ASSESSMENT OF THE HYDROGEOLOGY OF THE PIEDMONT, ALABAMA, AREA

GEOLOGICAL SURVEY OF ALABAMA

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ASSESSMENT OF THE HYDROGEOLOGY OF THE PIEDMONT, ALABAMA, AREA

A REPORT TO THE

CITY OF PIEDMONT UTILITIES BOARD

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By
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INTRODUCTION

In June 2009, the City of Piedmont Utilities Board requested that the Geological Survey of Alabama (GSA) evaluate the potential for development of additional public water supplies to supplement the groundwater currently provided by Ladiga Spring. To that end and by mutual agreement and contract with the City of Piedmont Utilities Board, the staff of the Groundwater Assessment Program of GSA conducted a hydrogeologic assessment of the city and surrounding area. This report summarizes the data collected and analyzed and presents interpretations of the hydrogeological characteristics of the area.

ASSESSMENT AREA

The assessment area includes the service area of the City of Piedmont Utilities Board and surrounding areas (fig. 1). Analysis of data for the project extends beyond the immediate area served by the city in northeastern Calhoun County in order to adequately evaluate the service area within the context of the geologic, hydrologic, and geochemical setting and to provide a more comprehensive study. Data from surrounding wells and geologic outcrops are significant in the assessment process and important in making recommendations concerning the development of additional groundwater sources.

HYDROGEOLOGY

GENERAL PHYSIOGRAPHIC AND GEOLOGIC SETTING

The project area lies in the Valley and Ridge Province (fig. 2), a region characterized by significant local topographic relief with generally parallel ridges and valleys. Paleozoic sedimentary rocks ranging in age from early Cambrian to early Pennsylvanian occur across the area with older rocks predominating to the southeast

Figure 1.—Index map showing the location of the City of Piedmont Utilities Board assessment area.

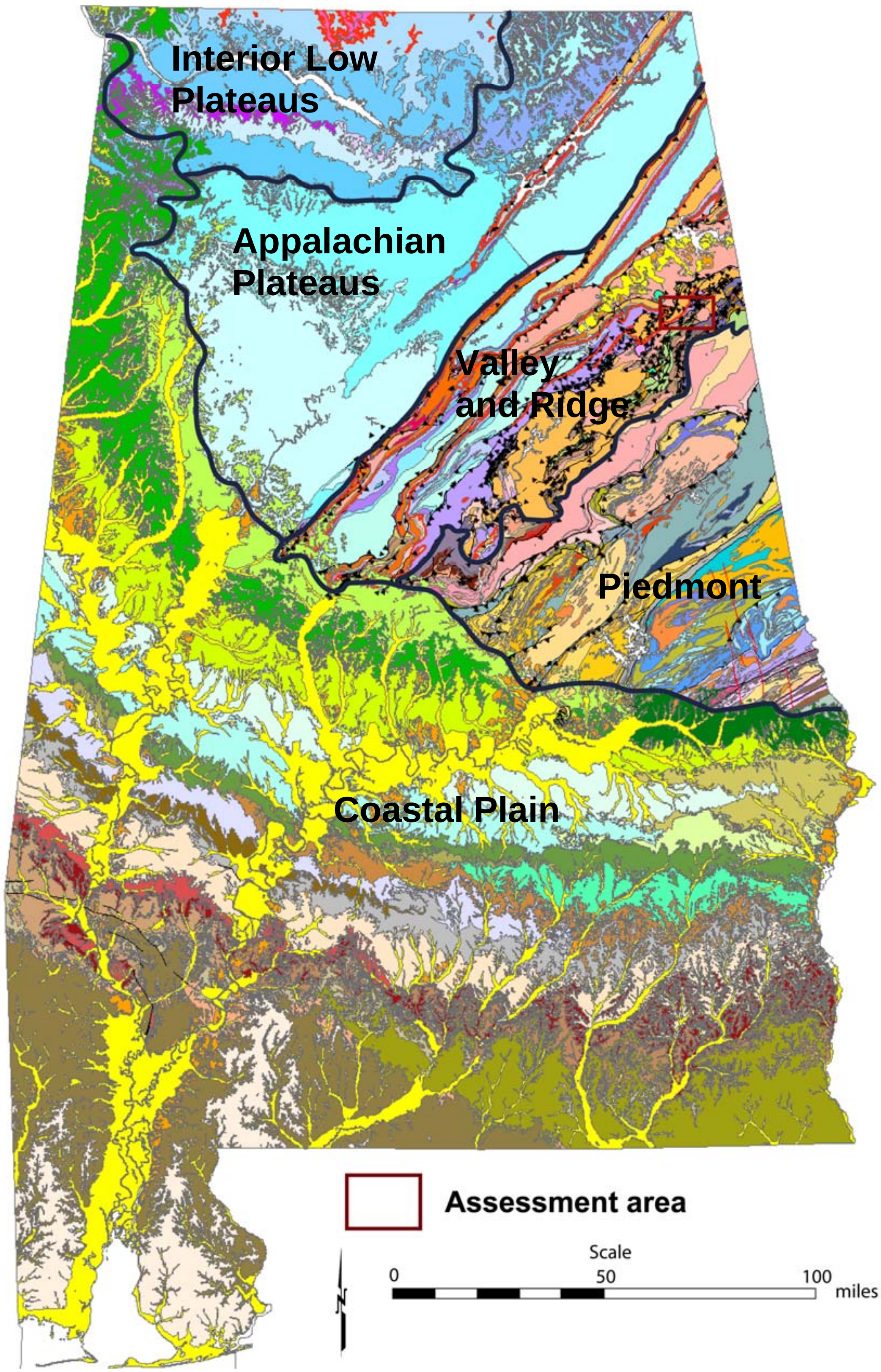


Figure 2.—Physiographic provinces, geology, and the City of Piedmont Utilities Board assessment area. See Geological Survey of Alabama (2006) for explanation of geologic units statewide. See plate 1 for geology of assessment area.

and younger rocks more prevalent to the northwest (plate 1). The physiography of the Valley and Ridge Province results primarily from differential erosion of fold and thrust belt tectonic features wherein more resistant rocks form ridges and less resistant rocks comprise the valleys. Thrust faults cross the assessment area in a general northeast-southwest direction and include the regionally extensive Pell City, Jacksonville, and Indian Mountain faults (plate 1). The present horizontal and vertical juxtaposition of rocks of widely varying ages and types is largely the result of southeast-dipping thrust faults which developed during the phase of major compressional tectonics that formed the Appalachian Mountains in the late Paleozoic Era (Alleghanian orogeny). Northwest translation (displacement) of the strata due to thrust faulting is on the order of tens of miles; palinspastic restoration of the Jacksonville thrust sheet, for example, in the vicinity of Piedmont indicates that the rocks were moved about 60 miles from southeast to northwest (Thomas and Bayona, 2005).

Although groundwater is stored in and flows through all of the geologic formations in the Piedmont assessment area, some rock units or portions thereof have greater potential as aquifers than others, especially with regard to the flow rates and water quality necessary for public water supplies. For example, numerous relatively shallow wells have been completed for domestic use in the Parkwood Formation or Floyd Shale, but the small flow rates from these wells indicate relatively poor aquifer transmissive properties of these geologic formations, making them unlikely targets for development of large capacity wells. In addition, the quality (geochemistry) of groundwater in some units such as the Parkwood Formation and Floyd Shale (mapped as undifferentiated in this report) is commonly poor, whereas other geologic formations generally contain groundwater with acceptable levels of dissolved ions. The Paleozoic stratigraphic section present in the Piedmont area is shown in figure 3 along with a brief description of each mapped unit; several units with significant potential are discussed below. No attempt was made to describe groundwater flow across the area through methods such as numerical flow modeling due to the lack of data and the rudimentary understanding of the hydrogeology. The focus of this investigation is to locate prospective areas for further evaluation for test well drilling.

STRATIGRAPHIC COLUMN - NORTHEASTERN CALHOUN COUNTY, ALABAMA			
SYSTEM	GROUP	FORMATION	LITHOLOGY
Pennsylvanian		Parkwood Formation	Gray/red/green shale, limestone, and sandstone
Mississippian		Floyd Shale	Dark-gray shale with minor chert, sandstone, limestone
		Tuscumbia Limestone	Gray limestone, chert
		Fort Payne Chert	Gray/olive chert, limestone, and shale interbeds
		Maury Formation	Green-gray shale
Devonian		Frog Mountain Sandstone	Gray sandstone, shale
Ordovician		Athens Shale	Dark-gray shale, limestone interbeds
	Knox Group undifferentiated in part	Newala Limestone	Light- to dark-gray limestone
Cambrian			Light- to medium-gray dolomite, chert, and limestone
		Conasauga Formation	Medium- to dark-gray dolomite, shale in lower part
		Rome Formation	Red, gray, yellow shale with sandstone and limestone
		Shady Dolomite	Blue-gray siliceous dolomite, shale beds in lower part
	Chilhowee Group undifferentiated	Weisner and Wilson Ridge Formations undifferentiated	Light-gray conglomerate, sandstone, and shale
		Nichols Formation	Dark-greenish-gray shale, minor siltstone and sandstone
		Cochran Formation	Tan-gray conglomerate, sandstone, and shale

Figure 3.—General stratigraphic column of the Piedmont, Alabama, area.

PRINCIPAL AQUIFERS AND PROSPECTS

TUSCUMBIA LIMESTONE AND FORT PAYNE CHERT

The cherty limestone and chert of the undifferentiated Mississippian Tuscumbia Limestone and Fort Payne Chert constitute a prospective aquifer (herein abbreviated "Tuscumbia/Fort Payne" and labeled Mtfp on plate 1) that has been found elsewhere in Alabama to be a prolific groundwater source of excellent water quality. The stratigraphic unit as mapped also includes the Maury Shale, a thin (1- to 5-foot thick) interval of greenish-gray shale that immediately underlies the Fort Payne Chert, which, though a significant stratigraphic unit, is generally impermeable and not considered part of the overlying aquifer interval. No effort was made in this investigation to distinguish the Fort Payne Chert from the overlying Tuscumbia Limestone, and the two are mapped together, following the precedent of the Geologic Map of Alabama (northeast sheet) (Osborne and others, 1988). Warman and Causey (1962) ascribed a thickness of about 350 feet to the Fort Payne in northern Calhoun County (they did not recognize the Tuscumbia Limestone), whereas Moser and DeJarnette (1992) indicate a maximum combined thickness of 175 feet for the Tuscumbia Limestone and Fort Payne Chert.

The Tuscumbia/Fort Payne/Maury outcrop belt can be mapped across the western part of the assessment area west and northwest of the Pell City fault (plate 1), where the outcrop generally forms a ridge broken locally by gaps. The Tuscumbia/Fort Payne/Maury geologic unit can be traced along strike northeastward from the area west of Possum Trot Road to the area west of Piedmont and northward into Cherokee County (plate 1). Along the outcrop belt and into the subsurface to the east-southeast, chert and limestone of the Tuscumbia/Fort Payne interval dip to the southeast beneath the younger shale and thin sandstone and siltstone beds of the undifferentiated Parkwood Formation and Floyd Shale (fig. 4). Cross section A-A' (plate 2) illustrates the geologic interpretation of the area immediately west of Porter Johnson Road and north of U.S. Highway 278. The Floyd Shale immediately overlies the Tuscumbia/Fort Payne and acts as a confining interval for the chert and cherty limestone aquifer. The Tuscumbia/Fort Payne also crops out in several smaller belts northeast of the Porter Johnson Road prospect area, each bounded to the west by a relatively small-scale thrust fault. Local changes in strike and dip along the Tuscumbia/Fort Payne outcrop area are significant in

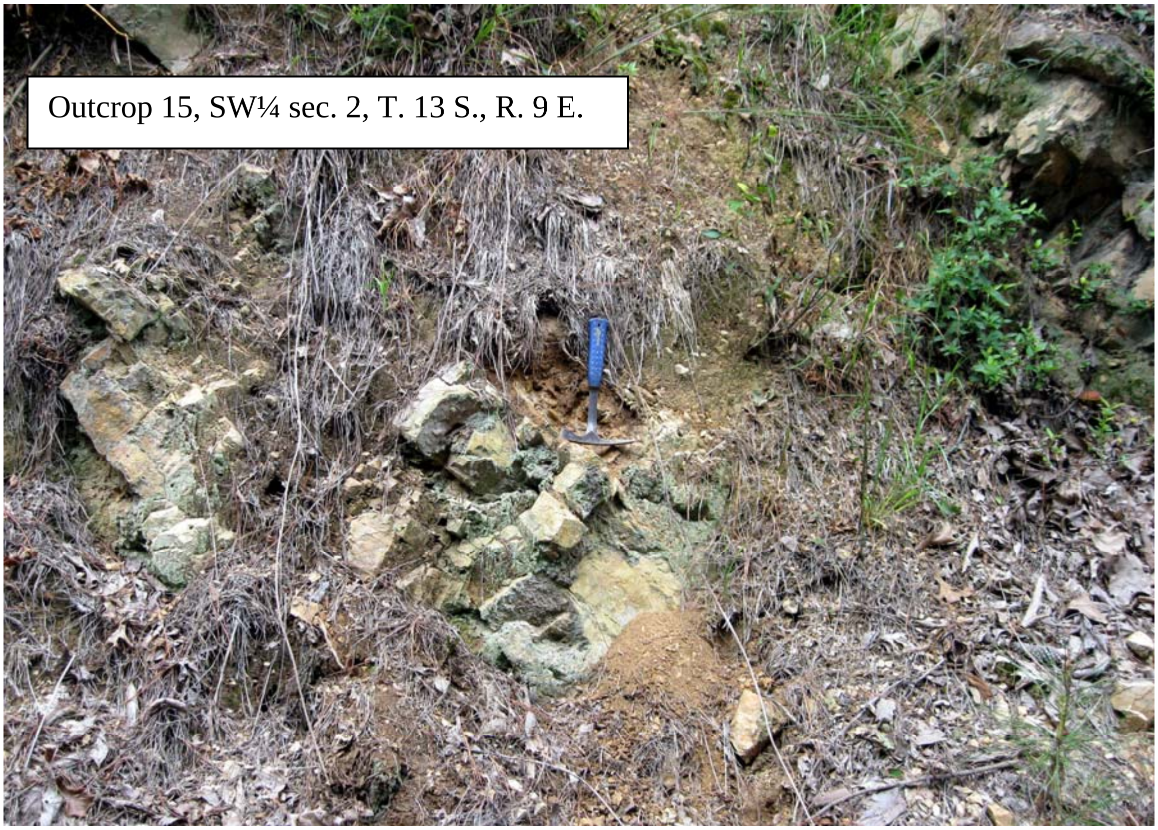


Figure 4.—Outcrops of the undifferentiated Tuscumbia Limestone and Fort Payne Chert near Piedmont, Calhoun County, Alabama. See plate 1 for map locations.

consideration of aquifer development and groundwater recharge due to the likelihood of enhancement of fracture development at or near the structural changes. Because bedding in the Fort Payne Chert commonly is undulatory, giving the rock a somewhat wavy or knobby appearance, the important task of determining local strike and dip of the formation is often somewhat difficult, especially when exposure surfaces are small.

Tuscumbia/Fort Payne beds or zones in outcrops exhibiting visible (macro) porosity are commonly composed of tan to light-gray fossil moldic chert with numerous fractures and dissolution features (fig. 5). Grain-rich fabrics (fossil fragmental) are common in the Tuscumbia Limestone, but chert is less prevalent than in the Fort Payne Chert. Grain-rich beds, dominated by echinoderm fragments or their molds, in the Fort Payne Chert are more prevalent in the middle to upper part of the unit, and thin shale interbeds are more common in the lower part of the formation. Dissolution channels, fractures perpendicular to bedding, and bedding plane conduits probably connect the porous intervals in the Tuscumbia/Fort Payne aquifer. The recently constructed well by the Calhoun County Water and Fire Protection Authority in sec. 17, T. 13 S., R. 9 E. (plate 1) along Possum Trot Road is a Tuscumbia/Fort Payne aquifer well; the test well was drilled in March 2009 to a total depth of 212 feet in the Fort Payne Chert. The producing intervals are porous and permeable tan to light-gray fractured chert and cherty limestone beds. Aquifer intervals are interbedded with medium- to dark-gray, dense, non porous chert and cherty limestone with few macro-scale fossil fragments, fractures, and dissolution cavities. It is anticipated that a test well drilled at or near the location shown on cross section A-A' (plate 2) would penetrate aquifer intervals within the Tuscumbia/Fort Payne similar in petrophysical characteristics to those encountered in the Calhoun County Water and Fire Protection Authority well.

KNOX GROUP

The undifferentiated Knox Group is considered to be a secondary objective in the Piedmont area. Elsewhere the Knox Group has been subdivided into the Copper Ridge Dolomite, Chepultepec Dolomite, Longview Limestone, and Newala Limestone. In northern Calhoun County, poor exposures of the Knox Group generally preclude differentiation, except west of the Pell City fault where the Newala Limestone has been recognized (Osborne and others, 1988). The unfaulted overall thickness of the Knox

Figure 5.—Outcrop hand sample of fractured, porous, fossil moldic chert of the Tuscumbia/Fort Payne interval (outcrop 34, sec. 36, T. 12 S., R. 9 E.), Calhoun County, Alabama. See plate 1 for map location.

Group is unknown in the Piedmont assessment area, but elsewhere in the Valley and Ridge Province of Alabama it can exceed 2,000 feet. The large area of Knox Group outcrop west of the Pell City fault may contain a non truncated section. Two outcrop belts of the Knox Group reached by Piedmont Utilities Board water lines are east-northeast of

Ladiga Spring (sec. 34, T. 12 S., R. 10 E.) and a smaller area west and southwest of Piedmont extending from the U.S. Highway 278 area about 3 miles to the southwest. Although good outcrops of the Knox Group are sparse, small, highly weathered exposures of fractured light-tan, white, and gray chert and cherty carbonate rocks are present in the general area of Old Piedmont Gadsden Road (fig. 6) and in the Piedmont recreation park area (sec. 6, T. 13 S., R. 10 E.). In this area the Knox Group dips steeply to the southeast, and the outcrop belt is bounded on the northwest and southeast by southeast-dipping thrust faults (plate 1). Cross section B-B' (plate 2) illustrates the geology of the area and shows that a test well positioned on the Conasauga Formation outcrop might encounter water-bearing strata in the Knox Group. Test well I-35 shown on cross section B-B' was drilled by the

Figure 6.—Outcrop of chert of the Knox Group (outcrop 9, sec. 6, T. 13 S., R. 10 E.), Calhoun County, Alabama. See plate 1 for map location.

city of Piedmont in 1958 to a depth of 144.5 feet below land surface in the Rome Formation with cavities reported by the driller from 120 to 136.6 feet and 140 to 142.4 feet. Pump testing, however, resulted in 52.41 feet of drawdown from a static water level of 15.79 feet below land surface after pumping at a rate of 30 gallons per minute for 13.6 hours, and the well was then abandoned. The results from this well and other wells that have penetrated the Rome Formation in the Piedmont assessment area indicate that the unit is not a major aquifer due to its lithologic composition of variegated shale and relatively thin or sparse sandstone and limestone interbeds.

CONASAUGA FORMATION, SHADY DOLOMITE, AND CHILHOWEE GROUP

Other stratigraphic units of interest that contain potential aquifer intervals are the Conasauga Formation, Shady Dolomite, and the Chilhowee Group. The Conasauga Formation occurs in a large area of generally low topographic relief with few outcrops east and northeast of downtown Piedmont and in a belt extending southwestward from the west side of the city. The Conasauga Formation is approximately 500 feet thick in the Piedmont area (Osborne and Szabo, 1984). Splays of the Jacksonville fault trend northeast from the main part of the city of Piedmont. These thrust faults are marked by ridges formed by resistant beds of sandstone of the Rome Formation dipping to the southeast on the hanging walls and the Conasauga Formation found in the intervening valleys (plate 1).

The lower part of the Conasauga Formation is predominantly shale, whereas the upper part of the formation contains significant dolomite and limestone intervals which locally are subject to dissolution along fractures and bedding planes and which also develop cherty beds resulting from weathering and near-surface processes. The principal water source for Piedmont is Ladiga Spring which is actually a series of springs that emanate from dolomite beds of the Conasauga Formation along and adjacent to the northeast side of a hill in the SE¼ sec. 34, T. 12 S., R. 10 E., Calhoun County. There are numerous smaller springs in the Piedmont area flowing from the Conasauga Formation. Numerous wells have been drilled in the outcrop area of the Conasauga Formation east and northeast of Piedmont. However, these wells were constructed for domestic use and are relatively shallow with small flow rates. Some of these wells produce groundwater from alluvial deposits and regolith overlying the bedrock, while others that penetrated more than just a few feet of the Conasauga Formation provide little indication of containing significant aquifer intervals, according to well records on file with the Geological Survey of Alabama.

The dolomite of the Conasauga Formation along Ladiga Creek dips approximately 10 degrees to the east and is marked by numerous fractures and solution conduits perpendicular to bedding (fig. 7), providing groundwater flow pathways. Linear to sub linear geomorphic, regolith, drainage, and topographic features in the area of outcrop of the Conasauga Formation east and northeast of Piedmont (fig. 8) are interpreted as representing discontinuities in bedrock such as fractures and joints resulting from tectonic stresses and weathering processes. Although these features may indicate pathways for groundwater flow, they are problematic as prospective drill sites, unless additional information characterizing depths, storage capacities, and hydraulic interconnectedness becomes available.

The Shady Dolomite is a poorly exposed interval of predominantly bluish-gray to pale-yellowish-gray cherty dolomite and limestone with subordinate amounts of shale and shaly limestone. The Shady Dolomite is thought to be about 500 to 1,000 feet thick in Calhoun County. The primary sources of information about the lithologic characteristics and thickness of the Shady are descriptions of drill cuttings and cores from water wells and test holes in the southern part of Calhoun County and a few outcrops south of Piedmont in the Choccolocco Valley (Warman and Causey, 1962; Osborne and Szabo, 1984). Weathered pieces of white to light-gray laminated chert comprise most of the outcrop of the Shady Dolomite in the Piedmont area and are probably silicified remnants of carbonate rocks similar to the sandy laminated dolomite described by Osborne and Szabo (1984) from cores from southern and eastern Calhoun County. Osborne and Szabo (1984) also describe some intervals of the Shady Dolomite as coarsely crystalline, porous chert with "boxwork" texture. The prospects of targeting the Shady Dolomite in the Piedmont area rely primarily on observations of the formation elsewhere in the county, the generally favorable results from wells and springs in the Shady Dolomite aquifer intervals in Calhoun County (Moser and DeJarnette, 1992), and on the structural geology at the northeastern end of Choccolocco Mountain where the Shady Dolomite dips beneath the Rome Formation and Conasauga Formation (plate 1). The spring that was formerly

Figure 7.—Conasauga Formation dolomite outcrop along Ladiga Creek (SE¼ sec. 34, T. 12 S., R. 10 E.), Calhoun County, Alabama. Solution conduits along joint sets A and B strike about North 85° East and North 30° West, respectively. See plate 1 for map location.

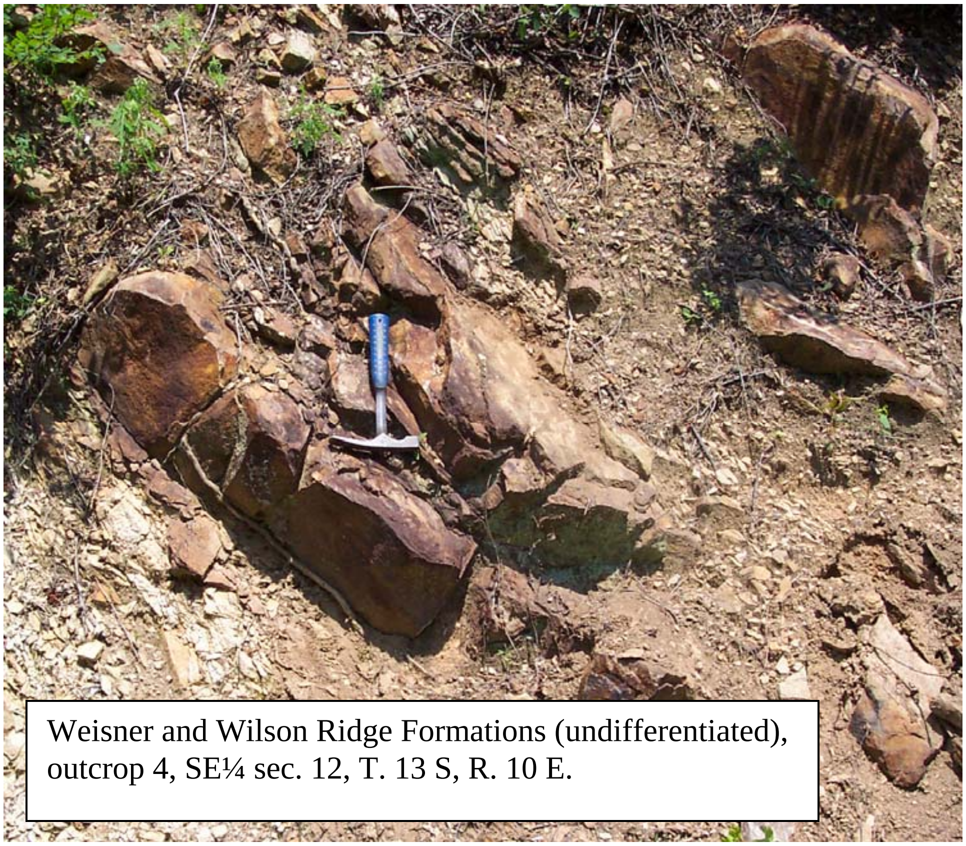
Piedmont's water supply and now forms the focal point of a city park in Piedmont (I-14, SE¼ sec. 6, T. 13 S., R. 10 E.) has been variously described as sourced in the Conasauga Formation (Moser and DeJarnette, 1992) or from dolomite of Cambrian or Ordovician age (Warman and others, 1960; Chandler and Moore, 1987), probably equivalent to the Copper Ridge Dolomite of the Knox Group. However, chert float of Shady Dolomite is present on the hillside just above the spring, indicating possible recharge from the steeply dipping Shady Dolomite and rocks of the Chilhowee Group southeast of the spring. Published water quality data for this spring (Avrett, 1968) also suggest a dolomite source.

Figure 8.—Satellite imagery of Piedmont and area east and northeast with interpreted linear to sub linear features. The set colored green trends about North 25-30° West; yellow set about North 85-86° East; and red set about North 35-40° East.

The Weisner and Wilson Ridge Formations undifferentiated is an interval of about 1,100 feet of interbedded sandstone, conglomerate, and silty shale (fig. 9) that underlies the Shady Dolomite. The Weisner and Wilson Ridge Formations, along with the Nichols and Cochran Formations, comprise the Chilhowee Group. On Choccolocco Mountain the formations have not been mapped separately, but east of the Indian Mountain thrust fault, the Weisner and Wilson Ridge Formations are mapped as a unit, whereas the Cochran and Nichols Formations are mapped separately (plate 1). While the Nichols and Cochran Formations have not been considered aquifers, springs and wells in the Weisner and Wilson Ridge Formations are known to be sources of groundwater to wells and springs in Calhoun County (Moser and DeJarnette, 1992). The Weisner Formation, in particular, is considered a prospective unit due to its general coarse-grained nature, considerable thickness, and fractures. Moreover, because the unit is generally a ridge-forming unit, water that flows from high to low elevations through the Weisner Formation acquires considerable head. Whether such groundwater remains confined in the Weisner Formation, making the unit or portions thereof an aquifer, or the water is forced into other formations due to the large pressure head that can develop, evaluation of the hydrogeology of the Piedmont assessment area should consider the Weisner Formation as an important component of the overall groundwater flow system. The Weisner Formation dips steeply at the northern end of the Choccolocco Mountain area to the northeast and east (fig. 9, lower photograph) and is likely present in the southern area of the city of Piedmont beneath the Shady Dolomite (plate 1).

FAULTS

In addition to the geologic units outlined previously that can serve as aquifers, faults can be conduits for groundwater flow. One of the largest springs in the state, Coldwater Spring near Anniston with an average flow exceeding 21,000 gallons per minute (Chandler and Moore, 1987), flows from a fault breccia (fracture) zone of the Jacksonville fault (Warman and Causey, 1963). Recharge for this spring is likely the Weisner Formation, which outcrops broadly on Coldwater Mountain to the northeast (Johnston, 1933). As mentioned previously, traces of three major faults, Pell City, Jacksonville, and Indian Mountain, are mapped through the Piedmont assessment area (plate 1) as well as numerous splays and faults of smaller magnitude (displacement and



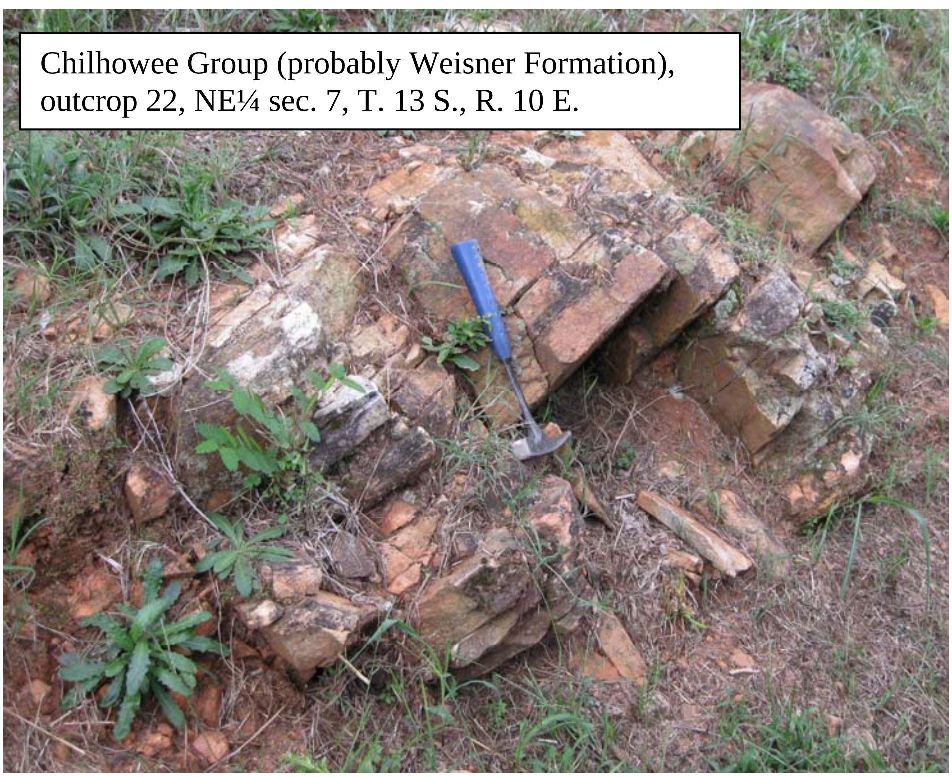


Figure 9.—Outcrops of Chilhowee Group rocks in the Piedmont assessment area. See plate 1 for map locations.

extent). Because actual observations of fault surfaces or zones are rare in the Piedmont assessment area due to soil and vegetative cover and because many faults occur in the incompetent rock such as shale, evidence of fault breccia in brittle rocks or other conduits for groundwater flow is generally lacking. Fractures and porosity associated with faults and accompanying folds are shown in figures 10 and 11. A fault zone separating the Conasauga Formation and rocks of the Knox Group would likely be penetrated in a test well drilled in the Piedmont sports complex area (cross section B-B', plate 2) previously discussed.

CONCLUSIONS

Evaluation of the complex geology of the Piedmont assessment area indicates several prospective areas and geologic units that warrant further evaluation for test well drilling. Principal among these is the area including and just east of the ridge underlain by the undifferentiated Mississippian Tuscumbia Limestone and Fort Payne Chert in the western part of the service area. Projection of the east- and southeast-dipping, porous and permeable beds of the Tuscumbia/Fort Payne interval beneath the relatively impermeable strata of the Parkwood Formation and Floyd Shale, coupled with recharge of the potential aquifer from the Tuscumbia/Fort Payne ridge, indicate a significant potential for aquifer development in the area. This concept has proven successful along the same trend of Tuscumbia/Fort Payne for the Calhoun County Water and Fire Protection Authority to the southwest.

Another area with significant aquifer potential is along the eastern side of a splay of the Pell City thrust fault, west and southwest of the city, where chert and dolomite of the Knox Group dip steeply to the southeast beneath the Conasauga and Rome Formations. Conditions for aquifer development may occur within the Knox Group due to weathering, dissolution (karst) along bedding or joints or fracturing of the Knox Group as a result of tectonic stresses that tilted the beds and formed the thrust faults. In addition, the thrust fault that juxtaposes rock units in the area may contain highly fractured rock (breccia) and constitute a groundwater flow conduit.

Jointed, and in some instances, silicified intervals of dolomite in the Conasauga Formation are proven aquifers in Calhoun County, including Ladiga Spring. Although no

Figure 10.—Fold and thrust fault in the Weisner and Wilson Ridge Formations undifferentiated with fractures in sandstone beds (outcrop 4, SE¼ sec. 12, T. 13 S., R. 10 E.), Calhoun County, Alabama. See plate 1 for map location.

Figure 11.—Tight fold in Fort Payne Chert in hanging wall of thrust fault (fault is to the lower right out of picture), Calhoun County, Alabama. Voids and fractures are common in some beds (outcrop 20A, SW¼ sec. 30, T. 12 S., R. 10 E.). See plate 1 for map location.

precise locations for test well drilling in the Conasauga Formation were identified in the course of this investigation, analysis of fracture and joint patterns along with satellite imagery indicate that aquifer zones in the formation may exist in the service area at depths that would warrant testing.

Chert and dolomite of the Shady Dolomite and coarse sandstone intervals of the Weisner and Wilson Ridge Formations of the Chilhowee Group should be considered potential aquifers where they occur beneath the Rome and Conasauga Formations in the southern part of the Piedmont Utilities Board service area. Northeast-dipping beds of these formations, coupled with the significant recharge area at the northern end of Choccolocco Mountain, present interesting possibilities for aquifer development.

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