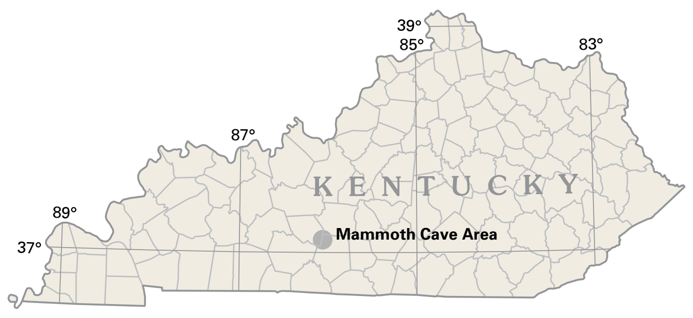
## CARBONATE-ROCK AQUIFERS—
Continued

Some of the common types of karst features that develop on the land surface where limestone is exposed in the Mammoth Cave area of central Kentucky are shown in **figure 28**. Recharge water enters the aquifer through sinkholes, swallow holes, and sinking streams, some of which terminate at large depressions called blind valleys. These depressions, along with karst valleys and sinkholes, form when all or part of a cavern roof collapses. Uncollapsed remnants of the cavern roof form natural bridges. Surface streams are scarce because most of the water is quickly routed underground through solution openings. In the subsurface, most of the water moves through caverns and other types of large solution openings.

Solution cavities riddle the Mississippian limestones that underlie the Mammoth Cave Plateau and the Pennyroyal Plain that borders the plateau to the south and southwest. Some of these cavities form the large, extensive passages of Mammoth Cave (**fig. 29**), one of the Nation's largest and best studied cave systems. As the cave's network developed, surface streams were diverted into the passages through sinkholes and flowed as underground streams through openings along bedding planes. Sand and other sediment carried by the underground streams abraded the limestone, thus further enlarging the solution openings through which the stream flowed. Vertical passages, usually developed at the intersections of joints, connect the horizontal bedding plane openings. Dissolution and erosional processes are still active at Mammoth Cave.

Aquifers in carbonate rocks of Cretaceous to Precambrian age yield water primarily from solution openings. Except for a basal sandstone aquifer, the Ozark Plateaus aquifer system consists of carbonate-rock aquifers whose hydrologic characteristics are like those of the limestones at Mammoth Cave. The Silurian–Devonian aquifers, the Ordovician aquifers, the Upper Carbonate aquifer of southern Minnesota, the Arbuckle–Simpson aquifer of Oklahoma, and the New York carbonate-rock aquifers are all in layered limestones and dolomites of Paleozoic age, in which solution openings are locally well developed. The Blaine aquifer in Texas and Oklahoma likewise yields water from solution openings, some of which are in carbonate rocks and some of which are in beds of gypsum and anhydrite interlayered with the carbonate rocks.

Aquifers in carbonate rocks of Tertiary and younger age have different permeability and porosity characteristics than aquifers in Cretaceous and older carbonate rocks. The aquifers in Tertiary and younger rocks are the Castle Hayne aquifer of North Carolina (in Eocene limestone), the Biscayne aquifer of South Florida (in Pliocene and Pleistocene limestones and interbedded sands), the North Coast limestone aquifer system in Puerto Rico (in limestone of Oligocene to Pliocene age), and the Floridan aquifer system of the southeastern United States (in limestone and dolomite of Paleocene to Miocene age). The strata that comprise these aquifers were deposited in warm marine waters on shallow shelves and are mostly platform carbonate deposits in which intergranular porosity is present as well as large solution openings. The Floridan aquifer system described below is the most productive and most studied example of this type of carbonate-rock aquifer.



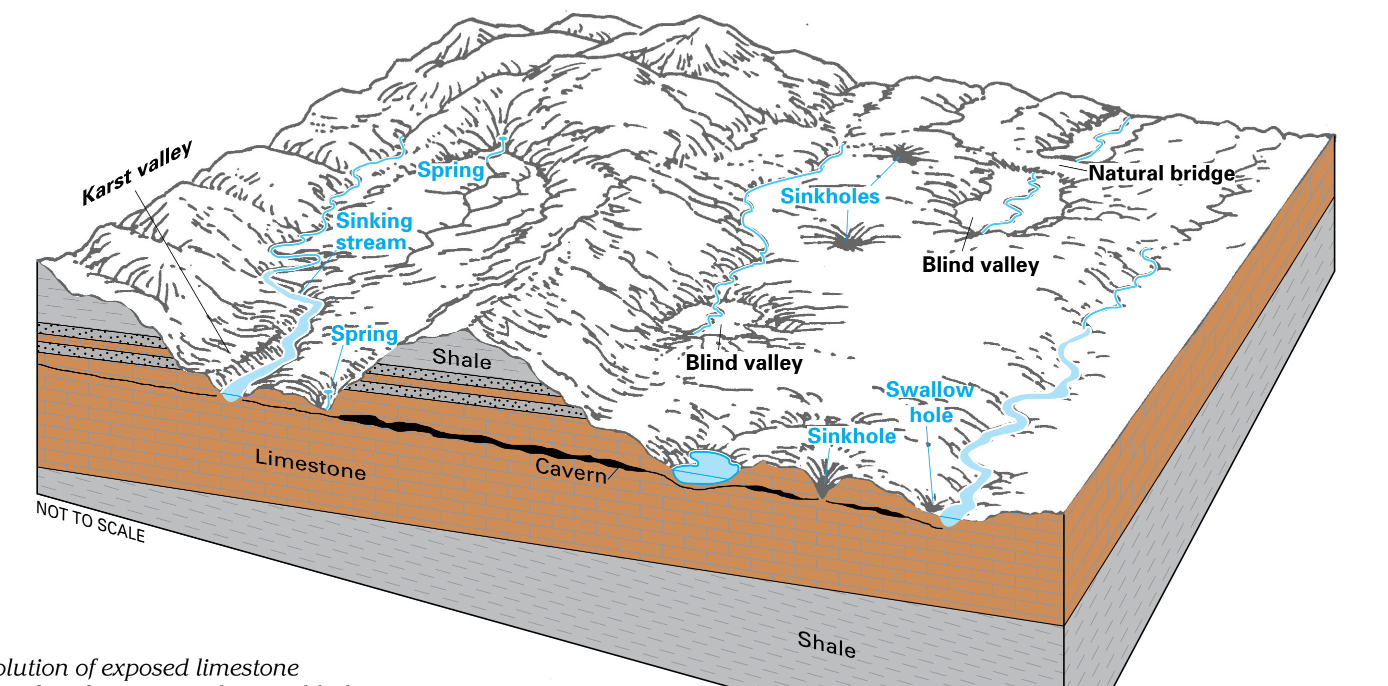




*Figure 28.* The dissolution of exposed limestone forms characteristic land-surface features, such as sinkholes, karst valleys, and sinking streams. Solution features are rare where the limestone is covered with noncarbonate rocks. Few surface streams occur because most of the precipitation is quickly routed into and through solution openings in the limestone.

Modified from Lloyd and Lyke, 1994

Joe Meiman, U.S. National Park Service, Mammoth Cave, Ky.

*Figure 29.* Where solution openings in limestone are large and well connected, they may form networks of cave passages such as this one at Mammoth Cave. The openings can be enlarged at the bottom as the limestone is eroded by sediment-laden streams flowing through them.

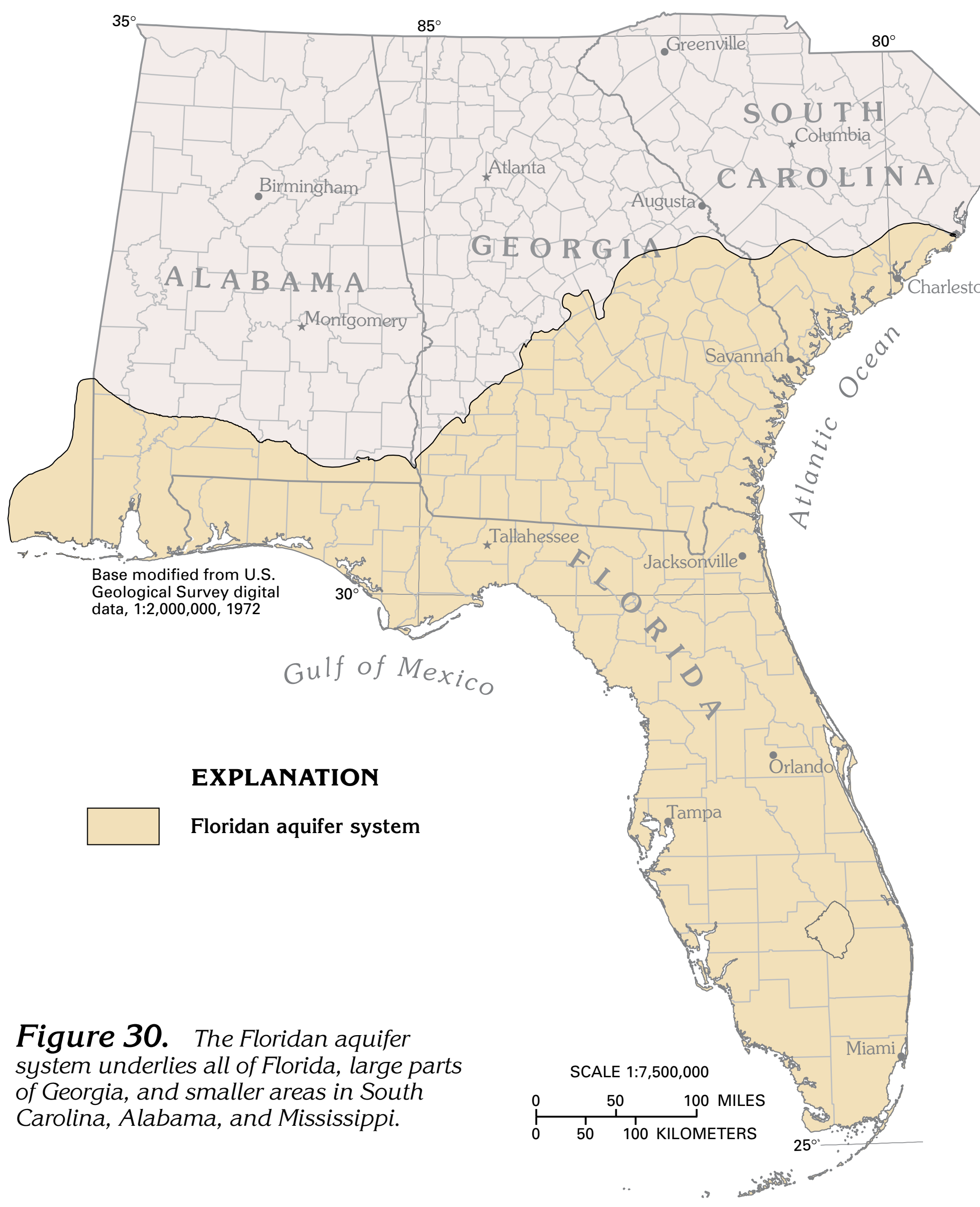
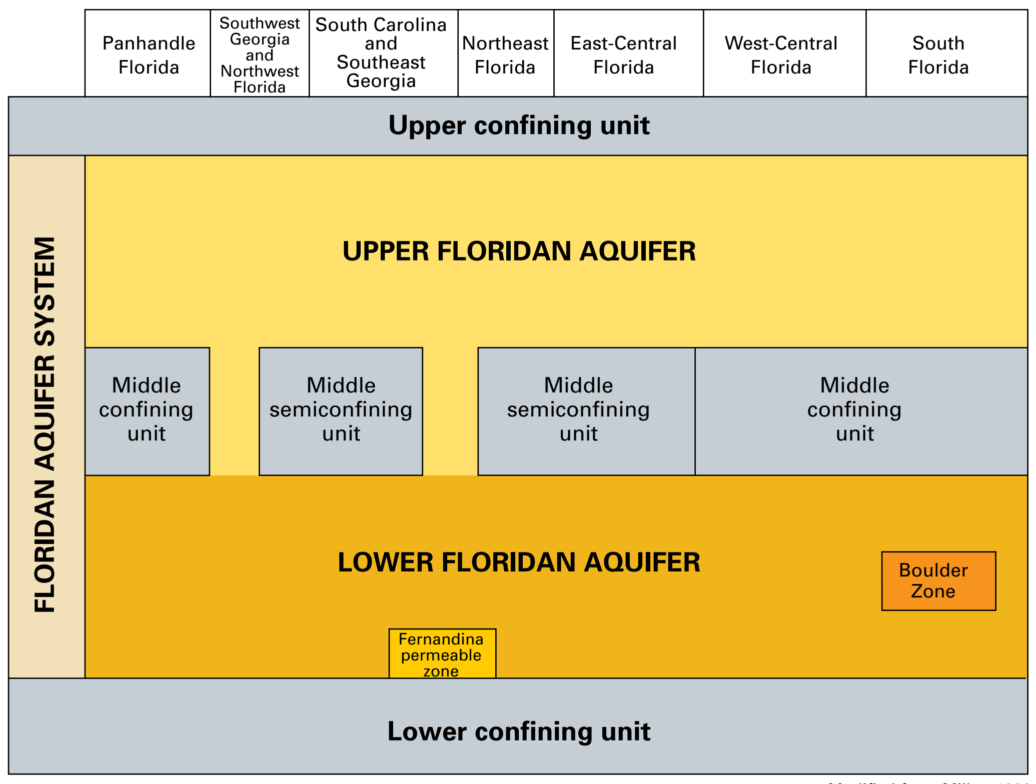



*Figure 30.* The Floridan aquifer system underlies all of Florida, large parts of Georgia, and smaller areas in South Carolina, Alabama, and Mississippi.

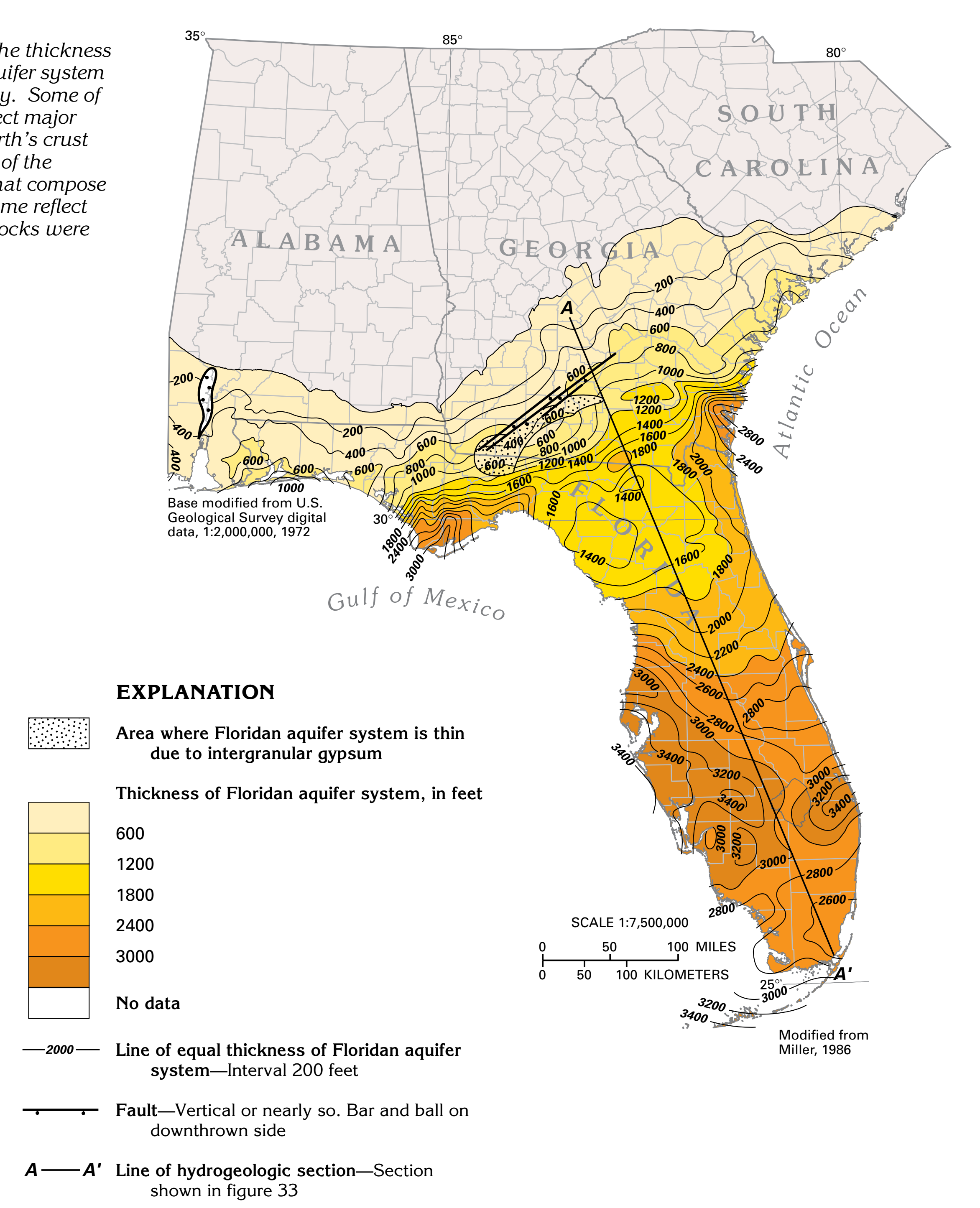
Modified from Miller, 1990

*Figure 31.* The Floridan aquifer system can generally be divided into an Upper Floridan aquifer and a Lower Floridan aquifer, separated in most places by a less-permeable confining unit. The Lower Floridan aquifer locally contains cavernous zones that are extremely permeable.




Modified from Miller, 1986

*Figure 32.* The thickness of the Floridan aquifer system varies considerably. Some of the variations reflect major warping of the Earth's crust during deposition of the carbonate rocks that compose the system and some reflect faulting after the rocks were deposited.




Modified from Miller, 1986

The Floridan aquifer system underlies an area of about 100,000 square miles in southeastern Mississippi, southern Alabama, southern Georgia, southern South Carolina, and all of Florida (**fig. 30**). The Floridan is one of the most productive aquifer systems in the world; an average of about 3.4 billion gallons per day of freshwater was withdrawn from it during 1990. Despite the huge withdrawals, water levels in the Floridan have not declined regionally; however, large declines have occurred locally at a few pumping centers.

The Floridan aquifer system is extremely complex because the rocks that compose the system were deposited in highly variable environments, and their texture accordingly varies from coarse coquina that is extremely permeable to micrite that is almost impermeable. Diagenesis has changed the original texture and mineralogy of the carbonate rocks in many places. The principal diagenetic processes that influence the porosity and permeability of the aquifer system are dolomitization (which increases the volume of connected pore space in fine-grained limestones) and calcite or dolomite overgrowths (which fill part or all of the connected pore space in pelletal limestone or coquina). Dissolution of the limestone has produced small to large conduits at different levels in the aquifer system. These factors produce much local variability in the lithology and the permeability of the aquifer system, but regionally the system consists of an upper and a lower aquifer, which are separated by a less-permeable confining unit (**fig. 31**). In parts of northeastern and northwestern Florida and southwestern Georgia, no confining unit exists and the Upper and Lower Floridan aquifers are directly connected. Two cavernous zones, the Fernandina permeable zone and the Boulder Zone, are present in the Lower Floridan aquifer. Low-permeability confining units bound the aquifer system above and below.

The thickness of the Floridan aquifer system ranges from a thin edge at its northern limit to more than 3,400 feet in parts of southern Florida (**fig. 32**). The map shows the combined thicknesses of the Upper and Lower Floridan aquifers and the middle confining unit where it is present. Some of the large-scale features on the thickness map are related to geologic structures. For example, the thick areas in southeastern Georgia and in the eastern panhandle of Florida coincide with downwarped areas which are called the Southeast and Southwest Georgia Embayments, respectively. In north-central peninsular Florida, the aquifer system thins over an upwarp which is called the Peninsular Arch. Faults in southern Georgia and southwestern Alabama form the boundaries of trough-like grabens. Clayey sediments within these downdropped structural blocks have been juxtaposed opposite permeable limestone of the Floridan aquifer system, and the low-permeability clay creates a damming effect that restricts the lateral movement of ground water across the grabens.