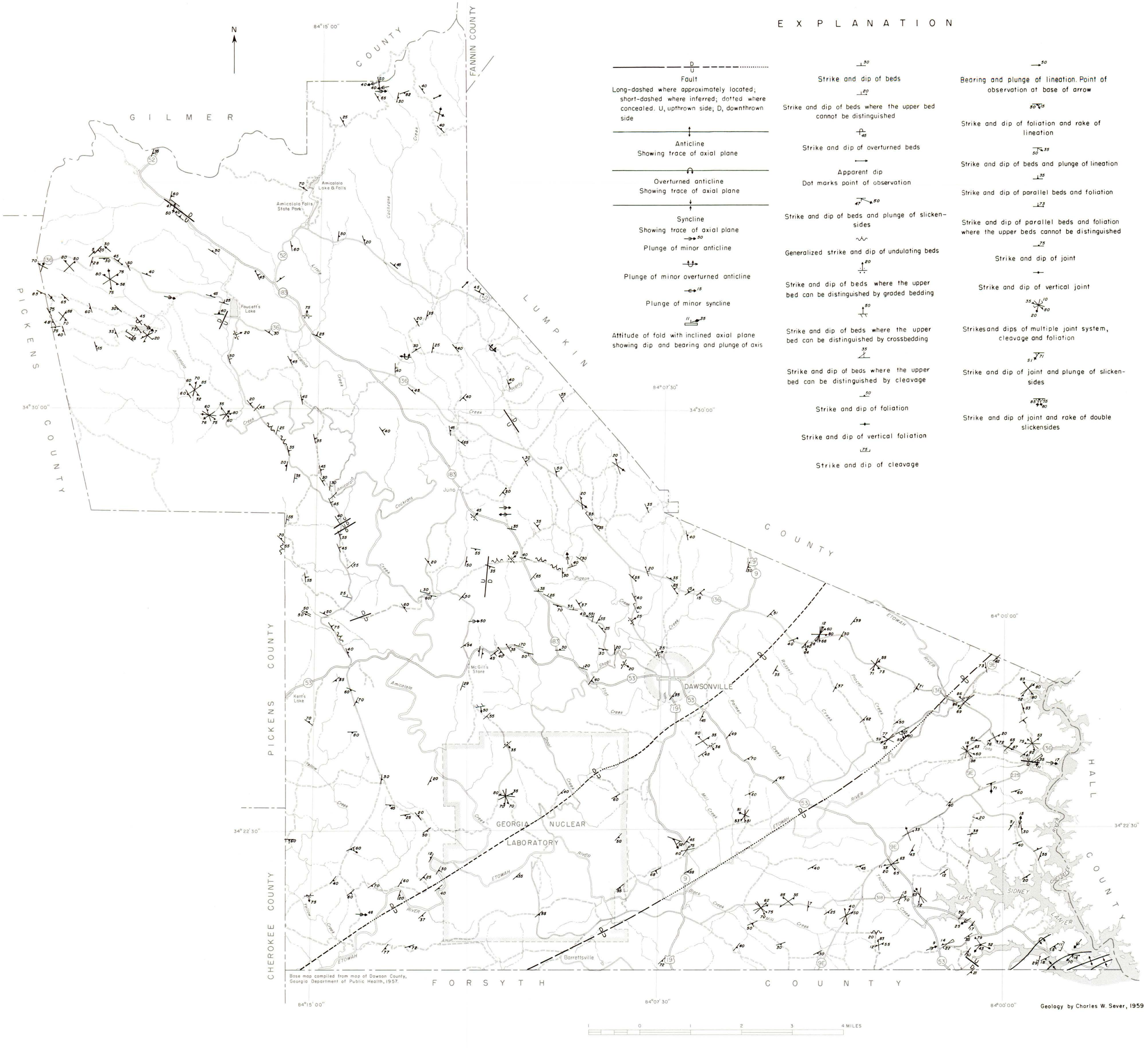

Figure 6.—Geologic structural map of Dawson County, Georgia.