

INTRODUCTION

The Gulf Coast Regional Aquifer-System Analysis (GC RASA) is a study of regional aquifers composed of sediments of mostly Cenozoic age that underlie about 230,000 mi² of the Gulf Coastal Plain in parts of Alabama, Arkansas, Florida, Illinois, Kentucky, Mississippi, Missouri, Tennessee, and Texas and all of Louisiana (fig. 1). The study also includes about 60,000 mi² of the Continental Shelf (Grubb, 1986). These regional aquifers, named the Gulf coast aquifer systems, are part of three aquifer systems: the Mississippi embayment aquifer system, the Texas coastal uplands aquifer system, and the coastal lowlands aquifer system (fig. 2). The Gulf coast aquifer systems have been divided into 10 water-yielding units based on geohydrologic and hydraulic factors (Weiss and Williamson, 1985; Pettijohn and others, 1988; Hosman and Weiss, 1991; and Weiss, 1990).

Permeable zone D is part of the coastal lowlands aquifer system and is composed mostly of middle Miocene deposits. Typically the deposits are complexly interbedded sands, silts, and clays (Hosman, 1991). Areas of maximum sand percentage (greater than 60 percent) generally occur in a band near and roughly parallel to the coast across Texas, Louisiana, Mississippi, and Alabama. The area of maximum sand percentage extends up into the outcrop area in Texas near the Texas-Louisiana border. Lobes of sand percentage greater than 60 percent extend downwind from the outcrop areas in southern Texas, central Mississippi, and southwestern Alabama but are not connected to a coastal band of greater sand percentage (Weiss, 1990). The relation of permeable zone D to overlying and underlying units is shown in figure 3. Zone D averages about 1,760 ft in thickness and generally dips from the outcrop area toward the Gulf of Mexico at about 55 to 80 ft/mi. Ground-water pumping from permeable zone D was about 330 Mgal/d during 1985 (Meko and others, 1990).

The Gulf Coast RASA is part of the U.S. Geological Survey's Regional Aquifer-System Analysis program. The program began in 1978 and is designed to provide an understanding and assessment of the Nation's ground-water resources on a regional basis (Bennett, 1979). A summary of progress in the RASA program through 1984 was given by Sun (1986), and progress on the Gulf Coast RASA was reported by Grubb (1987) and Williamson and others (1990).

Purpose and Scope

This report describes the water chemistry of permeable zone D (middle Miocene deposits), one of five units in the coastal lowlands aquifer system that has substantial pumping (330 Mgal/d) during 1985 (Meko and others, 1990, p. 14). The purpose of this report is to present mapped data that show the areal distribution of the concentration of dissolved solids and temperature, the primary water types and pH, and the concentrations of calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and silica. Also included are five maps showing the areal distribution of milliequivalent ratios of (1) magnesium to calcium, (2) magnesium plus calcium to bicarbonate, (3) magnesium plus calcium to sodium plus potassium, (4) bicarbonate to sulfate, and (5) bicarbonate to chloride. The maps of constituent ratios are included for comparison with the constituent ratios commonly reported for sea water and for water used for specific purposes such as industry and public supply. The ratios also have been used to show trends that may indicate major controls on the chemistry of the ground water.

Compilation of Maps

The maps in this report are based primarily on data from the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) and data from the Texas Department of Water Resources (Pettijohn, 1988). The data were accessed as explained by Pettijohn (1986) and values were plotted on maps in each 100-square-mile area where data exist. The 100-square-mile areas are the same as those illustrated by Grubb (1987, p. 115) and used for simulation of ground-water flow by Williamson (1987) and Williamson and others (1990).

These maps show regional trends in chemical properties. The concentrations of dissolved solids, major ions, and values for pH and temperature vary with depth within the aquifer. Point values can be smaller or larger than the values shown on the map, depending on whether the point is at the top or bottom of the aquifer. Because there are clusters of sampling sites at some locations, the median value of a property or constituent in each 100-square-mile area was selected for constructing maps. The density of sampling sites in each 100-square-mile area is shown as an inset on each of the maps of the respective property or constituent. The number of sampling sites per interval is indicated on the bar graph included with each map. The number of 100-square-mile areas and a summary of median values in 100-square-mile areas for each constituent, property, and ratio are shown in table 1.

The maximum values in table 1 are usually larger than the maximum line of equal concentration shown on the corresponding maps. In some instances the maximum value in the table is much larger than the maximum line shown on the map because the value in the table is for only one 100-square-mile area and there are not enough data of equal magnitude to justify adding additional intervals.

The major ions concentrations and pH are based on median values of all samples within each 100-square-mile area. The dissolved-solids concentrations greater than 10,000 mg/L and temperature are based on depth-averaged values from geophysical well logs (Pettijohn and others, 1988). The water type was computed from the cation and the anion that composed the largest percentage of milliequivalents per liter of the dissolved solids in a ground-water sample. Although water type was computed for each sampling site, only the most frequently observed water type (mode) in each 100-square-mile area is shown on the map. More detailed discussions of how the data were analyzed, processed, and mapped are given by Pettijohn (1986, 1988), Weiss (1987), and Pettijohn and others (1988).

Superimposed on selected maps are locations of geologic structures that are used as points of reference in describing the chemistry of the ground water from east to west. Uplift, midline, and downline are used as reference areas in describing the chemistry of the ground water from north to south. Uplift areas include outcrop and subcrop areas; midline refers to areas about midway between the outcrop and the downline limit of permeable zone D; and downline refers to areas adjacent to the downline limit of the data or the downline limit of permeable zone D. A map showing the location of salt domes (Beckman and Williamson, 1990) and boundary of salt dome basins (fig. 4) is included for the purpose of relating salt structures to constituent concentrations.

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1609	meter per kilometer
mile (mi)	1.609	kilometer
million gallons		cubic meters per
per day (Mgal/d)	0.04381	second
square mile (mi ²)	2.590	square kilometer

Sea level. In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L). Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32$$

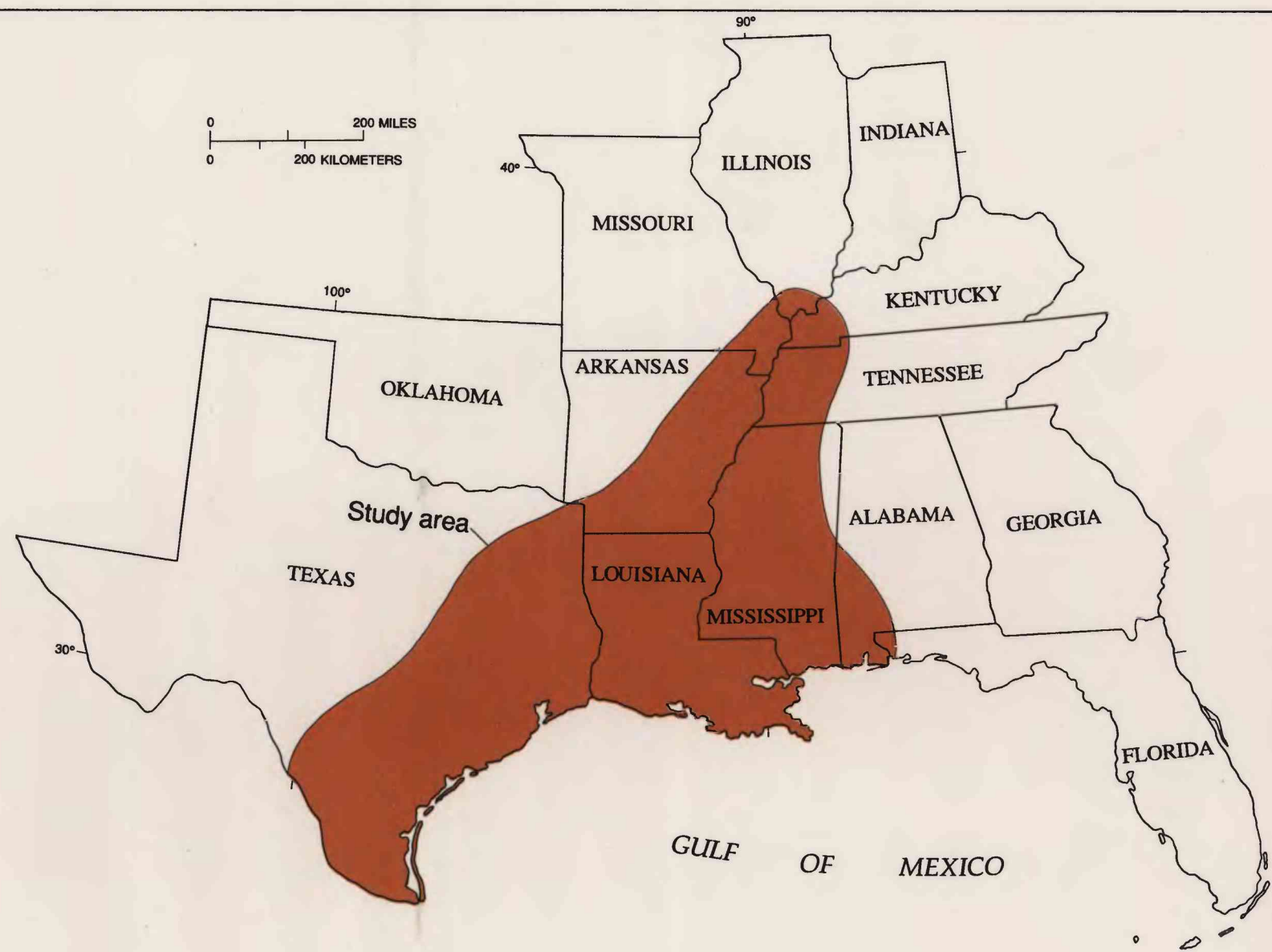


Figure 1.—Location of study area.

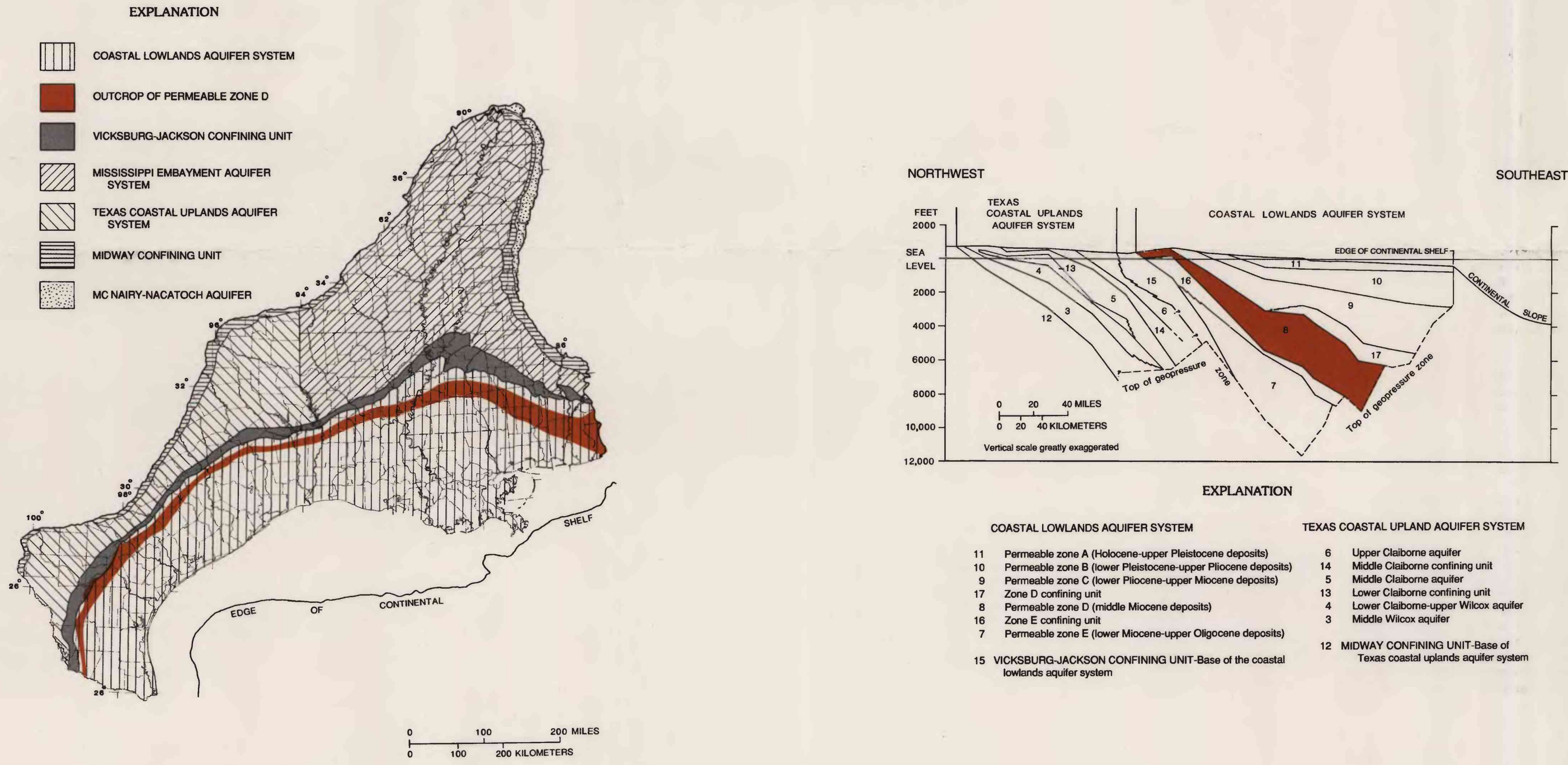


Figure 2.—Generalized outcrop of major aquifer systems and confining units in the Gulf Coast Regional Aquifer-System Analysis study area. Outcrop of permeable zone D (Middle Miocene deposits) superimposed.

Figure 3.—Diagrammatic geohydrologic section through southwest part of study area.

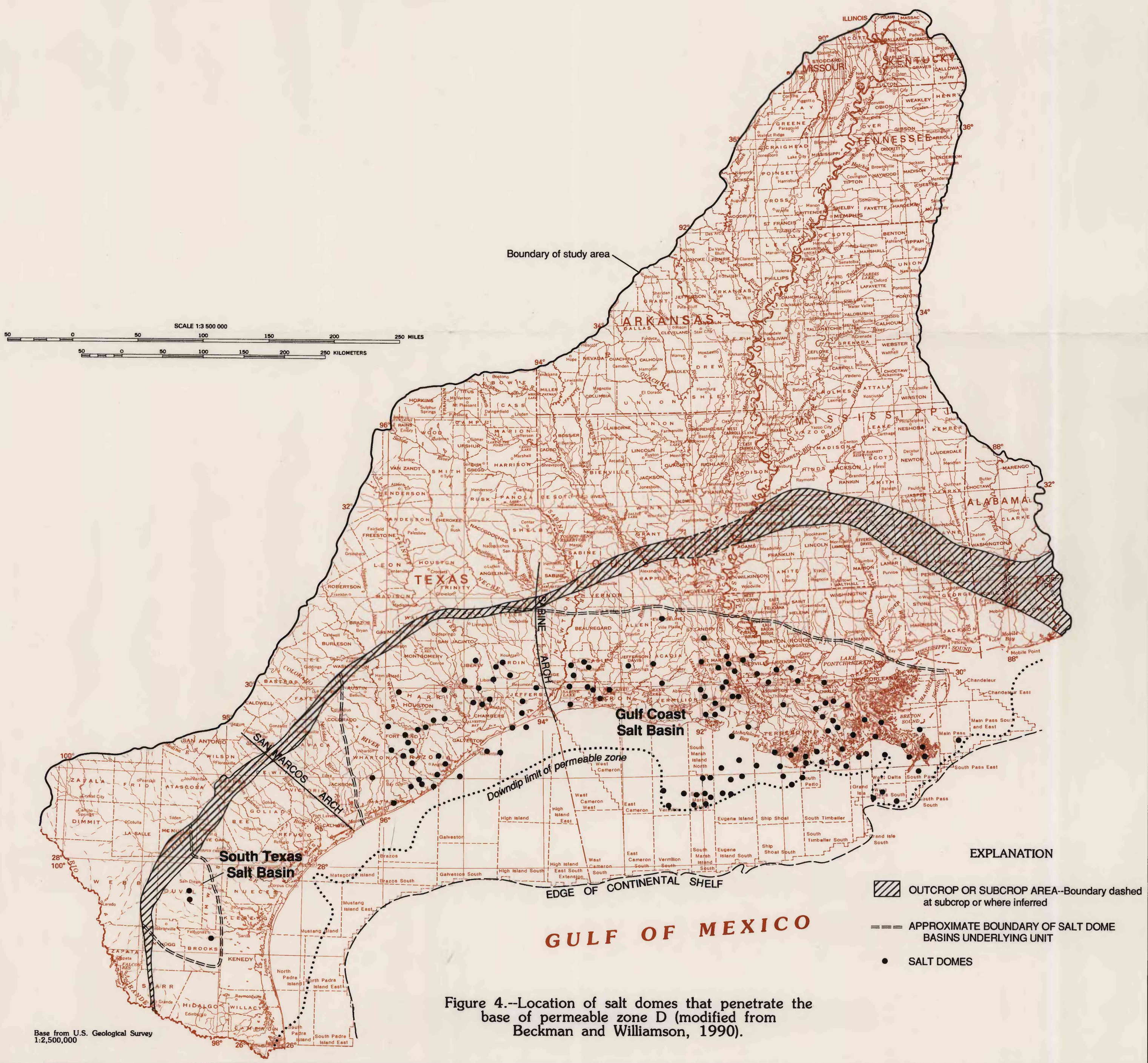


Figure 4.—Location of salt domes that penetrate the base of permeable zone D (modified from Beckman and Williamson, 1990).

SUMMARY AND CONCLUSIONS

The water chemistry of permeable zone D (middle Miocene deposits), which is part of the coastal lowlands aquifer system, is presented in a series of maps. These maps show the areal distribution of (1) the concentration of dissolved solids and temperature, (2) the primary water types and pH, (3) the concentrations of major ions and silica, and (4) the milliequivalent ratios of selected ions. Dissolved constituents, pH, temperature, and ratios are based on the median values of all samples in each 100-square-mile area.

The concentration of dissolved solids ranges from 15 to more than 1,000 mg/L along the outcrop, 500 to 35,000 mg/L near midline, and 35,000 to 223,000 mg/L in downline areas. The increase in concentration of dissolved solids in a downline direction is attributed to mineral-water interaction and specifically to the dissolution of evaporites comprising salt domes in the deeper parts of the permeable zone. The temperature ranges from 12 degrees Celsius in the outcrop area to 110 degrees Celsius along the coastline of southeastern Louisiana.

The primary water types in permeable zone D, which are based on the most frequently observed type (mode) in each 100-square-mile area, are calcium and sodium bicarbonate from the outcrop to midline areas east of the San Marcos arch and sodium chloride from midline to downline areas and in the area southwest of the San Marcos arch. The pH ranges from 4.7 in a downline area in southern Louisiana to 9.1 in a midline area in southeastern Louisiana.

The concentrations of major ions generally increase from the outcrop to the downline limit of the data. The concentration of dissolved calcium ranges from 0.1 mg/L in the outcrop to 21,600 mg/L near the coastline of southern Texas. The concentration of dissolved magnesium ranges from about 0.07 mg/L in areas from outcrop to midline to 1,310 mg/L in a downline area in southeastern Texas. The concentration of dissolved sodium ranges from 1.4 mg/L in the outcrop area of southeastern Alabama to 85,300 mg/L in the Continental Shelf area off the southeastern coast of Louisiana. The concentration of dissolved potassium ranges from 0.1 mg/L in outcrop and midline areas east of the Mississippi River to 489 mg/L in the Continental Shelf area off the southeastern coast of Louisiana. The concentration of dissolved bicarbonate ranges from 3 mg/L in the outcrop area of southwestern Alabama to 1,900 mg/L in the Continental Shelf area off the southeastern coast of Louisiana. The concentration of dissolved sulfate ranges from 0.2 mg/L in outcrop areas in southwestern Alabama to 5,700 mg/L in southern Texas. The concentration of dissolved chloride ranges from 0.4 mg/L in upline areas east of the Sabine arch to 142,000 mg/L in the Continental Shelf area southeast of the Louisiana coastline. The concentration of silica ranges from 2 mg/L in a downline area in southern Louisiana to 98 mg/L in the outcrop in southern Texas.

The milliequivalent ratio maps of constituents in water from permeable zone D show areal distributions and may trends in central Louisiana and appears to have no trend. The milliequivalent ratio of magnesium to calcium ranges from 0.01 near the coastline in southern Texas to 7 along the outcrop in southwestern Alabama and shows no general areal trend. The milliequivalent ratio of magnesium plus calcium to bicarbonate ranges from less than 0.01 in southwestern Mississippi to 1.810 in southern Texas and generally increases from midline to the downline limit of the data. The milliequivalent ratio of magnesium plus calcium to sodium plus potassium ranges from less than 0.01 in midline areas of southwestern Louisiana to 5.2 in southwestern Louisiana and generally decreases from the outcrop to the downline limit of the data.

The milliequivalent ratio of bicarbonate to sulfate ranges from 0.02 at the coastline in southern Texas to 1.430 upline in central Louisiana and appears to have no trend. The milliequivalent ratio of bicarbonate to calcium ranges from 0.01 near the coastline in southern Texas to 7 along the outcrop in southwestern Alabama and shows no general areal trend. The milliequivalent ratio of magnesium plus calcium to bicarbonate ranges from less than 0.01 in southwestern Mississippi to 1.810 in southern Texas and generally increases from midline to the downline limit of the data. The milliequivalent ratio of magnesium plus calcium to sodium plus potassium ranges from less than 0.01 in midline areas of southwestern Louisiana to 5.2 in southwestern Louisiana and generally decreases from the outcrop to the downline limit of the data.

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TABLE 1.—Summary of median values in 100-square-mile areas for selected properties and chemical constituents in ground water from permeable zone D (Middle Miocene deposits)

[All dissolved ion concentrations are in milligrams per liter. All dissolved ion concentrations used to calculate ratios, for example Ca/Mg, are in milliequivalents per liter. Temperatures are in degrees Celsius. pH is in standard units. Chemical symbols: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; HCO₃, bicarbonate; SO₄, sulfate; Cl, chloride; <, less than.]

Property or constituent	Statistics for median values of 100-square-mile areas			Number of 100-square-mile areas
	Median	Minimum	Maximum	
pH	7.1	4.7	9.1	426
Temperature	28	12	110	520
Dissolved-solids	1,044	15.0	232,000	551
Calcium	14.0	0.1	21,600	410
Magnesium	2.6	0.07	1,310	402
Sodium	84.5	1.4	85,300	408
Potassium	2.3	0.1	489	298
Bicarbonate	186	3.0	1,900	422
Sulfate	9.4	0.2	5,700	384
Chloride	23.0	0.4	142,000	432
Silica	28.0	2.0	98.0	335
Ratio Mg:Ca	0.39	0.01	7.0	402
Ratio Mg:Ca:HCO ₃	0.84	<0.01	1,810	395
Ratio Mg:Ca:Na+K	0.39	<0.01	5.2	291
Ratio HCO ₃ :SO ₄	11.9	0.02	1,430	379
Ratio HCO ₃ :Cl	2.2	<0.01	183	422

PROPERTIES AND CHEMICAL CONSTITUENTS IN GROUND WATER FROM PERMEABLE ZONE D (MIDDLE MIOCENE DEPOSITS), COASTAL LOWLANDS AQUIFER SYSTEM, SOUTH-CENTRAL UNITED STATES

by

ROBERT A. PETTIJOHN, JOHN F. BUSBY, AND JEFFERY D. BECKMAN

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