Characterization of Fractured Crystalline-Rock Aquifers at Selected Sites in the Vicinity of Lawrenceville, Georgia, 2001

by Lester J. Williams

INTRODUCTION

The U.S. Geological Survey (USGS) in cooperation with the city of Lawrenceville has been studying the availability of ground water in crystalline-rock aquifers in the vicinity of Lawrenceville, Georgia (map, upper right). The study area is located in the Piedmont physiographic province, which is underlain by igneous and metamorphic rocks. The aquifers in this region consist of saturated overburden (soil, alluvium, and saprolite) overlying fractured bedrock. Municipal wells drilled for water-supply place casing through the overburden and penetrate water-bearing fractures in the bedrock at depths typically no deeper than 600 feet below land surface. The fractures are formed from a combination of stresses that produce both high-angle joints and subhorizontal fractures and fracture zones. Well yields in the Lawrenceville study area range from less than 1 gallon per minute (gal/min) to more than 400 gal/min.

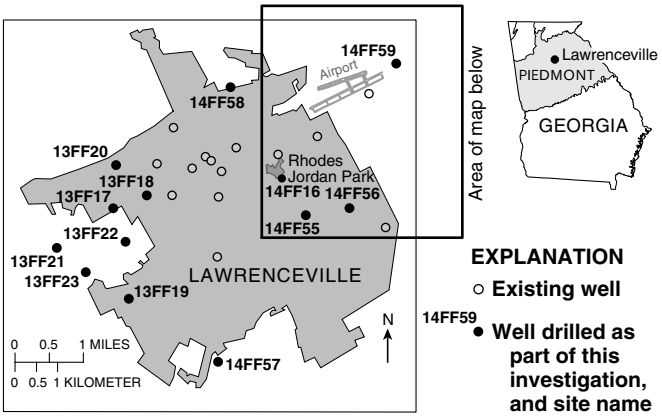
Objective

The primary objective for this study is to improve methods of evaluating the ground-water resource potential in igneous and metamorphic rocks. Because so little is known about crystalline-rock aquifers, this information is extremely valuable to municipalities like Lawrenceville that are trying to increase the amount of water that can be obtained from these aquifers. The technical highlights presented herein describe some of the results the USGS is obtaining from a subarea referred to as the Gwinnett County Airport vicinity (map, lower right).

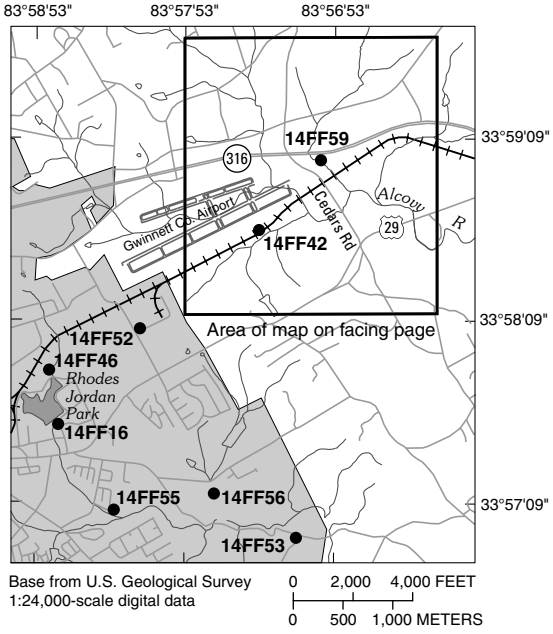
Results

As part of the study, the location of wells that have the potential for high yields, based on geologic and geophysical information, was chosen. One of these is well 14FF59, a flowing artesian well (photo, facing page) located east of the Gwinnett County Airport. The well penetrates a sequence of southward dipping (tilted) metamorphic rocks (map, facing page; geologic sections, following page). The well derives ground water from four major subhorizontal fractures at depths of 267, 282, 297, and 348 feet below land surface. The water-bearing fractures occur at a contact zone between major lithologic units and between layers in a layered metamorphic rock.

Well 14FF59 is located within the Alcovy River Basin and penetrates an amphibolite unit (nonwater bearing), button schist (nonwater bearing), and a biotite gneiss unit (water bearing). The fracture network in the vicinity of



The study area encompasses approximately 44 square miles including the city of Lawrenceville and surrounding areas. The city well field is located at Rhodes Jordan Park and is pumped at a rate of 250 gal/min for 7.5 hours per day. Twelve new test wells were drilled during 2001 (shown in black) including well 14FF59, the subject of this technical highlight, located about 2.5 miles northeast of the Rhodes Jordan Park.



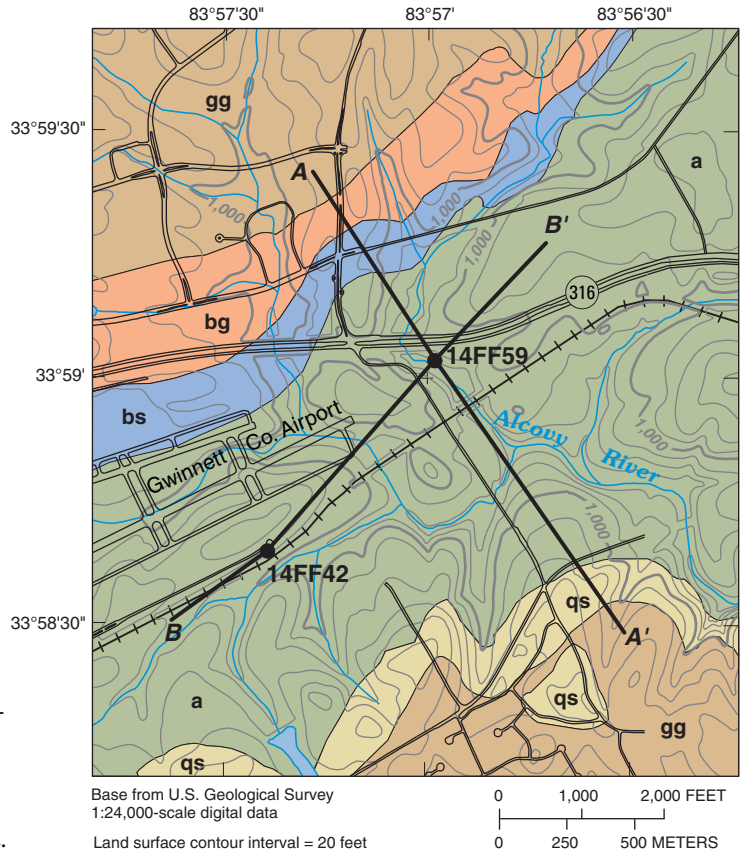
The study in the vicinity of the Gwinnett County Airport is an example of how the USGS uses geologic structural mapping and geophysical surveys to identify an area with a potential for high ground-water yields. The only previous well information in the area was from well 14FF42, which has a yield of less than 1 gal/min.

Flowing artesian wells, like 14FF59 shown above, are commonly found in areas that are topographically lower than the adjacent recharge area. This well flows about 40 gal/min out of two 1-inch openings through the blue pressure cap installed at the top of casing, and about 50–60 gal/min when left uncapped. The top of the stream of water is about 5.5 feet above land surface. (Photo by Randy Kath, State University of West Georgia.)

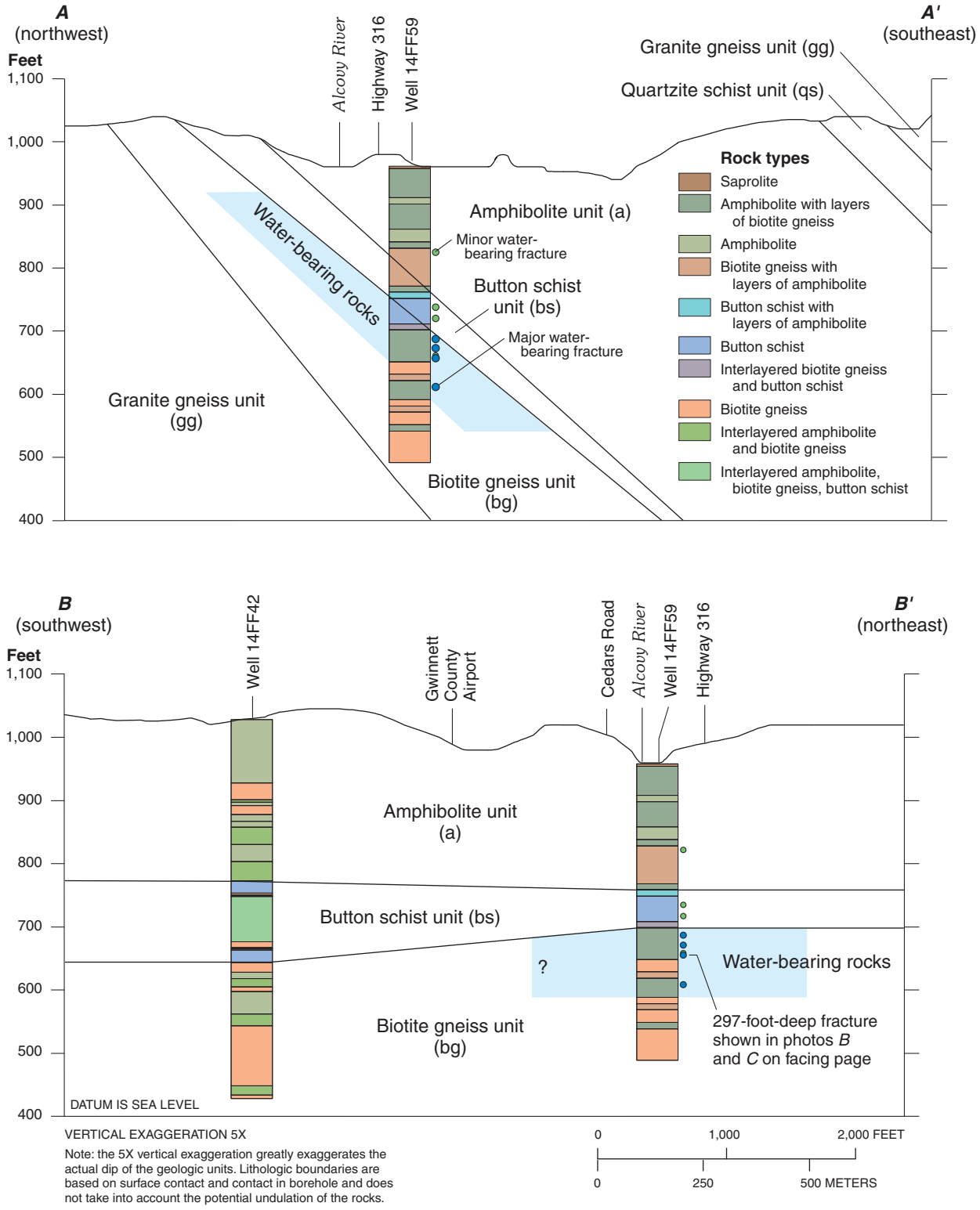
the well consists of well-developed, high-angle joint sets interconnected with subhorizontal, southeasterly dipping water-bearing fractures formed along compositional layering of the biotite gneiss. Well 14FF42, located 3,100 feet southwest of 14FF59 in an upland area, penetrates the same sequence of rocks, but the bedrock at this location lacks development of the subhorizontal water-bearing fracture zones and contains few high-angle joints.

The initial yield for well 14FF59, done by airlifting, was approximately 400–500 gal/min. A 72-hour pumping test indicated a yield of 300 gal/min with 82 feet of drawdown. Artesian flow from the well is about 50–60 gal/min.

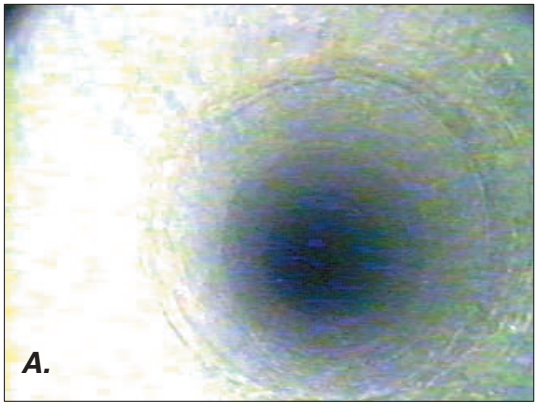
High-yielding, water-bearing fracture zones have been penetrated in a number of other wells in the vicinity of Lawrenceville. The majority of these fractures are at contact zones between major lithologic units or along layering in metamorphic rock. Typically, yields of less than 10 gal/min occur in wells that penetrate only high-angle joints. A few wells in the Lawrenceville area intercept zones of concentrated jointing and joints that are enlarged through dissolution. These wells generally have yields greater than 10 gal/min but do not yield significant quantities of water compared to wells with open, subhorizontal fractures.

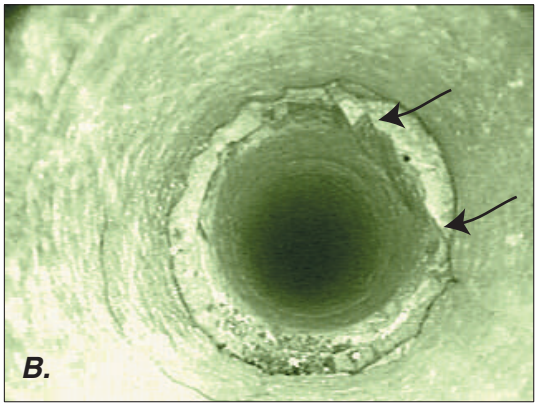


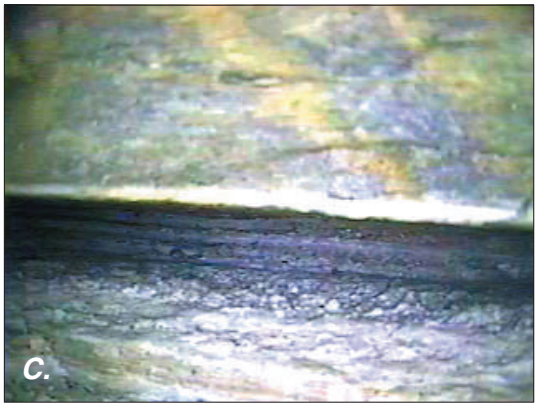
*The USGS completed geologic maps near the well site to identify major and minor lithologic units and to identify potential structural and textural characteristics that may enhance ground-water availability. Mapping was conducted by geologists walking traverses along roads, creeks, and rivers throughout the area. Locations of geologic sections **A–A'** and **B–B'** also are shown.*



*Geologic section **A–A′** shows the southward dipping sequence of rocks penetrated by well 14FF59 and the location of water-bearing fracture zones. Section **B–B′** shows the lithologic correlation between wells 14FF42 and 14FF59. The water-bearing fracture zones in the lower biotite gneiss unit were not present in 14FF42.*







Borehole video images from well 14FF59

***(A)** looking downhole at an unfractured portion of borehole (155 feet deep);*

***(B)** looking downward at the 297-foot-deep subhorizontal fracture, high angle joints (arrows) can also be seen; and*

***(C)** sideview looking back into the 297-foot-deep subhorizontal fracture. Aperture is approximately 3 to 4 inches wide.*

Summary and Conclusions

Well 14FF59 penetrates a sequence of layered metamorphic rocks that are well jointed and contain several large subhorizontal water-bearing fracture zones that deliver high yields of ground water into the well (cross sections, facing page; photos, to the left). Well 14FF42, located on a ridge top, penetrates the same sequence of rocks but is characterized by few joints, no development of open subhorizontal fractures, and low yield.

A 2.8-square-mile area was mapped to delineate the distribution of rock types and develop a preliminary structural interpretation for the area. The consistent strike and dip of the rocks allowed extrapolating lithologic units into the subsurface and anticipating depths of potential contact zones.

The relatively flat compositional layering (less than 20 degree dip), presence of high-angle joint sets, and development of subhorizontal water-bearing fractures along layering are believed to be key reasons for the high yield from well 14FF59.

The subhorizontal water-bearing fractures probably receive recharge from a relatively wide area. High-angle joint sets, which are pervasive throughout rocks in the study area, are probable conduits through which ground water can recharge the bedrock aquifer system.

The USGS continues to study the occurrence and interconnectivity of high-yielding water-bearing fracture zones in the vicinity of Lawrenceville. Techniques used in this study may be applied to other fractured crystalline-rock aquifers settings in the Piedmont.