COMMON TYPES OF WATER-BEARING FEATURES IN BEDROCK, ROCKDALE COUNTY, GEORGIA

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Abstract. Until recently, little was known about the specific types of water-bearing features or "zones" tapped by deep production wells in the crystalline igneous and metamorphic bedrock of the Piedmont physiographic province of Georgia (Fig. 1). Detailed study of the depth, nature, and yield of water-bearing features in Rockdale County, Georgia, indicates that foliation-parallel parting planes, sheet fractures, joints, and weathered veins are among the most common. An optical televiewer and other borehole-geophysical logging tools were used to delineate water-bearing features in 20 "open-hole" bedrock wells located in various parts of the study area (Fig. 1). Flowmeter measurements were used to determine the depth and yield of water-bearing zones in each well. Geologic mapping was used to correlate water-bearing features with various lithologic units in the area.

INTRODUCTION

As part of a larger investigation of groundwater resources, the U.S. Geological Survey—in cooperation with Rockdale County—assessed the depth, nature, and yield of water-bearing features in the bedrock (*parallel parting*, *sheet fractures*, *joints*, *weathered veins*, and *faults*) and their influence on the water availability in the county. Understanding the geologic setting and distribution of these features in the bedrock and their water-bearing potential is important for effectively tapping these zones and for development of large groundwater supplies in the crystalline bedrock areas of the Piedmont.

PARALLEL PARTING

Many high-yield wells (defined herein as 70 gallons per minute or greater) penetrate and derive water almost exclusively from openings formed parallel to foliation or compositional layering, herein referred to as "foliation-parallel partings" (Fig. 2). These water-bearing features are present at the contacts of major lithologic units and at the contacts between contrasting lithologies in compositionally layered rock (Williams and others, 2005). Combinations of small partings (typically less than ½ inch) and larger openings (typically 1–8 inches) locally form significant water-bearing zones in the bedrock. Foliation-parallel parting in the bedrock is controlled by lithology and structure; hence, the highest yields can be expected for wells that penetrate these systems in structural positions that enhance recharge.

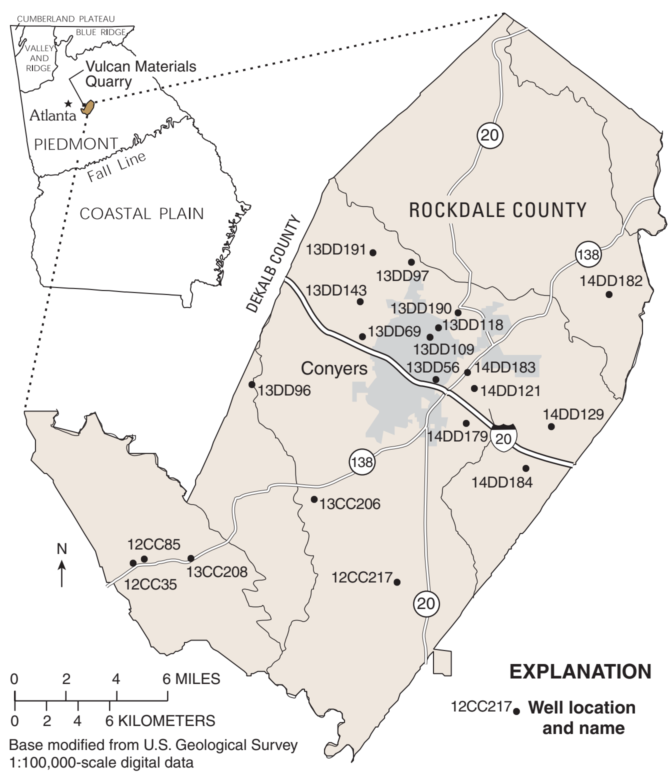
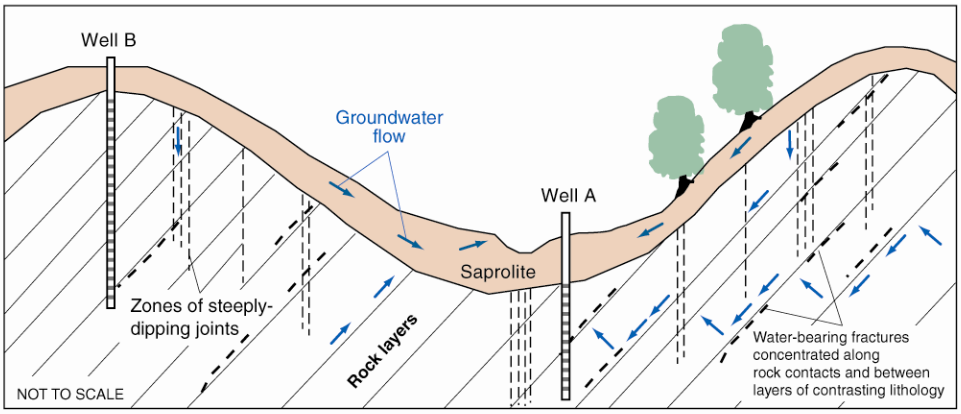
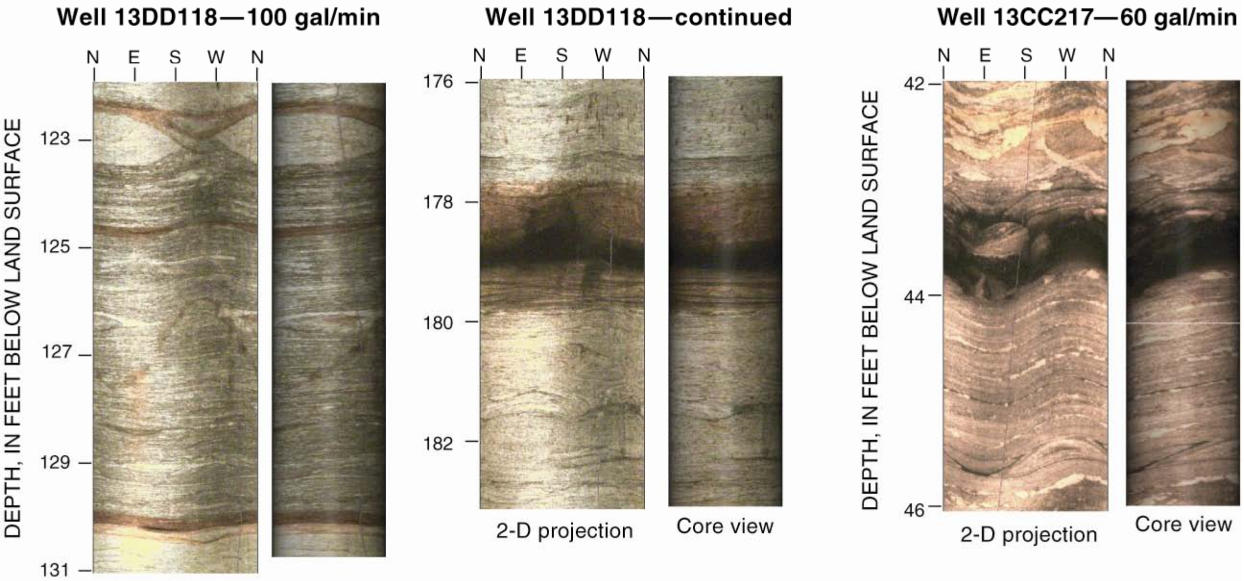


Figure 1. Location of wells used in this study, Rockdale County, Georgia.

A. A **conceptual model** shows the influence of foliation-parallel parting on groundwater flow (arrows) in compositionally layered rocks. **Well A** is located in a structurally favorable position for intercepting recharge, whereas **Well B** is located in a structurally less favorable position (Modified from McCollum, 1966).





B. Foliation-parallel parting, as shown in the **optical-televiewer images** above, are openings that form at lithologic contacts or along foliation planes. In borehole images, these ranged from small hairline partings (above left images) to much larger (1- to 8-inch) openings. The larger openings in some wells form important water-bearing zones; based on a flowmeter log from well 13CC217 (above right) most of the yield is derived from the opening at 44 feet below land surface. Optical-televiewer images are oriented to magnetic north and shown in both two-dimensional (2-D) projections and three-dimensional "virtual core" views. Cardinal directions are indicated at top of the 2-D projection (gal/min, gallons per minute; yield listed is for entire well and is estimated).

C. Photograph of **compositionally layered rock** showing strong differential weathering between quartz-rich and feldspathic layers. Scale is 3 feet. Photograph by L.J. Williams, U.S. Geological Survey.

Figure 2. (***A***) **Conceptual model of groundwater flow,** (***B***) **optical-televiewer images, and** (***C***) **outcrop photograph of common water-bearing features in compositionally layered rock, Rockdale County, Georgia.**

SHEET FRACTURES

In massive rock (not layered), many wells penetrate and derive water from sheet fractures (also known as *stress-relief fractures*). Sheet fractures (Fig. 3) are subhorizontal openings commonly formed in massive granite and weakly foliated granite gneiss, typically ten to several tens of feet below the saprolite/rock interface. Although not as productive as foliation-parallel partings, some sheet fractures have the capacity for storing moderate to large quantities of water, and wells tapping these features are locally productive. Because sheet fractures are developed through processes of unloading and weathering, the highest yields can be expected for wells that intercept these features in topographic positions that enhance recharge, such as valley bottoms.

JOINTS

Steeply-dipping joints (Fig. 4) are among the most common type of water-bearing features observed in the wells studied. These joints are important in that they enable vertical movement of water into and out of the bedrock and serve to hydraulically connect deeper production zones with sources of recharge, such as the overlying regolith. Although joints are abundant, in most areas these fractures generally are low yielding even in wells in which zones of concentrated jointing are penetrated.

WEATHERED VEINS AND PEGMATITE

Where the bedrock is weathered substantially, veins and pegmatite bodies (Fig. 5) may locally form productive water-bearing features. In several wells, large quantities of water are produced from dissolution openings formed along veins and at the contacts between country rock and pegmatite.

FAULTS

In some areas, the bedrock is intensely fractured or "shattered" by brittle fault zones (Fig. 6), which are identified by the presence of zones of fracture concentration, irregular fractures, and fault gouge. Because of their relatively narrow width (tens of feet wide), nearly vertical orientation, and en echelon geometry, brittle fault zones are much less likely to be penetrated by wells and currently none have been identified as important water-bearing zones in the area.

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Prowell, D.C. 1989. Cretaceous and Cenozoic tectonism in the Appalachians and crystalline basement beneath the Atlantic Coastal Plain. In Warren Manspeizer, Jelle DeBoer, J.K. Costain, A.J Froelich, Cahit Coruh, P.E. Olsen, G.J. McHone, W.A. Thomas, and G.W. Viele (eds.), The Appalachian–Ouachita Orogen in the United States. Geological Society of America, *The Geology of North America*, v. F-2, pp. 319–374.

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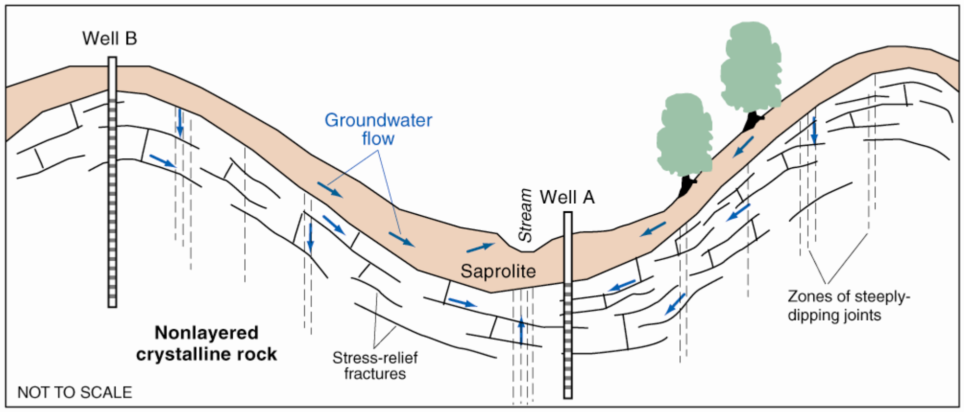
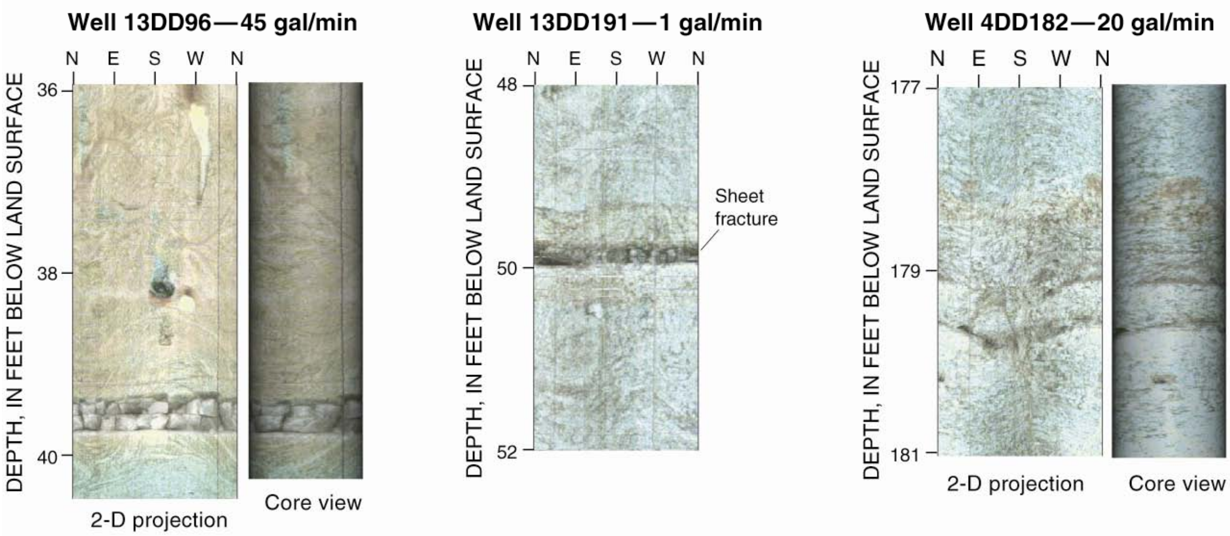
A. A **conceptual model** shows the influence of sheet fractures on groundwater flow in massive to weakly foliated rocks in Rockdale County. **Well A** is located in a topographically favorable position for intercepting recharge whereas **Well B** is located in a topographically less favorable position (Modified from McCollum, 1966).

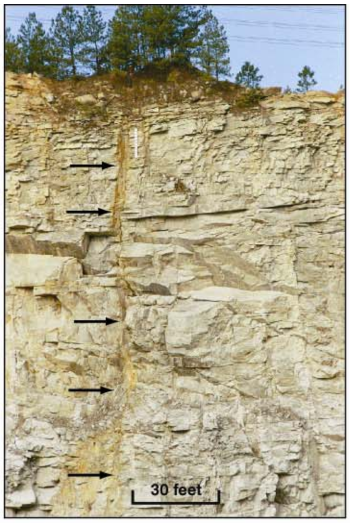




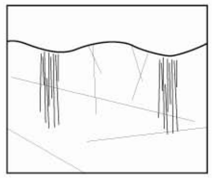
B. Sheet fractures, as shown in the **optical-televiewer images** above, are openings formed nearly parallel to land surface. In boreholes these types of water-bearing features typically form as a single fracture (above center) or a zone of fractures (above left). Image from well 14DD182 (above right) shows a partially developed sheet fracture. Optical-televiewer images are oriented to magnetic north. Cardinal directions are indicated at top of the two-dimensional (2-D) projection (gal/min, gallons per minute; yield listed is for entire well and is estimated).

C. Photograph of a **subhorizontal, water-bearing sheet fracture** in a dimension-stone quarry located in northern Rockdale County. Scale in the inset is 3 feet. Photograph by L.J. Williams, U.S. Geological Survey.

Figure 3. **(*A*) Conceptual model of groundwater flow, (*B*) optical-televiewer images, and (*C*) photograph of common water-bearing features in massive to weakly foliated rock, Rockdale County, Georgia.**



Weathering along steeply-dipping joints (arrows) extends 150 feet below land surface (left). Notice the thicker saprolite directly above the weathered joints. Photograph taken at the Vulcan Materials Quarry, Lithonia, Georgia, by David C. Prowell, U.S. Geological Survey. **Zones of joint concentration** are common throughout the study area (right).



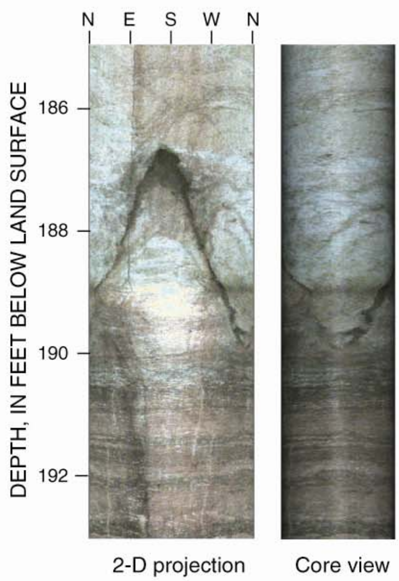
Conceptual model

A. **In areas underlain by massive bedrock**, zones of joint concentration enable water movement into the bedrock.

B. **Joints** in the borehole images to right are shown cross-cutting, gently-dipping foliation and compositional layering. The open joint shown for well 13DD69 (left image) occurs at the contact between a granite gneiss (above) and a biotite gneiss (below). Most of the yield in this well is actually from foliation-parallel partings deeper in the borehole and not the joint shown. Optical-televiewer images are oriented to magnetic north. Cardinal directions are indicated at top of the two-dimensional (2-D) projection (gal/min, gallons per minute; <, less than; yield listed is for entire well and is estimated).

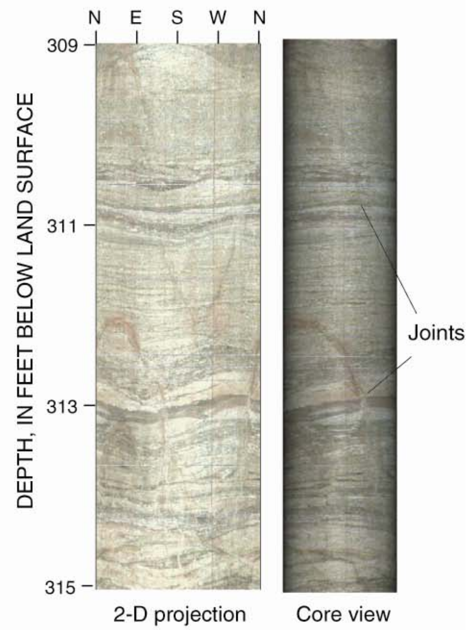
Well 13DD69—172 gal/min

(Open joint < 1 gal/min)



Well 13DD109—42 gal/min

(Hairline joints are not water bearing)



C. The stream channel just below dam is aligned **parallel to a large zone of joint concentration**. Joint systems influence drainage patterns throughout the study area, particularly in areas underlain by more massive bedrock. Photograph of Yellow River at Milstead, Rockdale County, by L.J. Williams, U.S. Geological Survey.

Figure 4. (*A*) Photographs and conceptual model for joints and zones of joint concentration, (*B*) optical-televiewer images, and (*C*) stream outcrop, Rockdale County, Georgia.

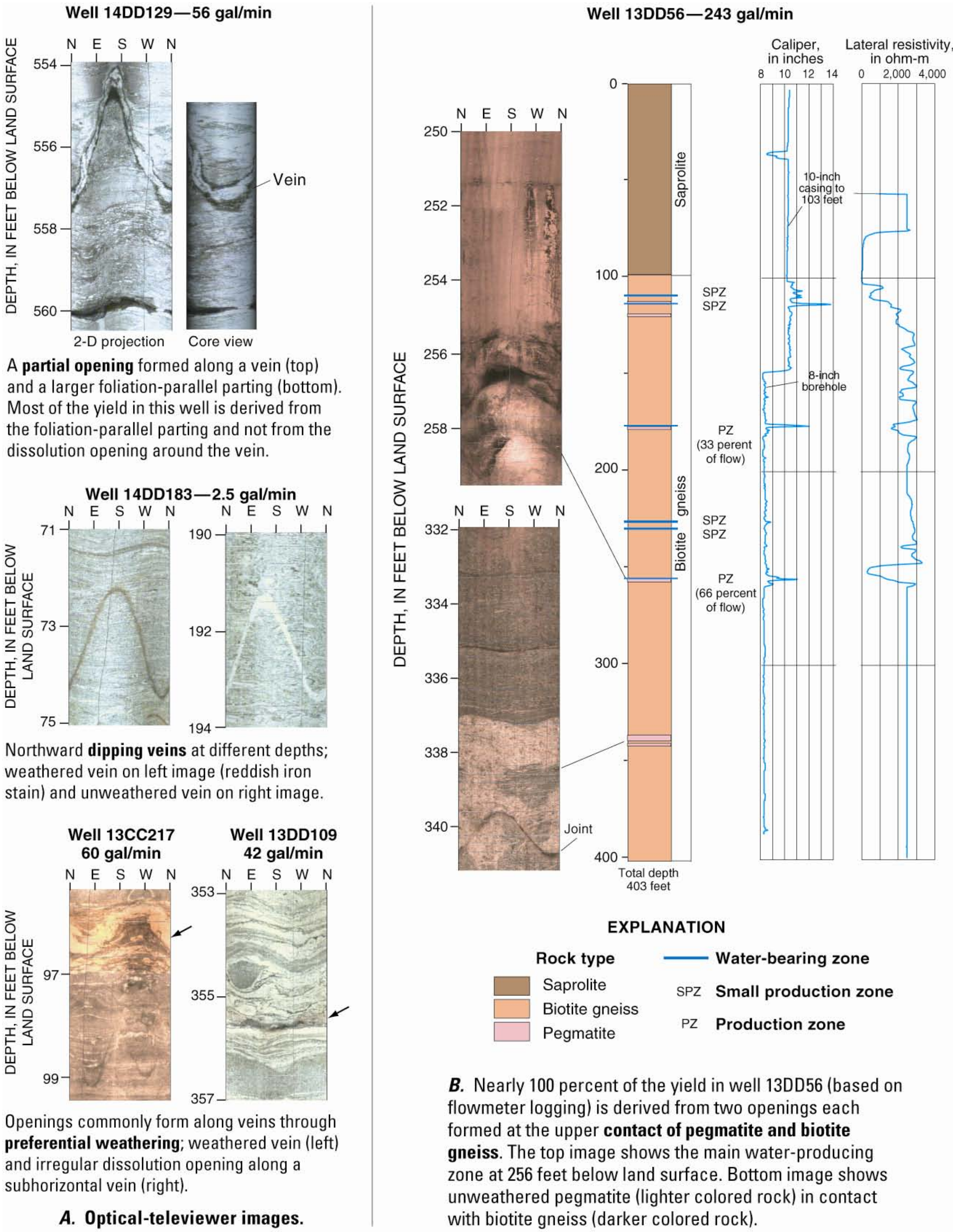
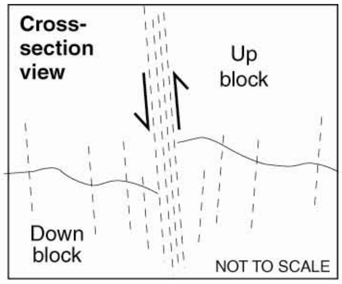
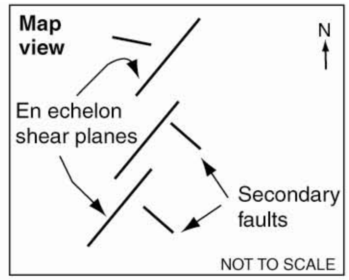


Figure 5. (*A*) Optical-televiewer images, and (*B*) geophysical log characteristics of water-bearing features associated with weathered veins and pegmatite bodies. Optical-televiewer images are oriented to magnetic north. Cardinal directions are indicated at top of the two-dimensional projection [gal/min, gallons per minute; yield listed is for entire well and is estimated].

A. **Brittle faults** are rarely observed in wells because of their narrow width, nearly vertical orientation (right), and en echelon geometry (far right). On a map scale, these features may form zones of parallel, closely spaced, en echelon faults 3 to 5 miles long (Prowell, 1989).





B. Three northeast-southwest striking northwest dipping **en echelon brittle faults** (dashed lines) are exposed in the Vulcan Materials Quarry, Lithonia, Georgia. View to southwest. The faults shown are approximately 160 feet apart and the quarry wall is approximately 150 feet high. Photograph on right shows a closeup of chlorite slickensides on a fault surface, oriented from lower left to upper right of photograph. Tip of pencil for scale. Quarry photograph by David C. Prowell, U.S. Geological Survey; closeup photograph by L.J. Williams, U.S. Geological Survey.

C. Brittle faults in the Rockdale County area are identified by the presence of **flinty crush rock**, which is a compact and lithified fault gouge that weathers into sharp angular pieces and forms a characteristic saprolite. The fault in the larger photograph to right (between dashed lines) strikes northeast-southwest and dips moderately to the northwest. View to the northeast. Closeup photograph shows the characteristically structureless material that occupies the center of these fault zones; ruler in center of photograph is 3 feet. Photographs taken at a borrow pit located east of Conyers in Newton County, Georgia. No wells are known to penetrate brittle faults in the study area, thus their water-bearing potential is unknown.

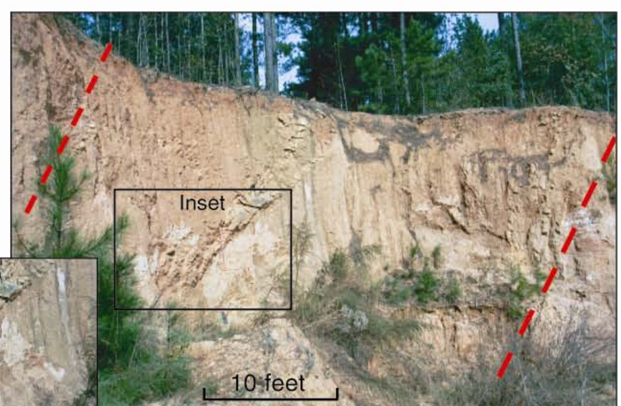


Figure 6. (*A*) Conceptual models of brittle fault geometry, and photographs of brittle faults (*B*) in the Vulcan Materials Quarry, Lithonia, Georgia, and (*C*) a borrow pit east of Conyers in Newton County, Georgia.