Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina

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REGIONAL AQUIFER-SYSTEM ANALYSIS

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METHOD OF STUDY

APPROACH

The study area (fig. 1) extends from the southern part of the Atlantic Coastal Plain, a geologic province that has been affected primarily by compressional tectonics (Brown and others, 1972) westward into the eastern part of the Gulf Coastal Plain, which has been affected predominantly by gravity tectonics (Murray, 1961), and southward to encompass the Florida platform, which is underlain by a thick sequence of shallow-water platform-type carbonate rocks. Rapid and complex facies changes occur in the area, especially in places where carbonate rock grades laterally into clastic rock. Correlation between clastic and carbonate units or between surface and subsurface units is at present imprecise in the study area. Accordingly, the stratigraphic units used herein have been delineated in the subsurface and mapped as chronostratigraphic units that may include several formations. Structure contour and isopach maps have been prepared for six such Cenozoic chronostratigraphic units. These maps, along with eight cross sections and a fence diagram, show the geometry of and relations between the mapped units. Altitudes on the maps and cross sections and on the fence diagram are related to the National Geodetic Vertical Datum (NGVD) of 1929, a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada. The NGVD of 1929 was formerly called mean sea level. For convenience of usage, however, the NGVD of 1929 is referred to as sea level in the text and on the figures and plates in this report.

The top and base of the Floridan aquifer system, as well as the top and base of major permeability variations within the system, commonly coincide with the top of a chronostratigraphic unit or a particular rock type. Such coincidence is not the case everywhere, however. The vertical limits of the aquifer system as mapped for this study represent the top and base of carbonate rocks that are generally highly permeable and that are overlain and underlain by low-permeability material. The low-permeability rock that delineates the system may be either a clastic rock or a carbonate. In places, the permeability contrast between the aquifer system and its upper and lower confining units may exist within a rock unit or a chronostratigraphic unit. For example, in places, the upper part of the Suwannee Limestone of Oligocene age consists of low-permeability micritic limestone underlain by highly permeable limestone comprised largely of pelecypod and gastropod casts and molds that is also part of the Suwannee. In this case, the top of the Floridan aquifer system would be placed at the top of the highly permeable cast-and-mold limestone rather than at the top of the Suwannee. The aquifer system is thus defined on the basis of its permeability characteristics rather than on the basis of lithology. Accordingly, the structure contour map of the top of the Floridan aquifer system presented in this report differs considerably from previously published maps that represent either the top of vertically continuous limestone or the top of a particular geologic horizon, regardless of its permeability. Structure contour maps representing the base of the aquifer system and the base of the upper major permeable zone within it (the Upper Floridan aquifer) were presented for the first time by Miller (1982a, b) in preliminary open-file publications and are reproduced in this report with minor modifications. Isopach maps of the total aquifer system and of the Upper Floridan aquifer are also presented.

Tops and thicknesses of both chronostratigraphic and permeability units were determined in each of 662 wells selected as key data points. The tops and bottoms of both types of units were established on the basis of the lithologic, paleontologic, and hydraulic characteristics of each unit as revealed in certain deep test wells. Geophysical log (chiefly electric log) patterns representative of each stratigraphic and permeability unit were determined, and the units were extrapolated subregionally primarily on the basis of these log patterns and supplementary descriptions of cores and drill cuttings. The mineralogic composition of rock samples from certain test wells was determined primarily by examining the samples with a binocular microscope. Three assumptions were made in extending relatively permeable and impermeable zones: (1) most of the porosity observed in drill cuttings and in core was effective porosity and therefore indicated a relatively permeable rock, (2) high- and low-porosity rocks were expressed on electric logs by different resistivity characteristics, and (3) once the electric log pattern of a zone was established as representing high or low permeability, the permeability of that zone was considered to remain essentially the same forthe geographic area in which the log pattern remained the same.

The locations of the wells that comprise the data network used in constructing the various maps and cross sections are shown on plate 1. On the cross sections (locations also shown on pl. 1) and in the text of the report, each well is designated by an abbreviation that identifies the State and county within which the well is located and a sequential project number within that county. On the cross sections, wells in Florida and Alabama are also located by the section-township-range grid of the Federal System of Rectangular Surveys within which they lie. For the well-numbering system used herein, the State abbreviations are those in common usage. The county abbreviations are as follows:

Alabama

Baldwin	BAL
Clarke	CL
Covington	COV
Escambia	ES
Geneva	GEN
Houston	HO
Mobile	MOB
Monroe	MON

Florida

Alachua	AL
Baker	BA
Bay	BAY
Bradford	BRA
Broward	BRO
Calhoun	CAL
Charlotte	CHA
Citrus	CI
Clay	CL
Collier	COL
Columbia	CO
Dade	DA
DeSoto	DE
Dixie	DIX
Duval	DUV
Escambia	ESC
Flagler	FL
Franklin	FRA
Gadsden	GA
Gilchrist	GIL
Glades	GL
Gulf	GF
Hamilton	HAM
Hardee	HAR
Hendry	HEN
Hernando	HER
Highlands	HI
Hillsborough	HIL
Holmes	HOL
Indian River	IR
Jackson	JX
Jefferson	JEF
Lafayette	LAF
Lake	LK
Lee	LEE
Leon	LN
Levy	LV
Liberty	LIB
Madison	MAD
Manatee	MAN
Marion	MAR
Martin	MTN
Monroe	MON
Nassau	NA
Okaloosa	OKA
Okeechobee	OKE
Orange	OR
Osceola	OS
Palm Beach	PB
Pasco	PAS
Pinellas	PIN
Polk	POL
Putnam	PUT
St. Johns	SJ
St. Lucie	SL
Santa Rosa	SR
Sarasota	SAR
Suwannee	SUW
Taylor	TAY
Union	UN
Volusia	VO
Wakalla	WAK
Walton	WAL
Washington	WAS

Georgia

Appling	AP
Atkinson	AT

Bacon	BAC
Baker	BAK
Ben Hill	BH
Berrien	BER
Brantley	BRA
Brooks	BRO
Bryan	BRY
Bullock	BUL
Burke	BU
Calhoun	CAL
Camden	CAM
Charlton	CHN
Chatham	CHA
Clinch	CLI
Coffee	COF
Colquitt	COQ
Cook	COK
Crisp	CRP
Decatur	DE
Dodge	DOE
Dooly	DO
Dougherty	DOG
Early	EA
Echols	EC
Effingham	EFF
Emanuel	EM
Evans	EV
Glynn	GLY
Grady	GR
Houston	HOU
Irwin	IR
Jeff Davis	JD
Jenkins	JEN
Laurens	LA
Lee	LEE
Liberty	LIB
Long	LO
Lowndes	LOW
McIntosh	MC
Mitchell	MIT
Montgomery	MO
Pierce	PI
Pulaski	PU
Screven	SCR
Seminole	SE
Tattnall	TAT
Telfair	TEL
Terrell	TER
Thomas	THO
Tift	TF
Toombs	TO
Treutlen	TR
Ware	WA
Wayne	WAY
Wheeler	WH
Wilcox	WX
Worth	WOR

South Carolina

Allendale	AL
Bamberg	BAM
Beaufort	BEA
Charleston	CHN
Colleton	COL
Dorchester	DOR
Hampton	HAM
Jasper	JAS

The designation SC-HAM-3, for example, means that the well is located in Hampton County, S.C., and that it is the third well within that county for which data were obtained. In general, wells selected as key wells are those for which geophysical logs are available along with drill cuttings and (or) core.

The tops and thicknesses of the different stratigraphic and permeability units delineated have been tabulated for each of the 662 wells used as control points. The tables are arranged alphabetically by the State and county in which the wells are located. This tabulation has been published as a data report by Miller, (1984) and is available from the Open-File Services Section, Central Distribution Branch, U.S. Geological Survey, P.O. Box 25425, Federal Center, Denver, CO 80025. The well tables are also on file in the office of the Regional Hydrologist, Southeastern Region, Water Resources Division, U.S. Geological Survey, 75 Spring Street, S.W., Atlanta, GA 30303, and are available for examination. The well data are stored in the U.S. Geological Survey computer and may be obtained as a computer printout or as card images from the Automatic Data Section, Office of the Assistant Chief Hydrologist for Scientific Publications and Data Management, Water Resources Division, U.S. Geological Survey, National Center, 12201 Sunrise Valley Drive, Reston, VA 22092.

Most of the key wells used as control points are oil test wells, which are generally the only wells deep enough to penetrate the entire Floridan aquifer system. Oil test wells can be recognized in the well tables by a number accompanying the property owner's name in the "Lease" column. For example, a well whose lease is designated as "#1 Gulf and Western 7-4" is an oil test well. The oil test data were supplemented by data from numerous water wells, particularly those drilled to test the potential for water production from or waste injection into deep zones in the aquifer system. In places where deep well control of any type is sparse, data were used from some of the thousands of shallow water wells in the project area, primarily in mapping the top of the aquifer system. All pertinent offshore well data were examined, although contouring was not extended seaward of the present-day shoreline. Interpretations made from borehole data were extended and supplemented by examination of publicly and privately owned reflection and refraction seismic data, particularly in southern Florida, southeastern Georgia, and offshore.

CORRELATION PROCEDURE

Correlation difficulties always arise in any study of regional scope because of the wide variations in depositional environments and, consequently of rock types that one encounters in mapping geology and permeability distribution over a large area. The present study was no exception. Complex facies changes occur between those parts of the region where mostly carbonate rocks were deposited and those parts that received mostly clastic sediments. Within the areas that are underlain mostly by carbonate rocks, such as the Florida peninsula, thick sequences of limestones were deposited in warm, shallow marine water over long periods of geologic time. Because the same shallow-marine environment persisted in much of Florida throughout Tertiary time, the textural or mineralogic changes in the carbonate rock column may be subtle in places. Diagenetic alteration at many locales has affected the carbonate rocks as much as or more than changes in primary depositional conditions. Also, in much of the Florida peninsula, the same rock type may recur at several horizons in the geologic column because the exact depositional and (or) diagenetic conditions that produced it were repeated several times.

All the preceding factors preclude regional correlation of stratigraphic units on the basis of lithology alone. They also account in large part for some of the uncertainty in correlation between surface and subsurface units in the project area and for the controversy that surrounds some published correlations. The existing stratigraphic correlation framework used in the study area is twofold, consisting of (1) detailed correlations involving many formation names in outcrop (largely clastic rock) areas and based primarily on lithology and supplemented by macropaleontology and (2) generalized, regionally extensive correlations involving only a few "formation" names in the deep subsurface (largely carbonate rock) areas and based primarily on micropaleontology. The subsurface correlations were made and many of the subsurface Tertiary "formations" were named at a time when only a few widely scattered deep wells existed and when no uniform procedure for naming geologic units was followed. The lithologic differences (often subtle) between such "formations," some of which were named because they contained a unique microfauna, are in many cases confined to a local area. The rock type supposedly characteristic of a given "formation" in a given well can often be found in a nearby well at a completely different stratigraphic horizon.

A worker attempting to make regional correlations in a particular study area is thus faced with the problem of trying to tie together well-defined surface or near-surface rock-stratigraphic units with nebulous subsurface biostratigraphic units (North American Commission on Stratigraphic Nomenclature, 1983) through an intervening area of complex facies change. Neither the surface nor the subsurface correlation framework traditionally used is adequate to describe the physical (or biologic) situation that exists in the rocks.

The equivalency of surface and subsurface geologic units in a project area can best be established by mapping time-rock or chronostratigraphic units. The units chosen for mapping in this report correspond mostly to the series within the Tertiary System or to parts of such series. Chronostratigraphic units include rocks deposited during a particular span of geologic time, regardless of whether they have the same lithology everywhere. The upper and lower boundaries of the time-rock units mapped in this report coincide with changes in rock type that occur in specific wells from which cores and (or) reliable drill cuttings are available. The different chronostratigraphic units delineated were then extended to other wells primarily on the basis of geophysical (mostly electric) log patterns. As correlations of a chronostratigraphic unit are extended laterally over a wide area, the rock types included in that unit may change, and the log pattern of the unit will also change. Different strata are grouped with a given chronostratigraphic unit if they can be shown to represent a logical lateral facies change or to be isochronous with other strata included in the unit elsewhere.

Because the units mapped in this report are time-rock units, their upper and lower boundaries are determined in part by the fauna (chiefly microfauna) that they contain. In general, the vertical range of the microfossils considered characteristic of a given time-rock unit coincides with the vertical boundaries of the various rock types assigned to that unit. Obvious exceptions are reworked or caving faunas. Benthic and planktic Foraminifera, supplemented by Ostracoda, were used chiefly for correlation. The different species considered characteristic of a particular time-rock unit in the study area are listed in table 1, along with a letter-number designation assigned to each species. On the cross sections in this report, the highest occurrence of a given characteristic species identified from a given well is shown by plotting the letter-number code for that species alongside the well column. All of the species that are considered in this report to be time diagnostic are illustrated elsewhere and are accordingly not illustrated herein. The principal reference used for identification, taxonomy, and stratigraphic range determination for the planktic Foraminifera was a paper by Stainforth and others (1975), supplemented by reports by Postuma (1971) and Berggren (1977).