INTRODUCTION

The Gulf Coast Regional Aquifer-System Analysis (Gulf Coast RASA) is a study of regional aquifers composed of sediments of mostly Cenozoic age that underlie about 230,000 mi^2 of the Gulf Coastal Plain in parts of Alabama, Arkansas, Florida, Illinois, Kentucky, Mississippi, Missouri, Tennessee, Texas, and all of Louisiana (fig. 1). The study also includes about 60,000 mi^2 of the Continental Shelf (Grubb, 1984). 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; Weiss, 1990).

The lower Claiborne-upper Wilcox aquifer is in sediments of Eocene age and is part of both the Mississippi embayment and the Texas coastal uplands aquifer systems. Relation of the aquifer to overlying and underlying units is shown in figure 3. The aquifer north of about latitude 35° north is the lower one-third of what Hosman and Weiss (1991) mapped as the middle Claiborne aquifer and is treated herein as a northward extension of the lower Claiborne-upper Wilcox aquifer so that comparison can be made directly with results from ground-water flow simulation (Williamson and others, 1990). The lower Claiborne-upper Wilcox aquifer is composed of a massive sand or a series of thick sand beds separated by relatively thin clay beds. Sand content is greater than 60 percent throughout Texas and in the northern Mississippi embayment. Sand content decreases to the southeast where it is less than 20 percent in parts of southeastern Mississippi. The aquifer averages about 260 ft thick and dips about 13 ft/mi along the Mississippi River from northwestern Mississippi to the downdip limit of the aquifer. Elsewhere the dip averages from about 40 ft/mi in southern Mississippi to about 144 ft/mi in southern Texas (Hosman and Weiss, 1988). Ground-water pumpage from the lower Claiborne-upper Wilcox aquifer was about 410 Mgal/d during 1985 (Mesko and others, 1990).

The Gulf Coast RASA is a 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 the lower Claiborne-upper Wilcox aquifer, one of 10 aquifers in the study area. Maps in this report show the areal distribution of the concentration of dissolved solids, temperature, the primary water types, pH, and the concentrations of calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and silica. Also included are five maps showing 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 comparing with the same 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 screened as explained by Pettijohn (1986) and values were posted 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 concentration of dissolved solids, major ion concentrations, 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 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 concentrations of major ions 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 are 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 reference points in describing the chemistry of the ground water from east to west. Updip, middip, and downdip are used as reference areas in describing the chemistry of the ground water from north to south. Updip areas include outcrop and subcrop areas; middip refers to areas about midway between the outcrop and the downdip limit of the data; and downdip refers to areas adjacent to the downdip limit of the data or the downdip limit of the aquifer. 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)	0.1894	meter per kilometer
mile (mi)	1.609	kilometer
million gallons per day (Mgal/d)	0.04381	cubic meters per 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:

$$°F = 1.8(°C) + 32$$

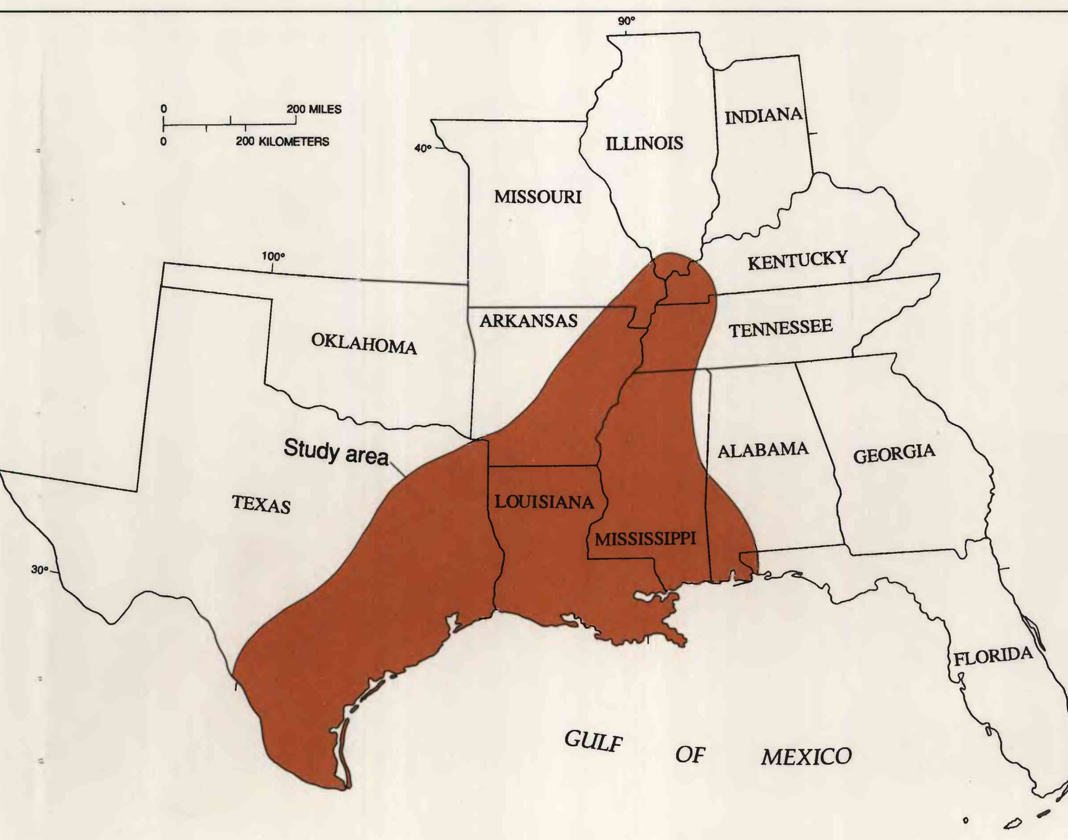

Figure 1.--Location of study area.

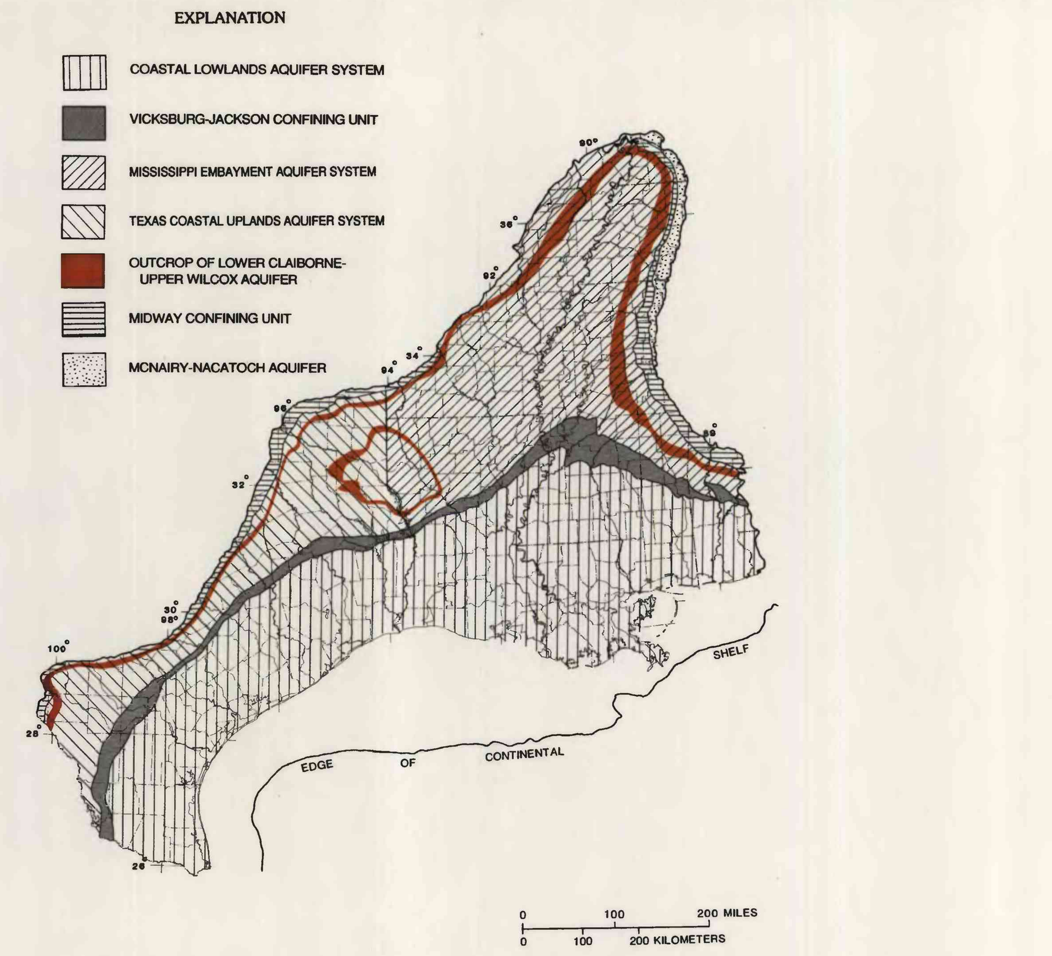

Figure 2.--Generalized outcrop of major aquifer systems and confining units in the Gulf Coast Regional Aquifer-System Analysis study area. Outcrop of the lower Claiborne-upper Wilcox aquifer superimposed.

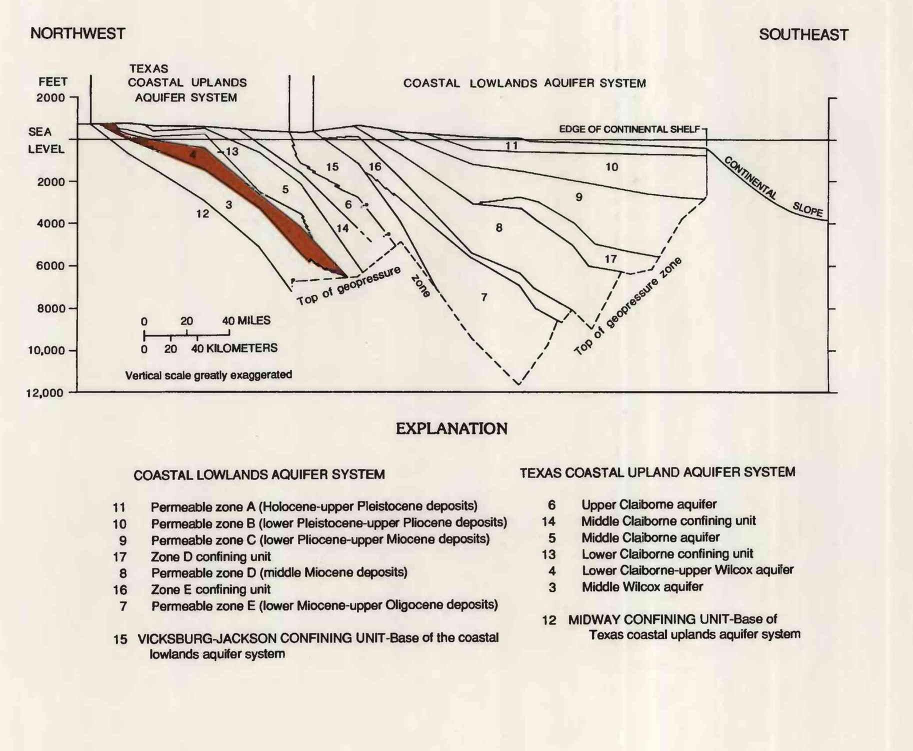

Figure 3.--Diagrammatic geohydrologic section through southwest part of study area.

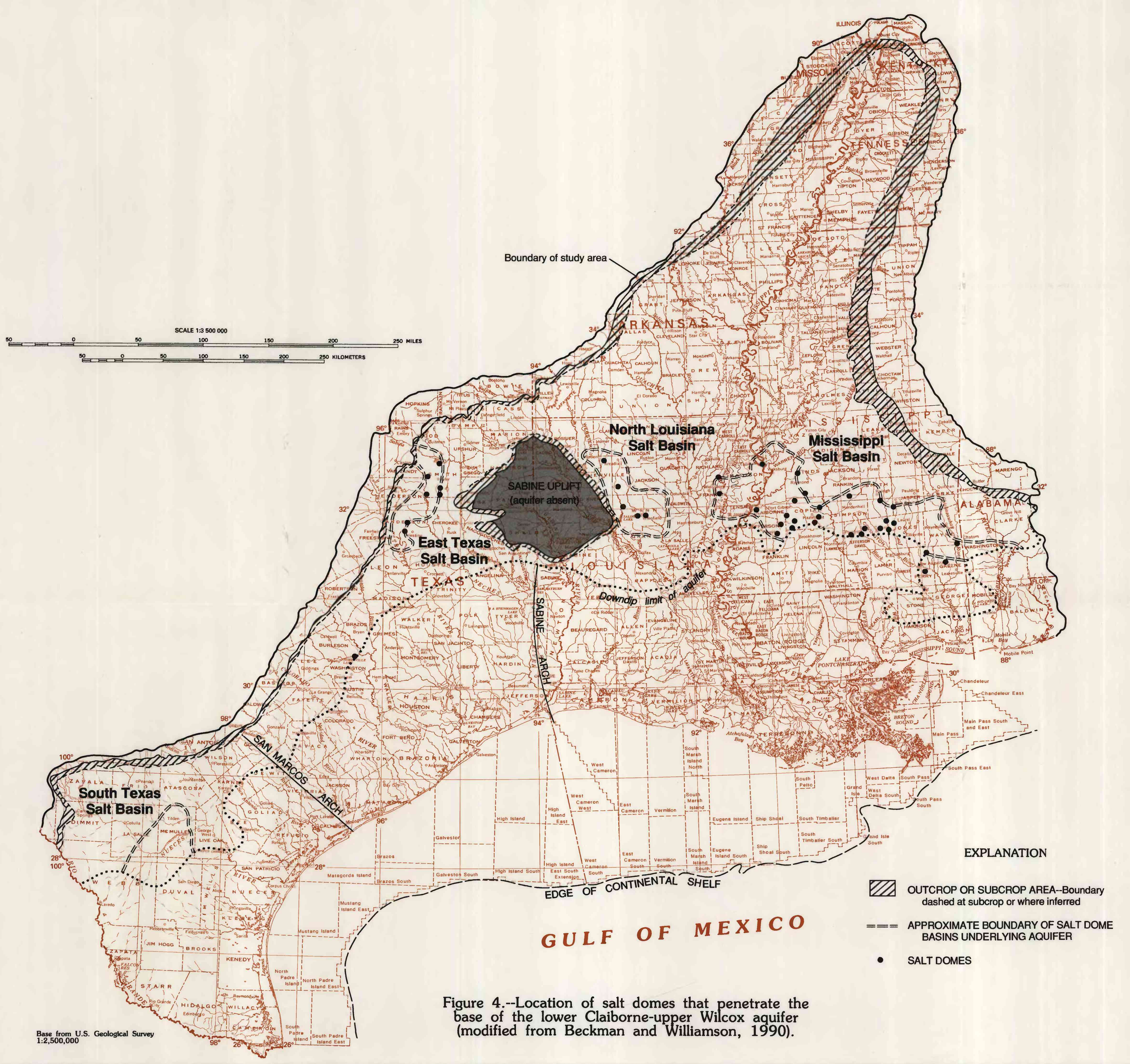

Figure 4.--Location of salt domes that penetrate the base of the lower Claiborne-upper Wilcox aquifer (modified from Beckman and Williamson, 1990).

SUMMARY AND CONCLUSIONS

The water chemistry of the lower Claiborne-upper Wilcox aquifer, which is part of the Mississippi embayment aquifer system and the Texas coastal uplands aquifer system, is presented by 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 25 mg/L in the outcrop area to 122,300 mg/L in a downdip area of Louisiana. The increase in concentration of dissolved solids in a downdip direction is attributed to mineral-water interaction such as dissolution of silicates in outcrop areas and dissolution of evaporites comprising salt domes in the deeper downdip parts of the aquifer. Temperature ranges from 13 degrees Celsius in the outcrop area to 74 degrees Celsius in a downdip area of southern Texas.

The primary water type, which is based on the most frequently observed type (mode) in each 100-square-mile area, is calcium bicarbonate in northeastern Arkansas, western Tennessee, southeastern Missouri, and in most of the outcrop area. It is sodium bicarbonate in Texas, Louisiana, Mississippi, and western Kentucky. The pH ranges from 5.1 in the outcrop area of eastern Texas to 8.8 near the downdip limit of the data in southwestern Alabama.

The concentrations of major ions generally increase from the outcrop area to the downdip limit of the data. The concentration of dissolved calcium ranges from 0.10 mg/L in northwestern Mississippi to 1,075 mg/L in east-central Louisiana near the downdip limit of the aquifer. The calcium concentration generally decreases from the outcrop area to the downdip limit of the data in most of the aquifer area. The concentration of dissolved magnesium ranges from 0.1 mg/L in west-central Mississippi to 467 mg/L in east-central Louisiana near the downdip limit of the aquifer. The magnesium concentration generally decreases from the outcrop to the downdip limit of the data in the area between the Trinity River and the Rio Grande. The concentration of dissolved sodium ranges from 1.1 mg/L in an updip area in western Tennessee to 31,780 mg/L in east-central Louisiana near the downdip limit of the aquifer. The sodium concentration generally increases from the outcrop to the downdip limit of the data. The concentration of dissolved potassium ranges from 0.2 in the outcrop area in northern Mississippi to 126 mg/L in east-central Louisiana near the downdip limit of the aquifer. The concentration of potassium generally increases from the outcrop to the downdip limit of the data in the area east of the Sabine uplift and decreases in the area west of the Sabine uplift.

The concentration of dissolved bicarbonate ranges from 4 mg/L in the outcrop area in east Texas to 1,760 mg/L near the downdip limit of the data in southern Texas. The bicarbonate concentration generally increases from the outcrop to the downdip limit of the data. The concentration of dissolved sulfate ranges from 0.2 mg/L in areas of western Kentucky and Tennessee and northwestern Mississippi to 590 mg/L near the downdip limit of the data in southern Texas. The concentration of dissolved chloride ranges from 0.8 in western Tennessee and northwestern Mississippi to 52,540 mg/L in east-central Louisiana near the downdip limit of the aquifer. The chloride concentration is generally the largest along the downdip limit of the data. The concentration of silica ranges from 1.6 mg/L in southeastern Mississippi to 66 mg/L in an outcrop area in southwestern Arkansas. However the silica concentration generally ranges from 10 to 20 mg/L in most of the aquifer area.

The milliequivalent ratio maps of constituents in water from the lower Claiborne-upper Wilcox aquifer show areal distributions and any trends in ratios from the outcrop area to the downdip limit of the data. The milliequivalent ratio of magnesium to calcium ranges from 0.04 to 7.7 with no indicated areal trend. The milliequivalent ratio of magnesium plus calcium to bicarbonate ranges from less than 0.01 to 33.3 and generally decreases from the outcrop area to the downdip limit of the data. The milliequivalent ratio of magnesium plus calcium to sodium plus potassium ranges from less than 0.01 to 14 and generally decreases from updip and outcrop areas to the downdip limit of the data.

The milliequivalent ratio of bicarbonate to sulfate ranges from 0.08 to 3,310 and generally increases from the outcrop to the downdip limit of the data in most of the aquifer area. The milliequivalent ratio of bicarbonate to chloride ranges from 0.02 to 269 and is the largest in the middip area and generally decreases in a southwesterly direction from western Mississippi to southern Texas.

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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 the lower Claiborne-upper Wilcox*

[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; HCO_3, bicarbonate; SO_4, 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	7.5	5.1	8.8	341
Temperature	24.0	13.0	74	452
Dissolved-solids	298	25.0	122,300	376
Calcium	7.6	0.1	1,075	331
Magnesium	2.6	0.1	467	321
Sodium	42.0	1.1	31,780	326
Potassium	2.2	0.2	126	264
Bicarbonate	184	4.0	1,760	350
Sulfate	10.0	0.2	590	336
Chloride	11.0	0.8	52,540	365
Silica	17.0	1.6	66	310
Ratio Mg:Ca	0.56	0.04	7.7	321
Ratio Mg+Ca:HCO_3	0.65	<0.01	33.3	312
Ratio Mg+Ca:Na+K	0.83	<0.01	14.0	254
Ratio HCO_3:SO_4	9.5	0.08	3,310	332
Ratio HCO_3:Cl	6.9	0.02	269	350

PROPERTIES AND CHEMICAL CONSTITUENTS IN GROUND WATER FROM THE LOWER CLAIBORNE-UPPER WILCOX AQUIFER, GULF COAST REGIONAL AQUIFER SYSTEMS, SOUTH-CENTRAL UNITED STATES

by

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