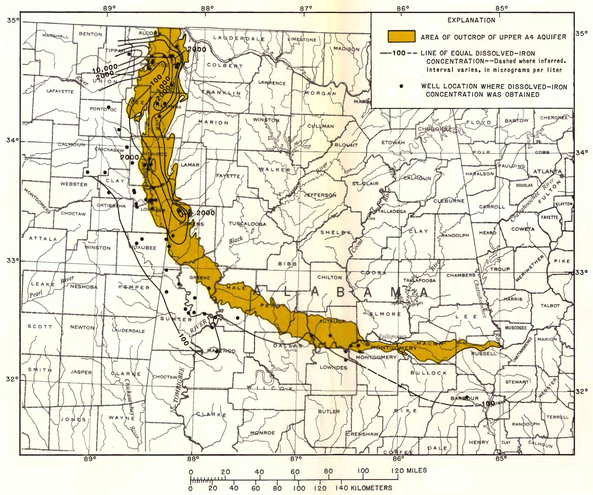
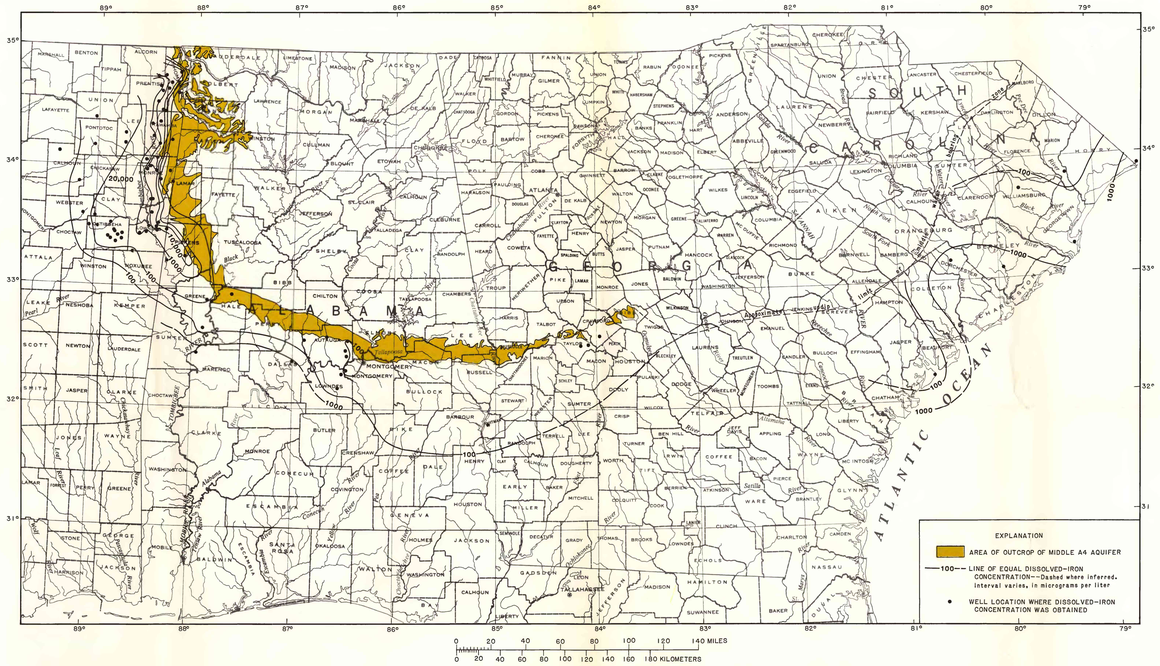
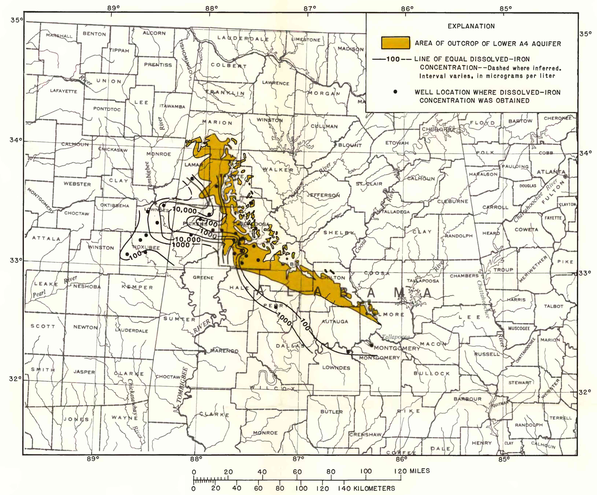


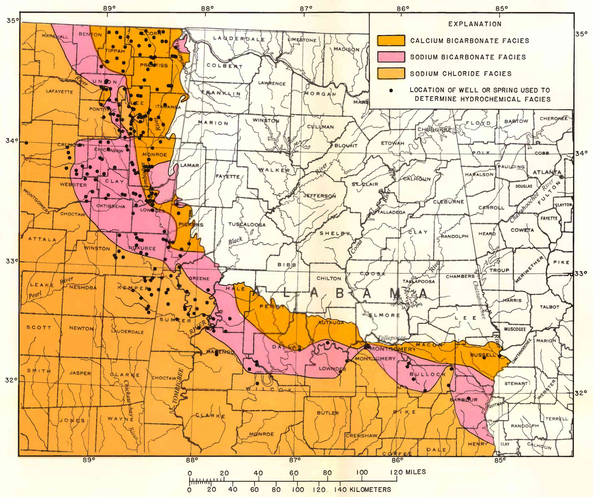
Dissolved iron in the upper water-bearing zone.



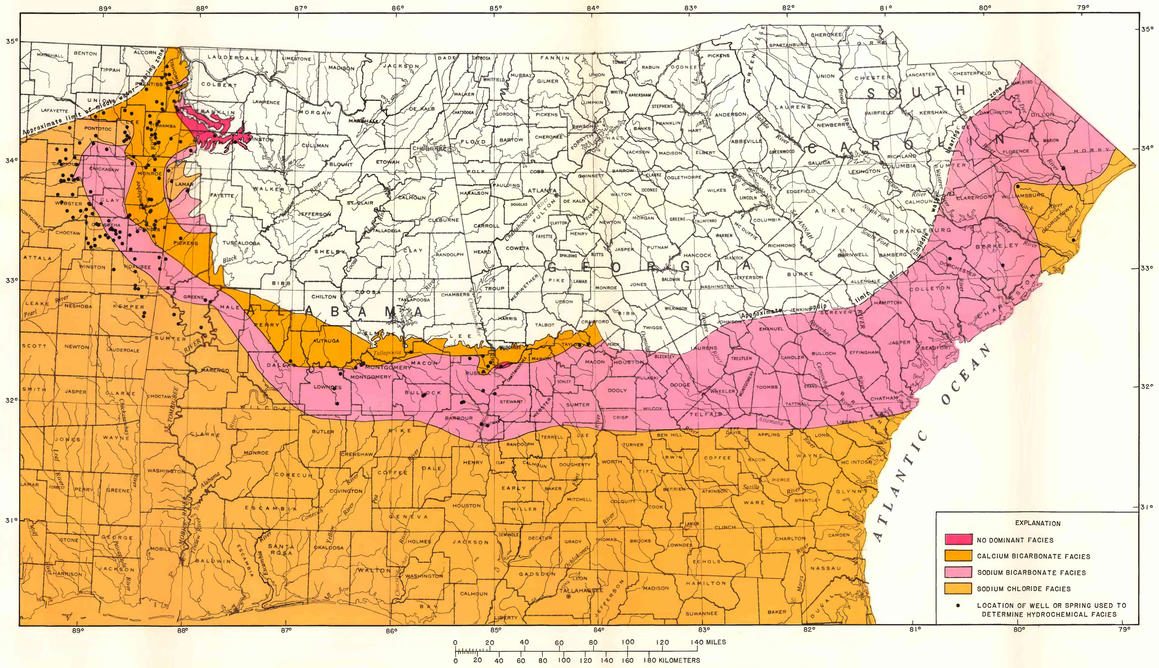
Dissolved iron in the middle water-bearing zone.



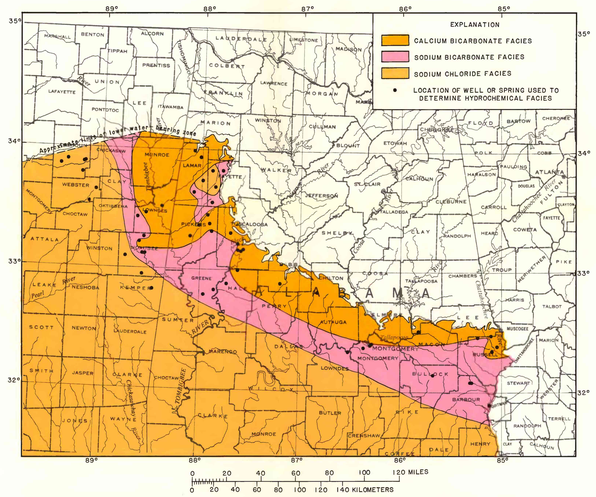
Dissolved iron in the lower water-bearing zone.



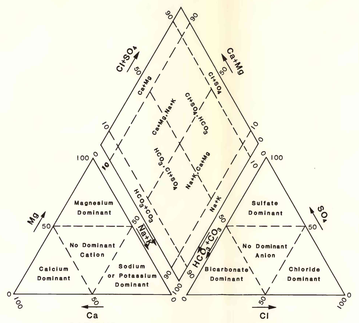
Hydrochemical facies of the upper water-bearing zone.



Hydrochemical facies of the middle water-bearing zone.



Hydrochemical facies of the lower water-bearing zone.



Modified Piper diagram depicting the classification scheme for hydrochemical facies.

DISSOLVED IRON MAPS

Dissolved iron is present in ground waters of the A4 aquifer in concentrations as great as 20,000 µg/L. These high concentrations of dissolved iron are localized in narrow bands in the water-bearing zones in Mississippi and Alabama suggesting that downgradient, dissolved iron is precipitated. Dissolved iron increases farther downgradient as the salinity of the ground water increases. Dissolved-iron data are poorly distributed throughout the study area and are generally not accurate within quantitative limits of ±5 percent, especially for waters containing high concentrations of iron. Iron hydroxide ($Fe(OH)_3$) may precipitate from solution as ground-water samples are exposed to the atmosphere, causing losses in the amount of iron in solution and resulting in lower measurable concentrations.

Upper Water-Bearing Zone

In the upper zone (upper left), waters containing high concentrations of dissolved iron occur in a narrow band which extends from Pickens and Lamar Counties, Ala., on the western border of Alabama northwest into northeastern Mississippi. Low concentrations of dissolved iron (less than 250 µg/L) occur in waters from wells in this zone east of Pickens County. The areal extent of ground water containing high dissolved iron may be inaccurate because of poor data distribution. Most of the data were obtained from wells in eastern Mississippi.

In the recharge areas, dissolved-iron concentrations were generally less than 100 µg/L. Dissolved-iron concentrations increased to greater than 10,000 µg/L downgradient, followed by systematic decreases to concentrations less than 200 µg/L in the still deeper, downgradient parts of the upper zone.

Middle Water-Bearing Zone

Waters of the middle zone (upper center) also contain dissolved-iron concentrations in excess of 20,000 µg/L. High dissolved-iron concentrations extend from western Alabama to northeastern Mississippi in the same geographic area as that shown for the upper zone. In this part of the study area, the dissolved-iron concentrations are less than 100 µg/L in the recharge areas, but increase to as much as 20,000 µg/L downgradient. Farther downgradient, dissolved-iron concentrations decrease to less than 100 µg/L before increasing again in the deeper downgradient parts of the middle zone. Near Demopolis, Alabama, where saline water occurs in the middle zone, dissolved-iron concentrations are as much as 5,400 µg/L. Both dissolved-iron and dissolved-solids concentrations increase in the deeper downgradient parts of the middle zone.

Available data show dissolved-iron concentrations to be low (less than 200 µg/L) throughout most of eastern Alabama and Georgia, where data are available. In South Carolina high concentrations of dissolved iron (as much as 5,000 µg/L) occur in the A4 aquifer, with the highest concentration in Marion and Berkeley Counties, and at nearby Calabash, N.C.

Lower Water-Bearing Zone

The waters of the lower zone (upper right) contain concentrations of dissolved iron as high as 16,000 µg/L. The highest iron concentrations occur in a narrow band which is mostly located near the Fall Line in western Alabama and extends into Lowndes County, Miss. Dissolved-iron concentrations are low (less than 100 µg/L) in the recharge area but increase downgradient to a "band" of high dissolved iron. Farther downgradient, the dissolved-iron concentrations decrease to less than 200 µg/L. There are few data from the deeper downgradient parts of the lower zone. Concentrations of dissolved iron are less than 800 µg/L eastward toward Montgomery, Ala. Dissolved-iron concentrations greater than 1,000 mg/L occur in northern Tuscaloosa County, near the Fall Line. The reasons for this occurrence are not clear.

HYDROCHEMICAL FACIES

Hydrochemical facies refers to a classification scheme for major cations and anions in natural waters (Back, 1961). Water chemistry can be described by labeling the water with its dominant cation and anion. The dominance criterion is based on percent of milliequivalents of each major cation (calcium, magnesium, and sodium plus potassium) and each major anion (chloride, sulfate, and bicarbonate plus carbonate). Thus, in a calcium-bicarbonate dominated water the calcium ion would be greater than 50 percent of the total cations, and the bicarbonate (plus carbonate) ion would be greater than 50 percent of the total anions. Water containing no cations or anions that individually amount to 50 percent or more of the total cations or anions requires a multiple ion designation, in decreasing order of dominance. For example, a magnesium-calcium-chloride-sulfate water would be a water containing magnesium ion in greater concentration than calcium ion, and chloride ion in greater concentration than sulfate ion; however, none of the ions would be greater than 50 percent of the total milliequivalents of cations or anions. The trilinear diagram (Piper, 1953) shows graphically the major ion chemistry of water samples (lower left). The locations of the various cation-anion dominances of the water samples have been mapped to show areal distributions of the hydrochemical facies.

Three hydrochemical facies dominate the A4 aquifer: calcium bicarbonate, sodium bicarbonate, and sodium chloride. Near the recharge areas, calcium and bicarbonate are the dominant facies of the low dissolved-solids waters. Downgradient, where the dissolved-solids concentrations increase, sodium and bicarbonate are the prevalent solutes, as a result of water-rock interactions (Lee, 1984b). Farther downgradient, where dissolved-solids concentrations exceed 500 mg/L, sodium and chloride are the dominant solutes, probably as a result of mixing with saline water known to exist in the deep downgradient parts of the water-bearing zones. Waters in parts of the recharge areas may be calcium chloride, sodium chloride, or sodium bicarbonate facies, where dissolved-solids concentrations are less than 50 mg/L. Because small amounts of sodium, calcium, chloride, or bicarbonate enter the water in these areas, dominance of a particular ion may occur owing to low dissolved-solids concentrations. Low dissolved-solids concentrations may permit the dominance of facies such as calcium-sodium chloride facies. For the purposes of these maps, these occurrences will be grouped in the no dominant facies category.

Upper Water-Bearing Zone

Hydrochemical facies of ground water in the upper zone (center left) consist of three major groups that occur in bands nearly parallel to the Fall Line throughout the study area. Calcium bicarbonate is the dominant facies in the recharge areas; farther downgradient, sodium bicarbonate is dominant; then sodium chloride dominates farther downgradient. The sodium chloride facies appears to have displaced sodium bicarbonate upgradient in a few areas. Ground-water withdrawals may have caused sodium chloride waters to move toward Tupelo, Miss., and Montgomery, Ala., from downgradient or from deeper zones. Similarly, in Greene County, Ala., ground-water discharge from the upper zone to the Sipsey and Black Warrior Rivers may be the cause of sodium chloride waters moving into this area.

Middle Water-Bearing Zone

The middle zone (lower center) shows a distribution of hydrochemical facies similar to that in the upper zone. Calcium bicarbonate facies extends into central Georgia near the areas of outcrop. Downgradient, a narrow band of sodium-bicarbonate facies is present that appears to broaden eastward into South Carolina. Farther downgradient, the ground waters are dominated by sodium chloride facies, probably from mixing of the fresher recharge waters with deeper saline water. In northeastern Mississippi, the sodium chloride facies extends eastward to Tupelo, Miss., perhaps due to upward leakage caused by pumping. Sodium-chloride water is dominant in Greene County, Ala., probably due to upward discharge of saline water. Sodium chloride facies appear to extend landward from the Atlantic coast into Williamsburg Co., S.C.

Lower Water-Bearing Zone

Hydrochemical facies of the lower zone (lower right) are primarily calcium bicarbonate in and near the recharge areas, sodium bicarbonate downgradient, and sodium chloride in the deeper downgradient parts. These areas form sequential bands that are oriented parallel to the outcrop areas of this zone. Although data are scarce downgradient, the transition from sodium bicarbonate to sodium chloride facies is similar to that in the middle and upper zones. A narrow band of sodium bicarbonate dominated water extends upgradient toward the Fall Line in Pickens and Tuscaloosa Counties, Ala. A small area of sodium bicarbonate and sodium chloride water occurs upgradient in Lamar, Pickens, and Fayette Counties, Ala. These areas are characterized by waters of low dissolved-solids concentrations and not produced from mixing with the higher dissolved solids, saline waters described in downgradient areas.

CONCLUSIONS

Water-quality maps of the three most prominent water-bearing zones of the A4 aquifer in the Southeastern Coastal Plain show the areal distributions of concentrations of dissolved solids, dissolved chloride, and dissolved iron, and hydrochemical facies. Dissolved-solids, dissolved-chloride, and dissolved-iron concentrations increase from outcrop toward downgradient areas. Dissolved solids and dissolved chloride systematically increase farther downgradient, owing to mineral-water interactions and to the presence of saline water in the deeper parts of the water-bearing zones of the A4 aquifer. Dissolved-iron concentrations decrease farther downgradient, however, then increase again as the ground water becomes more saline.

There are three major hydrochemical facies in the water-bearing zones of the A4 aquifer: calcium bicarbonate in the ungradient recharge areas, sodium bicarbonate downgradient from the recharge areas where waters contain dissolved-solids concentrations ranging from 50 to 500 mg/L, and sodium chloride in the deep downgradient parts of the zones.

The concentrations of dissolved solids and chloride appear to increase in ground-water discharge areas. Ground-water withdrawals near Tupelo and West Point, Miss., and Montgomery, Ala., may have caused more saline waters to move laterally from downgradient areas toward pumping centers. In Greene and Hale Counties, Ala., discharge to the Sipsey and Black Warrior Rivers has apparently caused saline water in the deep parts of the zone to move upward. A similar effect is observed in northern Lowndes County, Ala., with apparent discharge of ground water to the Alabama River.

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WATER-QUALITY MAPS FOR SELECTED UPPER CRETACEOUS WATER-BEARING ZONES IN THE SOUTHEASTERN COASTAL PLAIN

By
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1985