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 middle Claiborne 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 upper two-thirds of what Hosman and Weiss (1988) mapped as the middle Claiborne aquifer. Because the lower Claiborne confining unit does not exist north of about latitude 35° north the lower one-third of the aquifer is treated herein as a northward extension of the lower Claiborne-upper Wilcox aquifer so that comparisons can be made directly with results from ground-water flow simulation (Williamson and others, 1990). The middle Claiborne aquifer is composed of a massive sand or a series of thick sand beds with clay interbeds of varying thickness and extent. Sand content is greater than 60 percent throughout most of Texas and the Mississippi embayment north of Louisiana. Sand content decreases to the southeast where sand content is less than 20 percent throughout two large areas adjacent to the downdip limit of the aquifer. One area is located in eastern Louisiana and adjacent parts of Mississippi; the other area is in Alabama and adjacent parts of southeastern Mississippi. The aquifer averages about 470 ft thick and dips about 3 ft/mi along the Mississippi River from southern Illinois to northern Louisiana. Elsewhere the dip ranges from an average of about 60 ft/mi from northern Louisiana to the downdip limit of the aquifer to about 135 ft/mi in southern Texas. Ground-water pumpage from the middle Claiborne aquifer was 530 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 middle Claiborne aquifer. Maps in the 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 have also 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 concentrations of dissolved solids and major ions, 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 is 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 each map are locations of geologic structures that are used as points of reference 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 aquifer; 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.

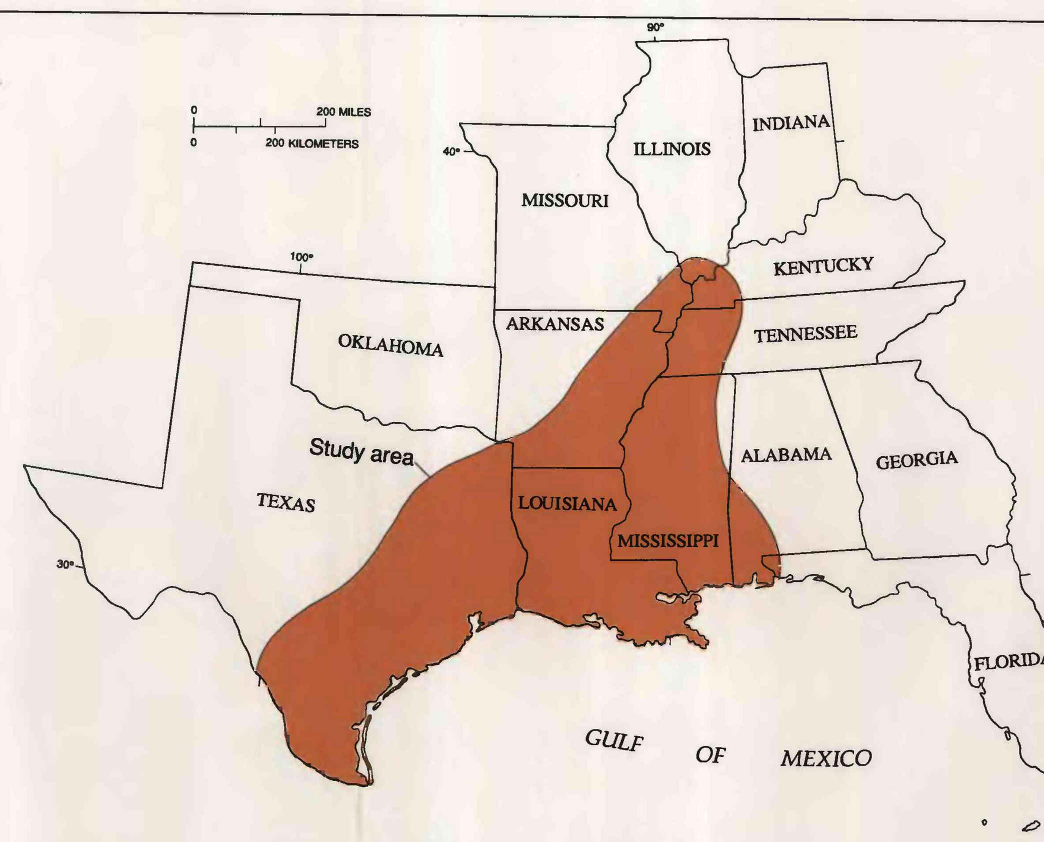

Figure 1.--Location of study area.

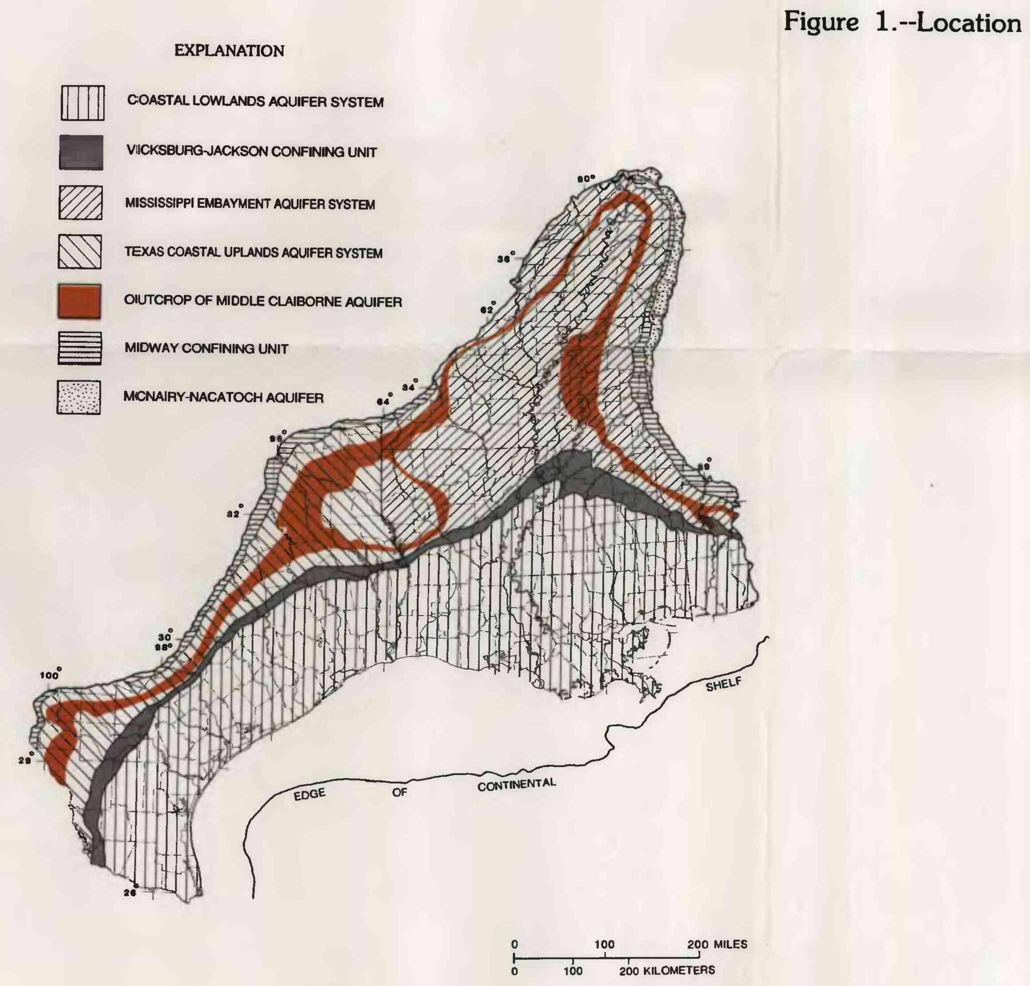

Figure 2.--Generalized outcrop of major aquifer systems and confining units in the Gulf Coast Regional Aquifer-System Analysis study area. Outcrop of the middle Claiborne aquifer superimposed.

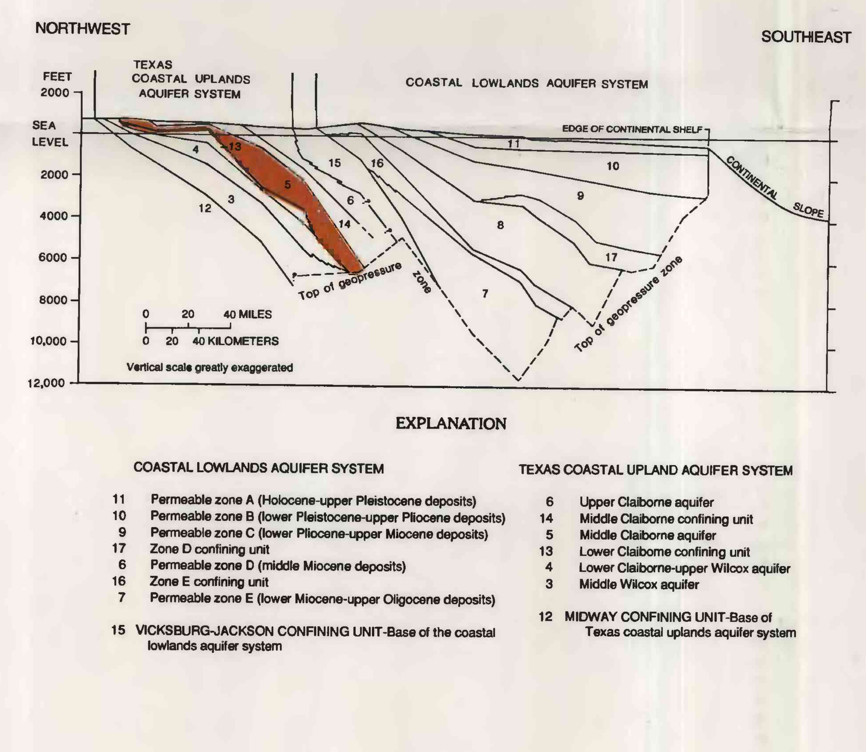

Figure 3.--Diagrammatic geohydrologic section through southwest part of study area.

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:

$$°F = 1.8(°C) + 32$$

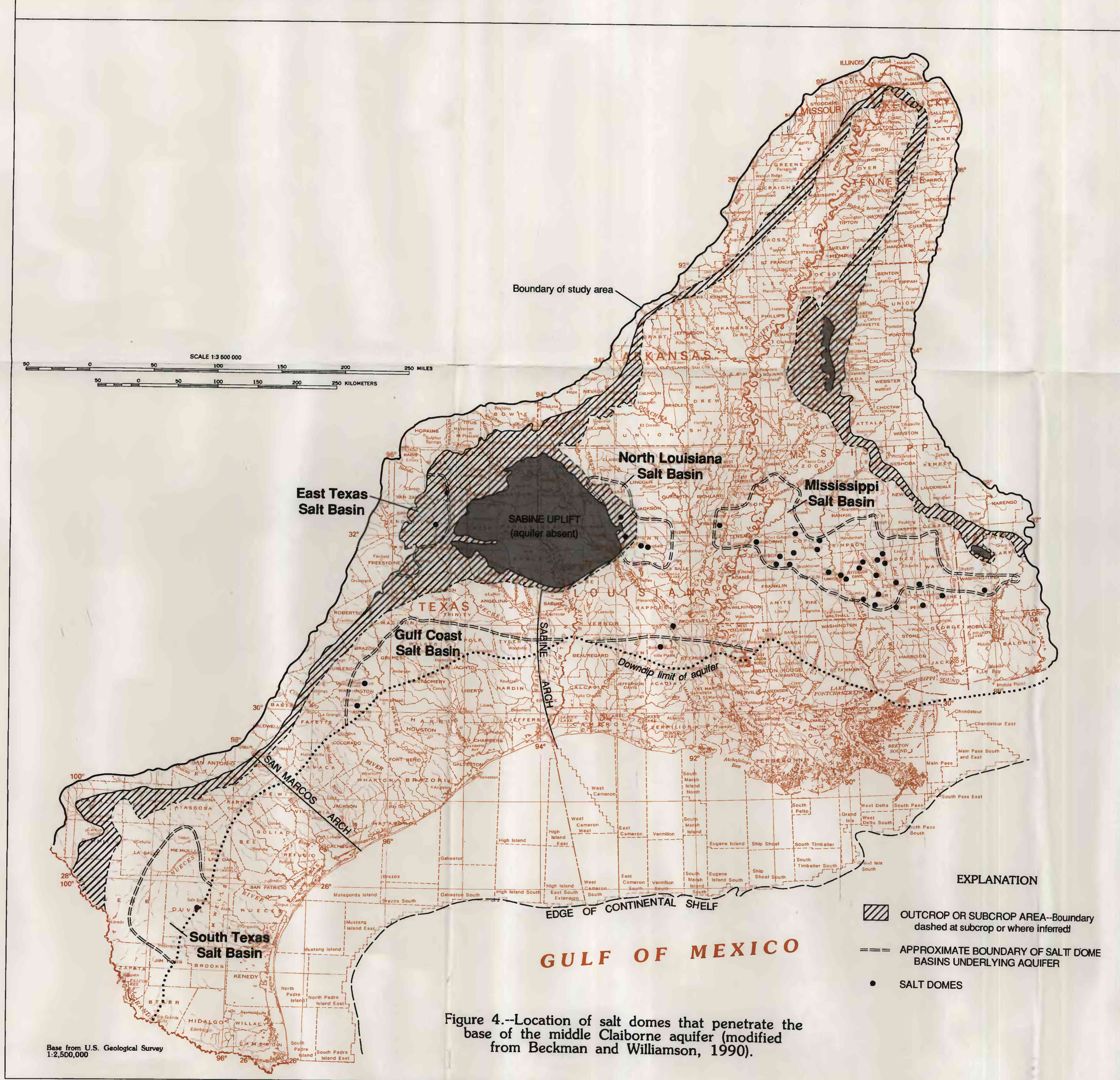

Figure 4.--Location of salt domes that penetrate the base of the middle Claiborne aquifer (modified from Beckman and Williamson, 1990).

SUMMARY AND CONCLUSIONS

The water chemistry of the middle Claiborne 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 mdian values of all samples in each 100-square-mile area.

The concentration of dissolved solids ranges from 23.5 mg/L in the outcrop area to 130,000 mg/L in a downdip area in 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 and subcrop areas and dissolution of evaporites comprising salt domes in the deeper downdip parts of the aquifer. The temperature ranges from 14 degrees Celsius in the outcrop area to 87 degrees Celsius in the downdip area of southern Louisiana.

The primary water types in the middle Claiborne aquifer, which are based on the most frequently observed water type (mode) in each 100-square-mile area, are calcium bicarbonate in northeastern Arkansas, western Tennessee, and western Kentucky and sodium bicarbonate in southern Arkansas, eastern Texas, northern Louisiana, and central Mississippi. It is sodium chloride in southern Texas and in downdip areas in southeastern Texas and southern Louisiana. The pH ranges from 4.5 in the outcrop area to 9.3 in a downdip area in southern Mississippi but generally ranges between 7.0 and 8.0.

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 the outcrop area and areas in southwestern Mississippi to 2,122 mg/L in the downdip area of southern Texas. The concentration of dissolved magnesium ranges from 0.10 mg/L in middip areas between the Sabine uplift and the southwestern corner of Alabama to 520 mg/L near the downdip limit of the data in southwestern Louisiana. The concentration of dissolved sodium ranges from 1 mg/L in the outcrop area east of the Mississippi River to 54,000 mg/L near the downdip limit of the data in southeastern Mississippi. The concentration of dissolved potassium ranges from 0.10 mg/L in western Kentucky to 160 mg/L in southeastern Louisiana.

The concentration of dissolved bicarbonate ranges from 2 mg/L in the outcrop area in eastern Texas to 2,280 mg/L near the downdip limit of the aquifer in southern Texas. The concentration of dissolved sulfate ranges from 0.10 mg/L in the outcrop in northern Mississippi to 3,780 mg/L in the area near the downdip limit of the aquifer in southern Texas. The concentration of dissolved chloride ranges from 1.3 mg/L in western Tennessee to 73,000 mg/L in southeastern Mississippi. The concentration of silica in water of the middle Claiborne aquifer ranges from 0.20 to 79 mg/L. However in most of the area the concentration is between 10 and 20 mg/L.

The milliequivalent ratio maps of constituents in water from the middle Claiborne aquifer show areal distributions and any trends in ratios from the outcrop to the downdip limit of the data. The milliequivalent ratio of magnesium to calcium (Mg:Ca) ranges from 0.01 to 4. The Mg:Ca ratio increases from the outcrop to the downdip limit of the aquifer in the area between the Sabine uplift and the San Marcos arch. In the area southwest of the San Marcos arch the ratio increases from outcrop to middip and decreases from middip to the downdip limit of the aquifer. The milliequivalent ratio of magnesium plus calcium to bicarbonate ranges from less than 0.01 to 24 and decreases from the outcrop area to middip and then increases near the downdip limit of the data. The milliequivalent ratio of magnesium plus calcium to sodium plus potassium ranges from less than 0.01 to 13 and generally decreases from the outcrop to the downdip limit of the data in all but the northern part of the Mississippi embayment aquifer system area.

The milliequivalent ratio of bicarbonate to sulfate (HCO_3:SO_4) ranges from about 0.05 to 2,660. The HCO_3:SO_4 ratio in the area of the Mississippi embayment aquifer system generally increases from the outcrop toward the Mississippi River and from north to south. The HCO_3:SO_4 ratio in the area southwest of the San Marcos arch generally increases from the outcrop area to the downdip limit of the data. The milliequivalent ratio of bicarbonate to chloride ranges from less than 0.01 to 101 and decreases from middip to the downdip limit of data in southeastern Mississippi and southwestern Alabama and from the outcrop to the downdip limit of the aquifer in the area southwest of the San Marcos arch.

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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 middle Claiborne aquifer*

[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: Median	Minimum	Maximum	Number of 100-square-mile areas
pH	7.5	4.5	9.3	517
Temperature	23.0	14.0	87	598
Dissolved-solids	322	23.5	130,000	580
Calcium	7.9	0.1	2,122	503
Magnesium	2.5	0.1	520	494
Sodium	70	1.0	54,000	499
Potassium	2.2	0.1	160	406
Bicarbonate	194	2.0	2,280	523
Sulfate	7.5	0.1	3,780	511
Chloride	15.0	1.3	73,000	550
Silica	16.0	0.2	79	459
Ratio Mg:Ca	0.55	0.01	4.0	492
Ratio Mg+Ca:HCO_3	0.58	<0.01	24	476
Ratio Mg+Ca:Na+K	0.46	<0.01	13	393
Ratio HCO_3:SO_4	12.9	0.05	2,660	491
Ratio HCO_3:Cl	5.0	<0.01	101	521

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

by

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