GEOHYDROLOGIC SYSTEMS OVERLYING LOWER CRETACEOUS ROCKS

In the CMRASA investigation, only those geohydrologic systems that occur within the Upper Cambrian through Lower Cretaceous rocks have been included in the analysis. In this report, however, a brief discussion of overlying geohydrologic systems also has been included to describe the general hydrologic relations of these systems to the underlying systems. The principal overlying systems in Kansas, as shown in figure 5, are: (1) The alluvial and glacial-drift aquifer system, (2) the High Plains aquifer system, and (3) the Great Plains confining system. The combined thickness of the High Plains aquifer system and the Great Plains confining system (fig. 6) ranges from a few feet along the eastern extent of the systems to as much as 2,500 feet in the northwest corner of the State.

Alluvial and Glacial-Drift Aquifer System

Alluvial aquifers are described as those that occur within the fluvial deposits underlying the valleys of principal streams in the State (fig. 3). These deposits, which range in thickness from a few feet to as much as 150 feet, are composed of unconsolidated clay, silt, sand, gravel, and boulders. The aquifers are a principal source of water supply for domestic, stock, municipal, industrial, and irrigation uses. Yields to wells commonly range from 10 to 500 gallons per minute but may exceed 1,000 gallons per minute in local areas. Water generally is suitable for all uses but may contain large concentrations of dissolved solids, chloride, sulfate, iron, or manganese in some areas. In the western part of Kansas, the alluvial aquifers commonly are an integral part of the High Plains aquifer system. In the central and eastern parts of the State, the hydrologic significance of these aquifers generally relates to recharge from or discharge to the adjacent stream. For this reason, the alluvial aquifers are not considered here in further detail.

Glacial-drift aquifers occur within the deposits of glacial till in northeastern Kansas (fig. 3). These deposits, which may be as much as 300 feet thick, are composed of unsorted clay, silt, sand, gravel, and boulders. Because of the abundance of intermixed clay and silt, yields of water to wells in the till commonly are small. Yields of 10 to 100 gallons per minute are obtained from isolated lenses of sand and gravel, whereas yields of 100 to 500 gallons per minute may be obtained locally from deposits of periglacial streams within the till. Although water from shallow wells generally contains less than 500 milligrams per liter dissolved solids, water from deep wells may contain large concentrations of some minerals. The hydrologic significance of the glacial-drift aquifers is related mostly to streams that drain the area. Thus, these aquifers are not considered to warrant additional discussion in this report.

High Plains Aquifer System

The High Plains aquifer system underlies the land surface in much of the western one-half of Kansas, as shown in figures 3 and 6. This aquifer, which is the principal source of ground water in Kansas, provides substantial supplies for domestic, stock, industrial, municipal, and irrigation wells. The aquifer system consists mostly of the Ogallala Formation of Miocene age. In some areas, the aquifer also includes undifferentiated Pleistocene deposits and Quaternary alluvium. This unconsolidated unit is a heterogeneous assortment of permeable sediments composed of clay, silt, sand, and gravel. Because the system has been described in detail in the High Plains Regional Aquifer-System Analysis (Gutentag and Weeks, 1980), a brief discussion is included only to define the hydrologic relation with underlying geohydrologic systems.

Thicknesses of the deposits, which generally increase toward the west, are as much as 600 to 700 feet in the southwestern Kansas. Saturated thicknesses of the aquifer range from a few feet to between 500 to 600 feet. Although well yields are not related directly to saturated thicknesses, the coarsest channel deposits commonly occur in areas of greatest saturation. Yields to wells generally range from 100 to 1,000 gallons per minute but may be as much as 2,500 gallons per minute. Water in the High Plains aquifer system, which commonly contains less than 500 milligrams per liter dissolved solids, is of suitable quality for most uses. Recharge to the High Plains aquifer system is mostly from precipitation on the land surface and from rivers or intermittent streams crossing the area. The aquifer system discharges to streams and to alluvial aquifers in central Kansas and discharges downgradient into Lower Cretaceous and Jurassic rocks in the southwestern part of the State.

Great Plains Confining System

The Great Plains confining system consists of Upper Cretaceous rocks that underlie most of western Kansas, as shown in figure 6. These rocks are composed mostly of shale, chalk, and limestone that are sufficiently impermeable to retard the vertical movement of water. Thus, the rocks form a confining unit where they underlie the sand and gravel of the High Plains aquifer system or overlie the sandstones of the Great Plains aquifer system. Thicknesses of the confining system increase from a few feet at the southern and eastern margins to more than 2,000 feet in the northwestern part of the State.

Because most of the rocks of Late Cretaceous age are fine-grained and indurated, they generally yield little or no water to wells. Yields of 5 to 10 gallons per minute are obtained from domestic and stock wells completed in sandstone beds of the Upper Cretaceous rocks. Irrigation wells completed in some of the limestone have produced as much as 2,000 gallons per minute in areas of southwestern Kansas. These yields, however, are obtained from zones of fracture and collapse in the limestone that directly underlie and are in hydraulic connection with the High Plains aquifer system.

OVERLYING GEOHYDROLOGIC SYSTEMS

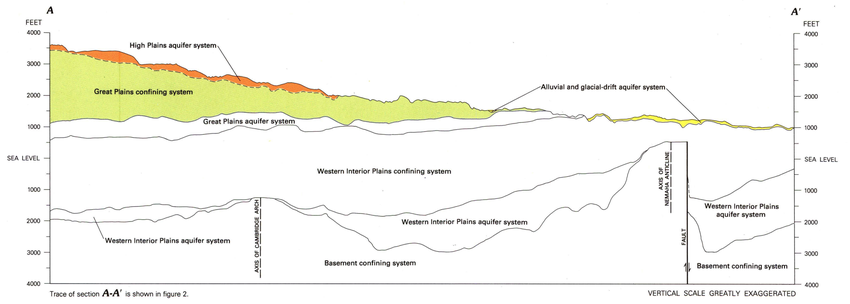

FIGURE 5.—Geohydrologic section showing relation of overlying geohydrologic systems to geohydrologic systems within Upper Cambrian through Lower Cretaceous rocks.

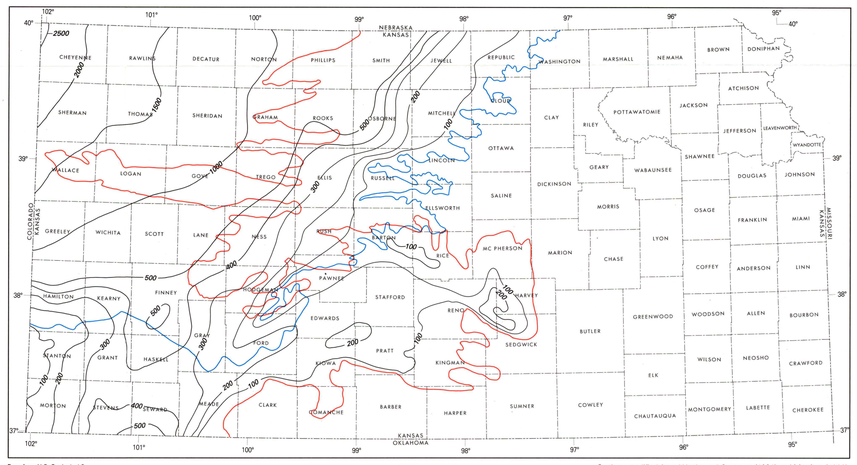

FIGURE 6.—Map showing extent and combined thickness of High Plains aquifer system and Great Plains confining system.

GREAT PLAINS AQUIFER SYSTEM

GEOHYDROLOGIC SYSTEMS IN LOWER CAMBRIAN THROUGH LOWER CRETACEOUS ROCKS

Great Plains Aquifer System

The Great Plains aquifer system, which underlies much of the western two-thirds of Kansas, includes all of the rocks of Early Cretaceous age. This aquifer, which is an important source of ground water in the western part of the State, commonly provides an adequate supply for domestic, stock, and public-supply wells. The unit generally is overlain by the Great Plains confining system, as shown on the geohydrologic section in figure 7, but also in the southwestern part of the State by the High Plains aquifer system. Depths to the top of the Great Plains aquifer system increase from the outcrop on the east and south to as much as 2,500 feet in the northwest corner of the State. Thicknesses of the unit generally increase toward the west and are more than 700 feet locally, as shown in figure 8.

Rocks in the section are a sequence of interbedded sandstone, siltstone, and shale. Permeabilities of the shale and siltstone are relatively slight, whereas those of the sandstone are moderate to large depending on the percentage of silt included or the degree of cementation. Sediments in this sequence probably were deposited along a coastline of an alternately advancing and retreating sea. Thus, the beds are discontinuous over large areas, and lithology in the section differs from one place to another. In general, however, the rocks are mostly sandstone in the upper and lower parts of the section, but mostly siltstone and shale in the intervening part. For this reason, the system has been divided into an upper and lower aquifer unit and an intervening confining unit.

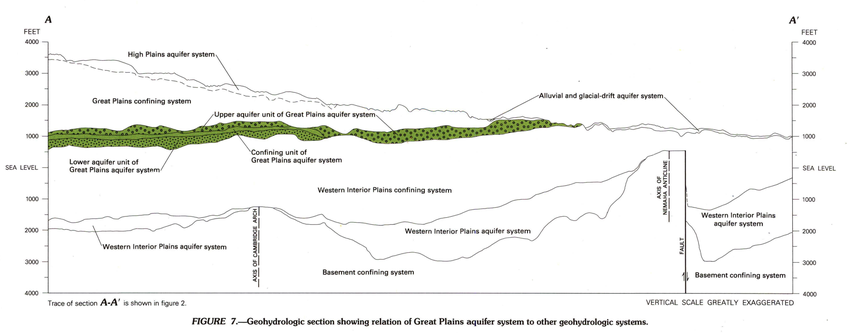

FIGURE 7.—Geohydrologic section showing relation of Great Plains aquifer system to other geohydrologic systems.

Upper Aquifer Unit

The upper aquifer unit of the Great Plains aquifer system in Kansas is stratigraphically equivalent to the Dakota Formation. The geohydrologic unit is equivalent, in part, to the Maha aquifer defined by the CMRASA study (D.G. Jorgensen, U.S. Geological Survey, written commun., 1985). The upper aquifer unit ranges in thickness from a few feet at the outcrop to as much as 400 feet in the northern and northwestern parts of the State. Yields of water to wells commonly range from 10 to 100 gallons per minute but may exceed 1,000 gallons per minute where the unit has only a small percentage of clay or silt and the sandstone is uncemented. Quality of the water in the aquifer commonly is suitable for domestic, stock, and irrigation use in areas near the outcrop, or where the unit directly underlies the High Plains aquifer system. In areas toward the north and west where the aquifer is deeply buried, the water is saline and unsuitable for most uses.

Confining Unit

The confining unit of the Great Plains aquifer system in Kansas is stratigraphically equivalent to the Kiowa Shale. This geohydrologic unit is equivalent, in part, to the Apishapa confining unit defined by the CMRASA study (D.G. Jorgensen, U.S. Geological Survey, written commun., 1985). Thicknesses of the confining unit differ greatly from one area to another and range from a few feet at the outcrop to as much as 300 feet elsewhere. Rocks in this part of the section are composed mostly of shale with thin layers of siltstone and sandstone. Because most of the sediments in the interval are fine grained, permeabilities are slight. Yields to wells from the unit generally are less than 1 to 2 gallons per minute, but sandstone beds may produce as much as 10 to 50 gallons per minute locally.

Lower Aquifer Unit

The lower aquifer unit of the Great Plains aquifer system in Kansas is stratigraphically equivalent to the Cheyenne Sandstone. This geohydrologic unit is equivalent, in part, to the Apishapa aquifer defined by the CMRASA study (D.G. Jorgensen, U.S. Geological Survey, written commun., 1985). The lower aquifer unit thickens from the southern and eastern margins to as much as 300 feet in the northern part. Rocks in the interval are composed of fine-grained sandstone with lenses of sandy shale and conglomerate. Yields to wells commonly range from 10 to 100 gallons per minute but may exceed 1,000 gallons per minute locally where the unit has only a small percentage of silt and the sandstone is uncemented. The quality of water in the aquifer is suitable for domestic and stock use in the outcrop area, but elsewhere the water is too saline for most uses.

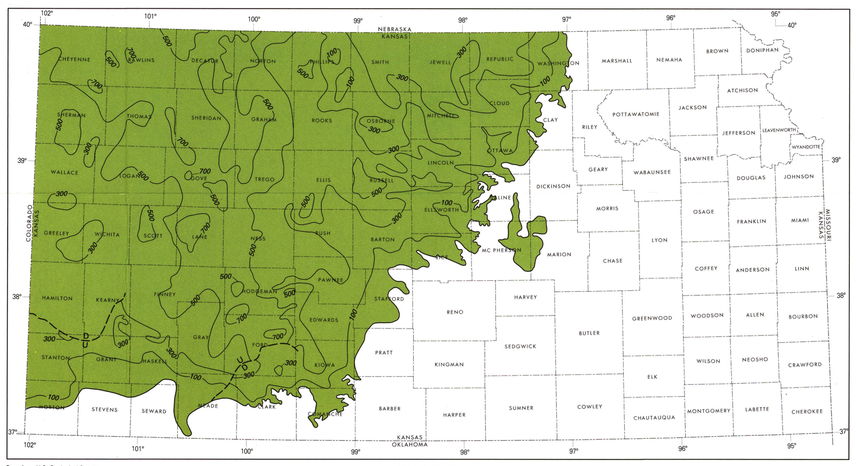

FIGURE 8.—Map showing extent and thickness of Great Plains aquifer system.

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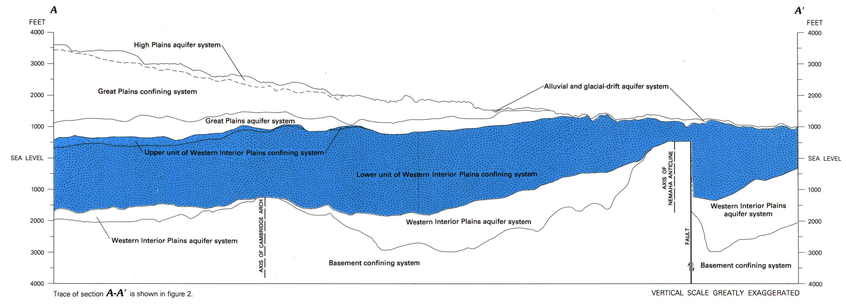
BASEMENT CONFINING SYSTEM

Igneous, metamorphic, and metasedimentary rocks of Precambrian age have been defined as the basement confining system (D.G. Jorgensen, U.S. Geological Survey, written commun., 1985). This system underlies the Western Interior Plains aquifer system in most of the State, but underlies the Western Interior Plains confining system in areas along the Central Kansas uplift, Cambridge arch, and Nemaha anticline. Because the surface of the basement confining system has been deeply eroded and weathered, the rocks commonly are fractured and covered by residual material (fig. 13). Water occurring in this upper zone generally is similar in composition to water in the overlying aquifer from which it was derived. The basement confining system is not considered to be a usable source of water in Kansas. Therefore, the top of the basement confining system (fig. 13) represents the lower limit of aquifers capable of providing usable yields to wells in Kansas.

WESTERN INTERIOR PLAINS CONFINING SYSTEM



FIGURF 9.—Geohydrologic section showing relation of Western Interior Plains confining system to other geohydrologic systems.

Western Interior Plains Confining System

Rocks of Late Mississippian (Chesterian) through Late Jurassic age in Kansas form a thick sequence (more than 6,000 feet) of sedimentary rocks that are defined as the Western Interior Plains confining system (figs. 9 and 10). This sequence of fine-grained sedimentary rocks extends throughout the State except for a very small area in the southeast corner (fig. 10). Due to significant hydrologic differences, two units in this system are described separately. The relation of the confining system and the units to other geohydrologic systems is shown on the geohydrologic section in figure 9. Rocks of Late Jurassic age in the sequence are designated as the upper unit of the system, whereas rocks of Permian, Pennsylvanian, and Late Mississippian age are designated as the lower unit.

Upper Unit

The upper unit is comprised of Upper Jurassic rocks, including the Morrison Formation, that generally underlie the western and northwestern part of Kansas, as shown in figure 9. Where present, the unit underlies the Great Plains aquifer system. Rocks in the upper unit are composed mostly of shale and sandy shale but have a silty sandstone near the base. Thicknesses range from a few feet to as much as 300 feet in local areas. The fine-grained sedimentary rocks generally yield little water to wells, but a few sandstone beds locally produce small yields that may be saline. Where the overlying Cretaceous rocks have been removed in southwestern Kansas, the quality of water in the sandstone is improved by direct recharge from the High Plains aquifer system. In that area, water from the Upper Jurassic sandstone has been used in conjunction with water from overlying aquifers for irrigation supplies. The potential yield to wells in Finney and Kearny Counties was estimated (Kume and Spinazola, 1985) to range from 30 to 300 gallons per minute.

Lower Unit

Rocks in the lower unit form a thick sequence of mostly fine-grained sedimentary rocks that extend throughout the State except for the southeastern corner, as shown in figure 10. This unit underlies all of the Upper Jurassic rocks in the upper unit, as well as part of the alluvial and glacial-drift, and Great Plains aquifer systems. Rocks in this section are mostly shale, sandstone, and limestone that have slight permeability. Thicknesses are greatest in the western two-thirds of the State, where the unit is buried beneath younger rocks. In that area, thicknesses range from about 1,800 feet at the northern boundary to about 6,300 feet at the southern boundary. The lower unit crops out in most of the eastern one-third of the State. Thicknesses in the outcrop area generally decrease eastward as a result of differential erosion. Where deformation occurred, the beds thin to about 500 feet over the Nemaha anticline and thicken abruptly to about 2,500 feet in the Forest City basin.

Rocks of Permian age, including the Big Basin Formation, Day Creek Dolomite, Whitehorse Formation, Nippewalla Group, Sumner Group, Chase Group, Council Grove Group, and Admire Group, constitute about one-half of the section in the lower unit. In general, the Permian rocks crop out in east-central Kansas and underlie all of the western part. Rocks in the section include about 3,000 feet of mostly shale, siltstone, and sandstone with some thin-bedded limestone near the base. Most of the sedimentary rocks in the section are typical of those deposited in arid areas where salt, gypsum, anhydrite, and other evaporite deposits commonly are intermixed. Three thick salt units occur within the interval.

In general, Permian rocks do not yield significant quantities of usable water to wells. In southwestern Kansas, solution cavities in the Day Creek Dolomite yield from 300 to 1,000 gallons per minute, but large concentrations of sulfate make the water unacceptable for use. The Cedar Hills Sandstone of the Nippewalla Group also contains large quantities of saline water that is unusable for most purposes. Thin limestone beds in the Chase and Council Grove Groups commonly yield 10 to 20 gallons per minute to wells in eastern Kansas. Water from wells in the outcrop area may be usable for domestic supplies, but the water is saline elsewhere.

Virgilian, Missourian, Des Moinesian, Atokan, and Morrowan rocks of Pennsylvanian age and Chesterian rocks of Late Mississippian age constitute the remaining one-half of the lower unit. These rocks crop out in the eastern part of Kansas and underlie the remaining part. Rocks in this part of the section include about 3,300 feet of interbedded shale, limestone, and sandstone with thin layers of coal. Generally, the Pennsylvanian and Chesterian rocks are composed of fine-grained sedimentary rocks that yield little or no water to wells. Channel-like deposits of sandstone in the Douglas Group may yield as much as 100 gallons per minute to wells near the outcrop area in eastern Kansas. Some limestone beds in Upper Pennsylvanian rocks also yield 10 to 20 gallons per minute to wells in fractured zones near the outcrop area. Water in these areas commonly is of suitable quality for domestic and stock use but is saline elsewhere.

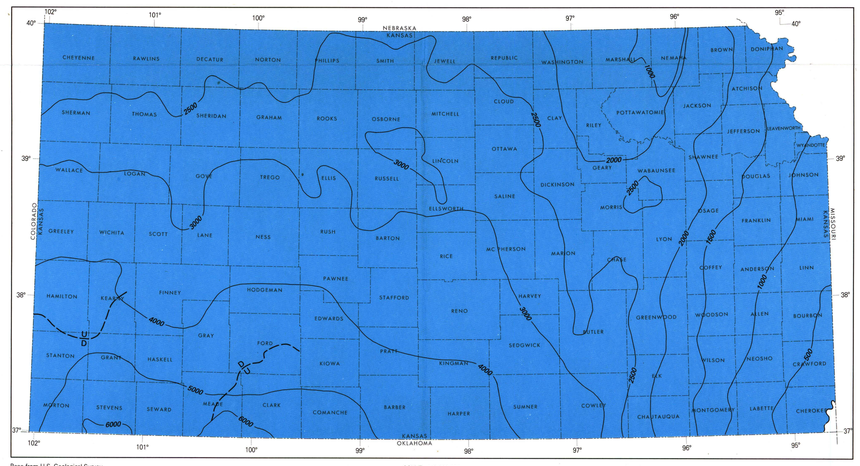


FIGURE 10.—Map showing extent and thickness of Western Interior Plains confining system.

WESTERN INTERIOR PLAINS AQUIFER SYSTEM

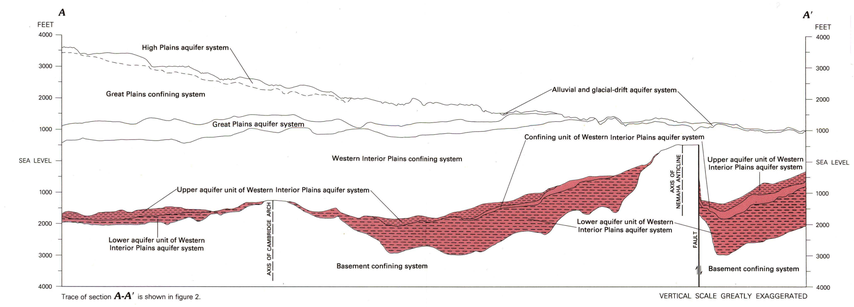


FIGURE 11.—Geohydrologic section showing relation of Western Interior Plains aquifer system to other geohydrologic systems.

Western Interior Plains Aquifer System

The geohydrologic unit in rocks of Late Cambrian through Late Mississippian age in Kansas is defined as the Western Interior Plains aquifer system (figs. 11 and 12). In a small area of southeastern Kansas, the system also has been included as part of a CMRASA subregional analysis (Imes, 1990) for the Ozark Plateau aquifer system with adjacent States. For ease of mapping and convenience of discussion, and to avoid problems related to interpretation of stratigraphic and hydrologic differences within the small, transitional area, only the terminology for the Western Interior Plains aquifer system is used in this report. Although the Upper Cambrian through Upper Mississippian rocks function collectively as an aquifer system, two aquifer units and an intervening confining unit are described, as shown on the geohydrologic section (fig. 11).

Upper Aquifer Unit

Rocks that comprise the upper aquifer unit include all of the carbonate rocks of Kinderhookian through Meramecian age, as shown with related stratigraphic units in table 1. Only the uppermost rocks of Kinderhookian age are included in the unit. Rocks in the upper aquifer unit are composed mostly of limestone and dolomite with some thin layers of shale. Rocks in the unit crop out in the southeastern part of the State and underlie the remaining part except where they have been eroded from the Central Kansas uplift, Cambridge arch, and Nemaha anticline (fig. 12). Thicknesses of the upper aquifer unit are greatest in the basin areas, with as much as 1,500 feet in the Hugoton embayment.

Although the limestone and dolomite generally are quite dense, permeable zones have been created by fracturing and dissolution. The most significant zones occur in relation to the erosional surfaces marked by unconformities. Water in the aquifer near the outcrop area commonly is a source of supply for domestic wells (contains less then 500 milligrams per liter dissolved solids). However, the water may be contaminated in local areas by the effects of mining activities (Spruill, 1987). Yields to wells generally range from 25 to 100 gallons per minute (Macfarlane and others, 1981) but may exceed 1,000 gallons per minute from intensely fractured zones.

Confining Unit

A predominantly shale sequence ranging in age from Early Kinderhookian to Late Devonian is described as the confining unit of the Western Interior Plains aquifer system. The confining unit extends across most of the eastern one-half of the State, except where it has been removed by erosion on the Nemaha anticline. Thicknesses are as much as 200 feet in the Sedgwick and Salina basins and 300 feet in the Forest City basin.

Rocks in the confining unit are mostly clayey to silty shale with thin layers of silty limestone. Because the permeability of these fine-grained deposits is slight, the unit is not considered to be a source for water supplies. The unit is most significant in eastern Kansas, where it is a confining unit between the upper and lower aquifer units of the system.

Lower Aquifer Unit

A thick series of mostly carbonate rocks of Late Cambrian through Early Devonian age in Kansas is described as the lower aquifer unit of the Western Interior Plains aquifer system. Rocks in the lower aquifer unit are composed of limestone, dolomite, shale, and sandstone. These rocks extend throughout the State except for isolated areas on the Central Kansas uplift, Cambridge arch, and Nemaha anticline. The lower aquifer unit underlies the confining unit of the Western Interior Plains aquifer system in most of the eastern one-half of Kansas but is in direct contact with the upper aquifer unit in the western part. Thicknesses of the lower aquifer unit generally are related to the major structural features. Rocks of the unit are thin or missing over the uplifts and thickest (about 1,200 to 1,600 feet) in the basins. Thicknesses in the western part of the State range from about 200 feet at the northern boundary to about 3,000 feet in the Hugoton embayment on the south.

Rocks of Middle Ordovician through Early Devonian age in the lower aquifer unit (as shown in table 1) are composed of limestone and dolomite, alternating with thick beds of shale. Because the carbonate rocks commonly are dense, permeability in the unit probably is a result of local fracturing and solution weathering related to erosional surfaces. A loose- to well-cemented, silty sandstone occurs in the Simpson Group. Drillers report that zones of the loose sand are very permeable, but the areal extent of those zones is limited. Middle Ordovician through Lower Devonian rocks are not commonly used as a source for water supplies.

The rocks of Late Cambrian through Early Ordovician age in Kansas are designated collectively as the Arbuckle Group. Rocks in the section, except for a thin basal sandstone, are mostly dolomite that differ only with respect to the minor sand and chert included. Studies of the Arbuckle in Kansas (Walters, 1958) indicate that most of the permeability is related to erosion and dissolution at the unconformable surfaces. It is probable that water moves through numerous sinks and caverns in a karst-like zone related to these surfaces.

Yields to wells from the Arbuckle Group in southeastern Kansas commonly range from 30 to 150 gallons per minute, but may exceed 500 gallons per minute locally (Bevans and others, 1985). Quality of water in this area is suitable for public-supply systems. Elsewhere in Kansas, the water is too mineralized for most uses. Records indicate that large quantities of oil-field brines are disposed into the Arbuckle in many areas of the State.

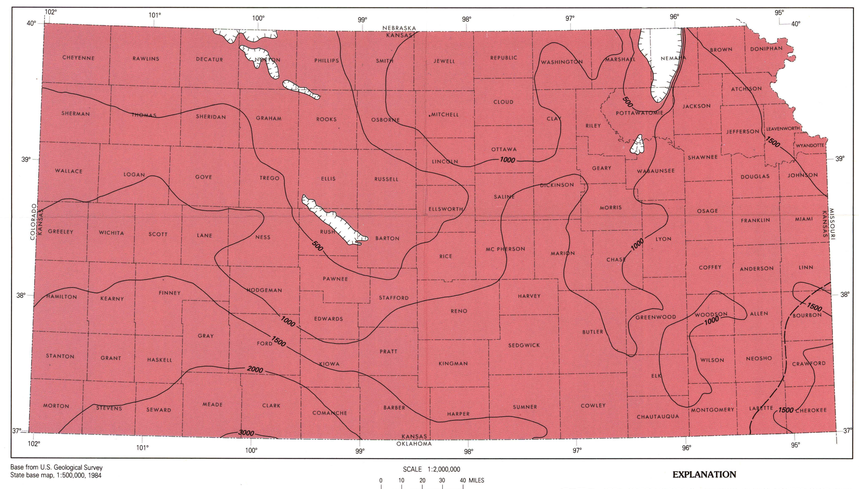


FIGURE 12.—Map showing extent and thickness of Western Interior Plains aquifer system.

BASEMENT CONFINING SYSTEM

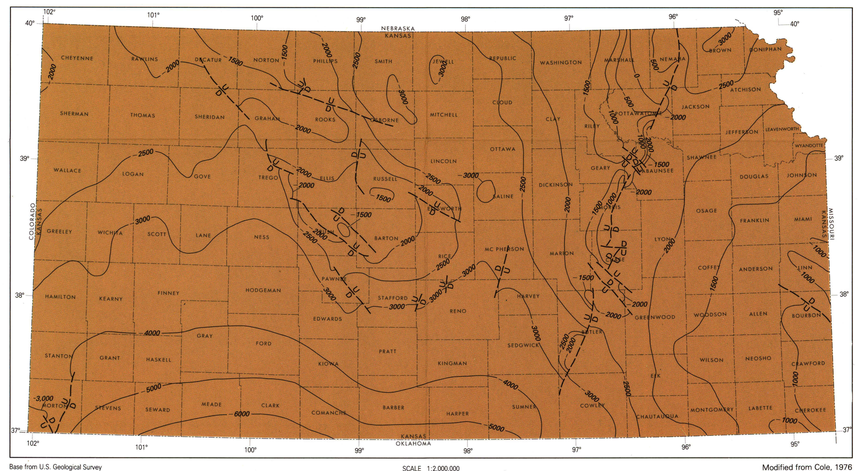


FIGURE 13.—Map showing altitude of top of basement confining system.

GEOHYDROLOGIC SYSTEMS IN KANSAS WITH EMPHASIS ON SYSTEMS IN UPPER CAMBRIAN THROUGH LOWER CRETACEOUS ROCKS

By
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