U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA-722-C (SHEET 2 OF 2)

THICKNESS OF UNITS

Upper Unit

In Kansas, the thickness of the upper unit of the Western Interior Plains confining system ranges from a few feet along its eastern limit and near where it is absent from the subsurface in Gove County to about 300 feet in parts of northwestern Kansas and western Hamilton County (fig. 6). In general, the upper unit of the confining system thickens from its eastern limit toward the northwest. The broad area of thinning along the eastern limit is due in part to beveling by erosion of the upper unit before deposition of overlying rocks.

The abrupt changes in thickness near the Bear Creek fault indicate an indirect relation to the subsidence in the overlying Permian rocks. It is probable that the thickness of the unit on the north (upthrown) side of the fault was decreased mostly by erosion after deposition.

Lower Unit

The thickness of the lower unit of the Western Interior Plains confining system in Kansas differs greatly in relation to several major factors. Where the unit is buried beneath younger rocks in the western part of the State, the thickness may represent most of the original deposition. Where the unit crops out in the eastern part (fig. 1), the abrupt changes in thickness indicate a relation to major deformation and erosion.

Thickness is greatest in the western part of Kansas where the lower unit is buried beneath Jurassic and Cretaceous rocks (fig. 7). In that area, thickness increases from about 1,800 feet near the Kansas-Nebraska State line to about 6,300 feet near the Kansas-Oklahoma State line. The general pattern of thickening is interrupted by the Central Kansas uplift, which is a northwest-trending structure (fig. 3). The lower unit thins over the uplift and thickens toward the southwest into the Hugoton embayment. The abrupt changes in thickness in the area between the Bear Creek and Crooked Creek-Fowler faults reflect the dissolution and removal of salt within the Permian rocks of this unit (Gutentag and others, 1981).

In the outcrop area, the effects of erosion on the lower unit are evident as the thickness decreases toward the east and toward the southeast corner where the rocks are absent (fig. 7). The effect of deformation created by the Nemaha anticline also is evident where the unit thins over the anticline and thickens rapidly eastward into the adjacent basin.

GENERALIZED HYDROLOGIC CHARACTERISTICS OF UNITS

Upper Unit

The upper unit of the Western Interior Plains confining system is composed mostly of sandy shale and silty sandstone that commonly yield little water to wells. Generally, water in the unit is saline and unacceptable for most uses. In parts of southwestern Kansas, where the overlying Cretaceous rocks have been removed by erosion, sandstone beds have received direct recharge from the High Plains aquifer. Sandstone beds in the upper unit in Morton and Stanton Counties are a source of water that commonly is used in conjunction with water from the overlying Great Plains or High Plains aquifer systems (Gutentag and others, 1981). That part of the well yield contributed by the upper unit in Morton and Stanton Counties has not been identified separately from that yielded by overlying aquifer systems. The sandstone is reported to have the potential for well yields that range from 30 to 300 gallons per minute in Finney and Kearny Counties (Kume and Spinazola, 1985).

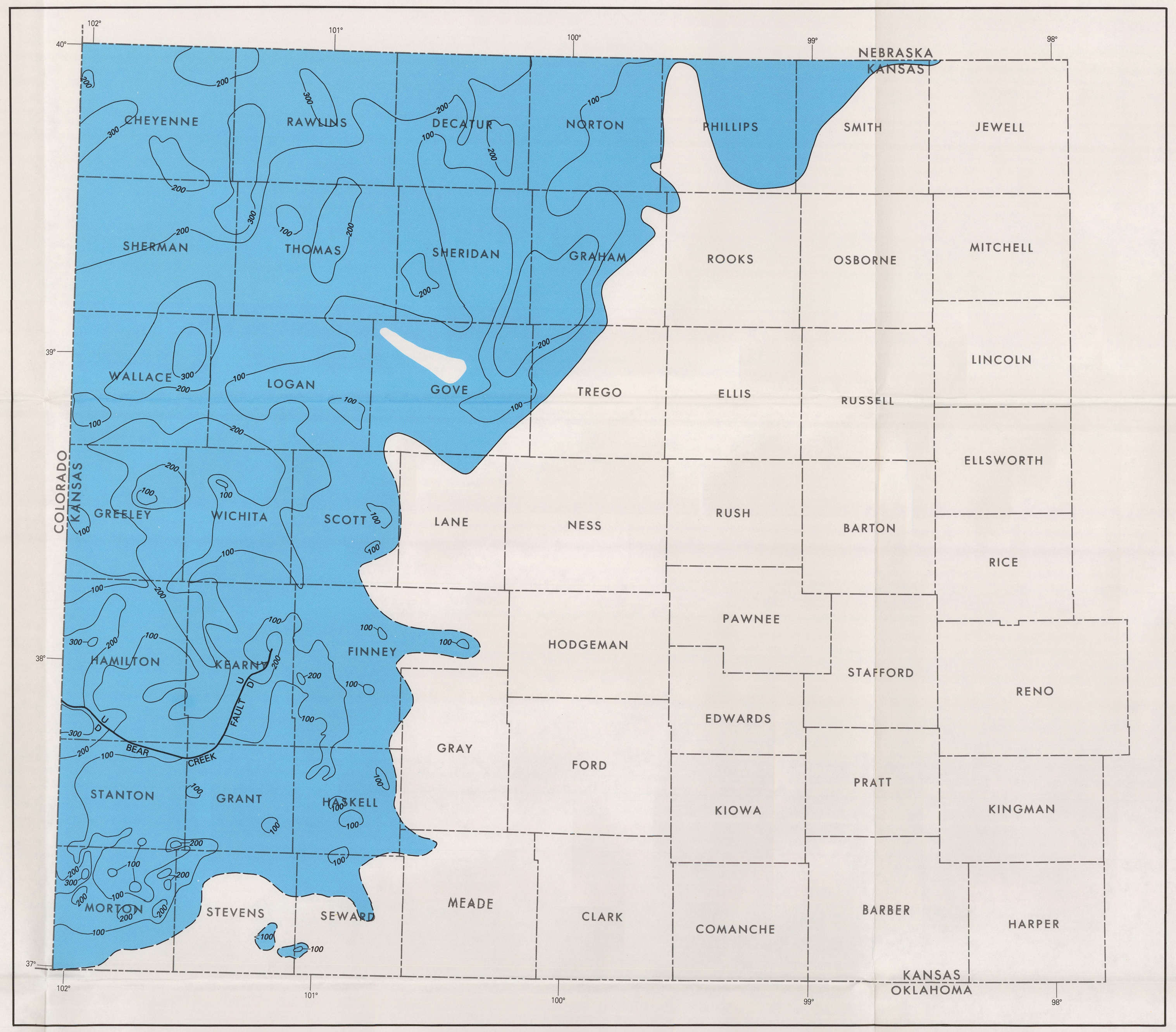
Lower Unit

Rocks of Permian age underlie about 80 percent of the State and constitute nearly one-half of the section in the lower unit of the confining system (table 1). These rocks include almost 3,000 feet of shale, siltstone, and sandstone that grade downward into interbedded shale, limestone, and sandstone near the base. Sediments in much of the Permian section are typical of those deposited in arid climates, where salt, gypsum, anhydrite, and other evaporite deposits commonly are intermixed. Three major salt units that occur within the Permian section are discussed in the section "Salt Units within the Lower Unit."

Most of the Permian rocks in the section do not yield substantial quantities of water to wells. In small areas of southwestern Kansas, however, solution cavities that formed in the anhydrite and gypsum beds of the Day Creek Dolomite have yielded from 300 to 1,000 gallons per minute to wells. Because of the large concentrations of sulfate, however, the water is not acceptable for irrigation use. In many areas, the Cedar Hills Sandstone also yields large quantities of saline water that is not usable for most purposes. Near the outcrop areas in eastern Kansas (fig. 1), limestone in the Chase and Council Grove Groups commonly yields from 10 to 40 gallons per minute to domestic wells. Locally, yields may exceed 200 gallons per minute where the limestone is intensely fractured (Bevans and others, 1985).

Rocks of Pennsylvanian age crop out in a broad band through eastern Kansas and underlie all of the State except for a small area in the southeast corner (fig. 1). Upper Mississippian (Chesterian) rocks are deeply buried in the subsurface in all or part of 12 counties in southwestern Kansas (Merriam, 1963) near the boundary with Oklahoma (fig. 1) and represent the lower part of the lower unit. Together, these sedimentary rocks constitute the lower 3,400 feet of the lower unit of the Western Interior Plains confining system. The section consists of alternating marine and continental sedimentary rocks that include shale, limestone, and sandstone with numerous thin coal beds.

Generally, the Pennsylvanian and Upper Mississippian rocks are composed of fine-grained sedimentary rocks that yield little or no water to wells. In the outcrop area, the weathered rocks near the land surface commonly yield a few gallons per minute to domestic wells. Where channel-type sandstone occurs in the Douglas Group, yields to domestic wells range from 10 to 40 gallons per minute. Locally, yields from this sandstone may exceed 100 gallons per minute (Bevans and others, 1985).



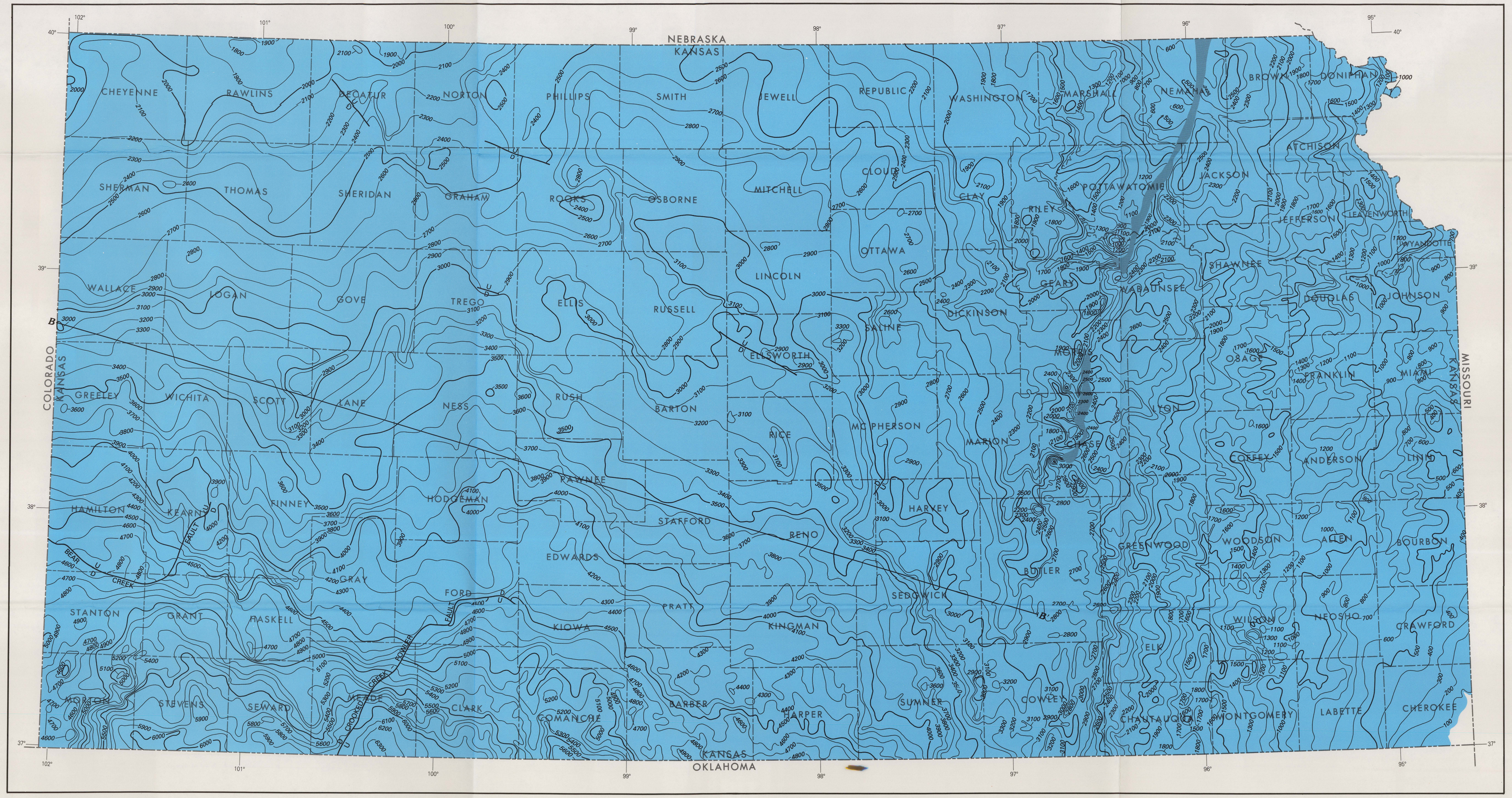
Base from U.S. Geological Survey
State base map, 1:500,000, 1984

SCALE 1:1,000,000
0 10 20 30 40 MILES
0 20 40 KILOMETERS

FIGURE 6.—Geohydrologic map showing thickness of upper unit.

EXPLANATION

🟦	AREA OF UPPER UNIT OF CONFINING SYSTEM
☐	AREA WHERE UPPER UNIT OF CONFINING SYSTEM IS ABSENT
—100—	LINE OF EQUAL THICKNESS OF UPPER UNIT—Interval 100 feet
U/D	FAULT—U, upthrown side; D, downthrown side
— — —	LIMIT OF UPPER UNIT—Dashed where approximate



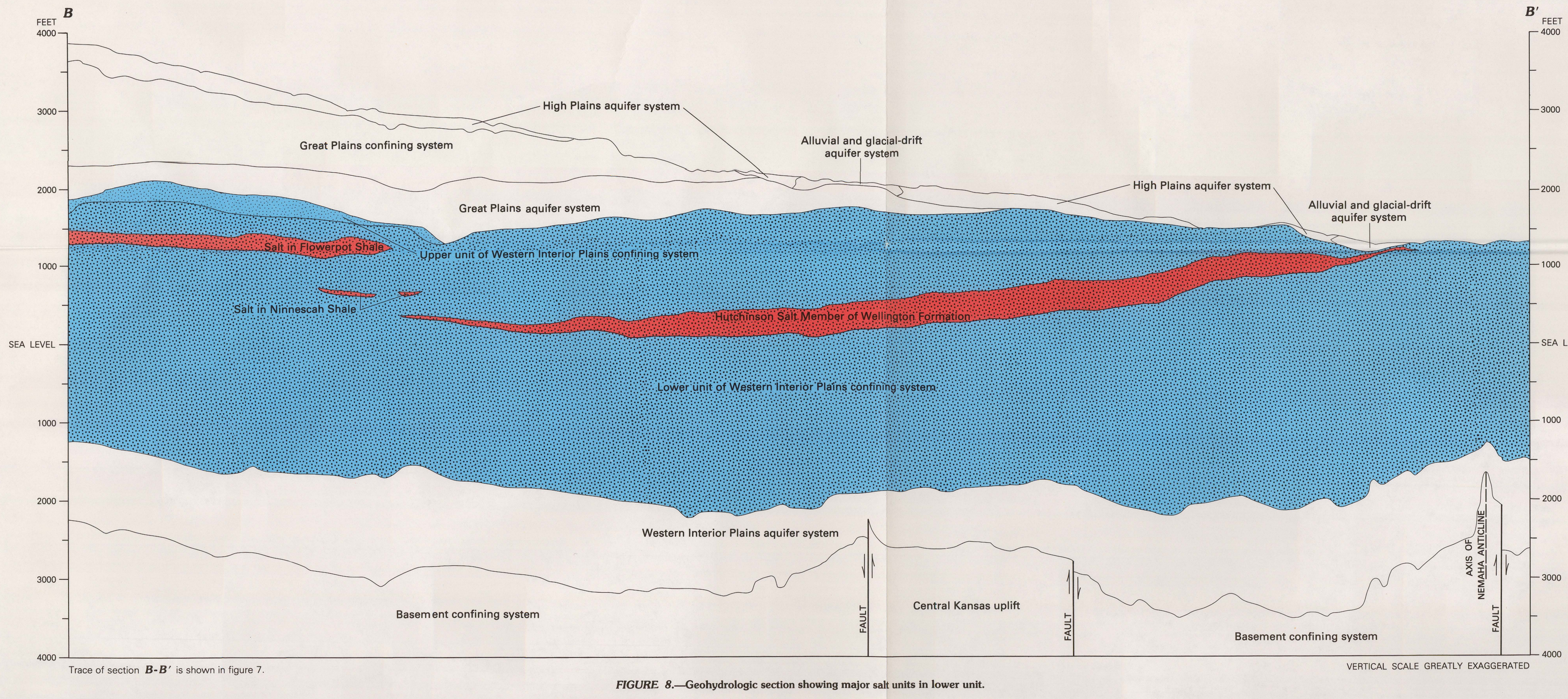
Base from U.S. Geological Survey
State base map, 1:500,000, 1984

SCALE 1:1,000,000
0 10 20 30 40 MILES
0 20 40 KILOMETERS

FIGURE 7.—Geohydrologic map showing thickness of lower unit.

EXPLANATION

🟦	AREA OF LOWER UNIT OF CONFINING SYSTEM
☐	AREA WHERE LOWER UNIT OF CONFINING SYSTEM IS ABSENT
▨	AREA OF ABRUPTLY CHANGING THICKNESS
—100—	LINE OF EQUAL THICKNESS OF LOWER UNIT—Interval 100 feet
U/D	FAULT—U, upthrown side; D, downthrown side
B——B′	TRACE OF SECTION



B
B′
FEET
4000
3000
2000
1000
SEA LEVEL
1000
2000
3000
4000
High Plains aquifer system
Great Plains confining system
Alluvial and glacial-drift aquifer system
Great Plains aquifer system
High Plains aquifer system
Alluvial and glacial-drift aquifer system
Salt in Flowerpot Shale
Upper unit of Western Interior Plains confining system
Salt in Ninnescah Shale
Hutchinson Salt Member of Wellington Formation
Lower unit of Western Interior Plains confining system
Western Interior Plains aquifer system
Basement confining system
FAULT
Central Kansas uplift
FAULT
AXIS OF NEMAHA ANTICLINE
FAULT
Basement confining system
VERTICAL SCALE GREATLY EXAGGERATED

Trace of section B-B′ is shown in figure 7.

FIGURE 8.—Geohydrologic section showing major salt units in lower unit.

SALT UNITS WITHIN LOWER UNIT

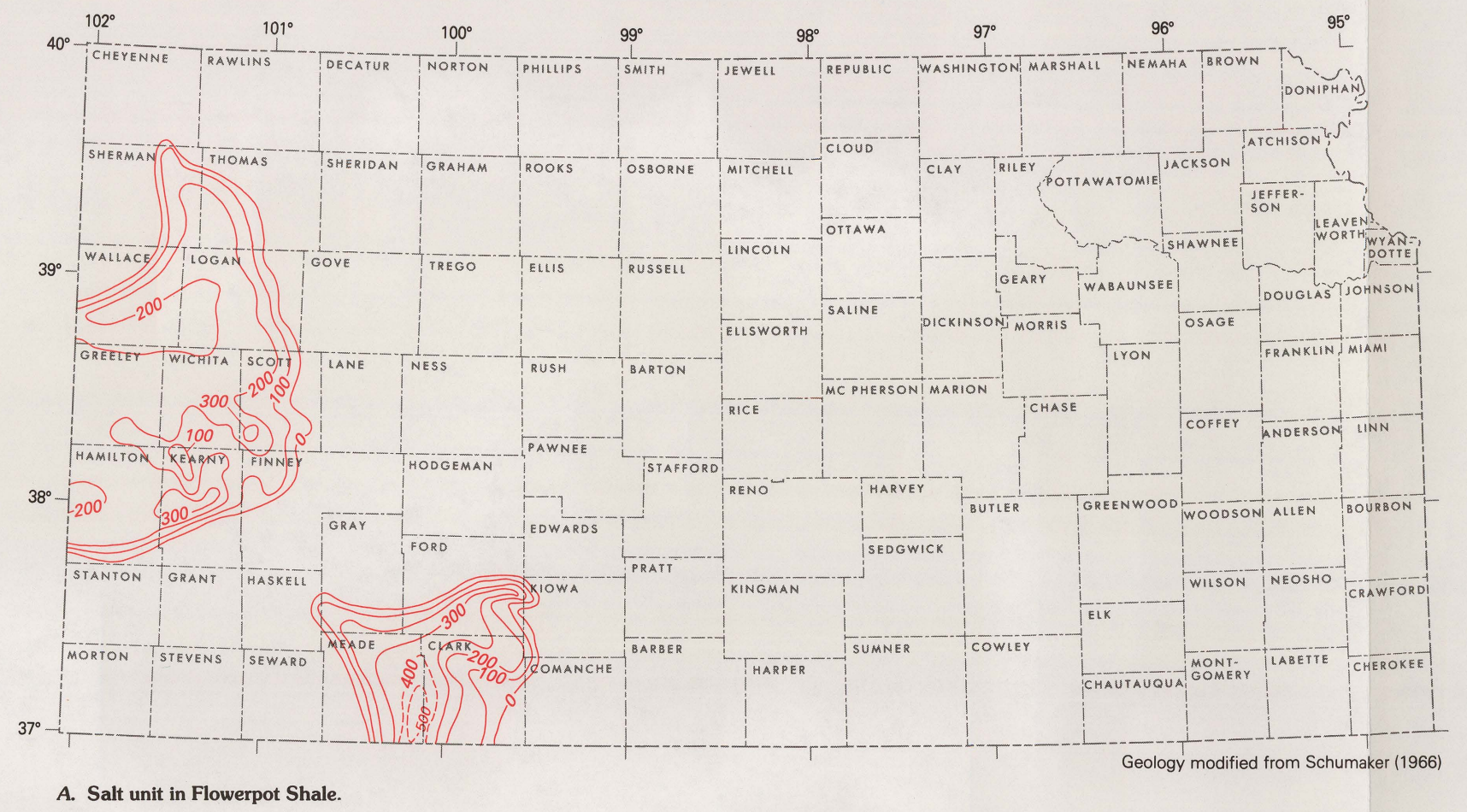
Bedded salt is an effective confining material that restricts vertical ground-water movement. The presence of these beds infers that virtually no water moves through the salt from the rocks above or below. In Kansas, the salt units also have a significant effect on water quality and geologic structure. Where circulating water dissolves and removes salt from the edges of a deposit, the resulting brine is transmitted to adjacent aquifers. This brine affects the quality of the water in rocks hydraulically downgradient from the salt deposit (Gogel, 1981). Where this brine is discharged at the land surface, the streamflow quality also is affected (Gogel, 1981).

The dissolution and removal of salt creates voids that eventually cause the collapse of overlying rocks. The depression between the Bear Creek and Crooked Creek-Fowler faults (figs. 4 and 5) probably is the result of collapse or subsidence after dissolution and removal of evaporites from the Blaine Formation and the Flowerpot Shale rather than the result of structural movement (Gutentag and others, 1981). Several large sinkholes in Meade and Clark Counties, including Big Basin, are associated with dissolution of salt in the Flowerpot Shale and the collapse of over-lying rocks (Merriam, 1963). Sinkholes in McPherson, Harvey, and Sedgwick Counties are associated with dissolution of salt in the Hutchinson Salt Member of the Wellington Formation (Merriam, 1963).

In Kansas, three major salt units occur in the lower unit of the Western Interior Plains confining system (fig. 8). The uppermost salt unit is in the Flowerpot Shale of the Nippewalla Group (fig. 8 and table 1). The salt unit in the Flowerpot Shale (fig. 9A) occurs in a small area in southwest Kansas where the maximum thickness is about 500 feet and a larger area in west-central Kansas where the maximum thickness is about 300 feet. A comparison of the southeast edge of the larger area and the northwest edge of the smaller area to the location of the Bear Creek and Crooked Creek-Fowler faults (figs. 5 and 6) indicates a reasonable correlation. Thus, absence of the uppermost unit between the two faults is attributed to the dissolution and removal of the salt (Gutentag and others, 1981).

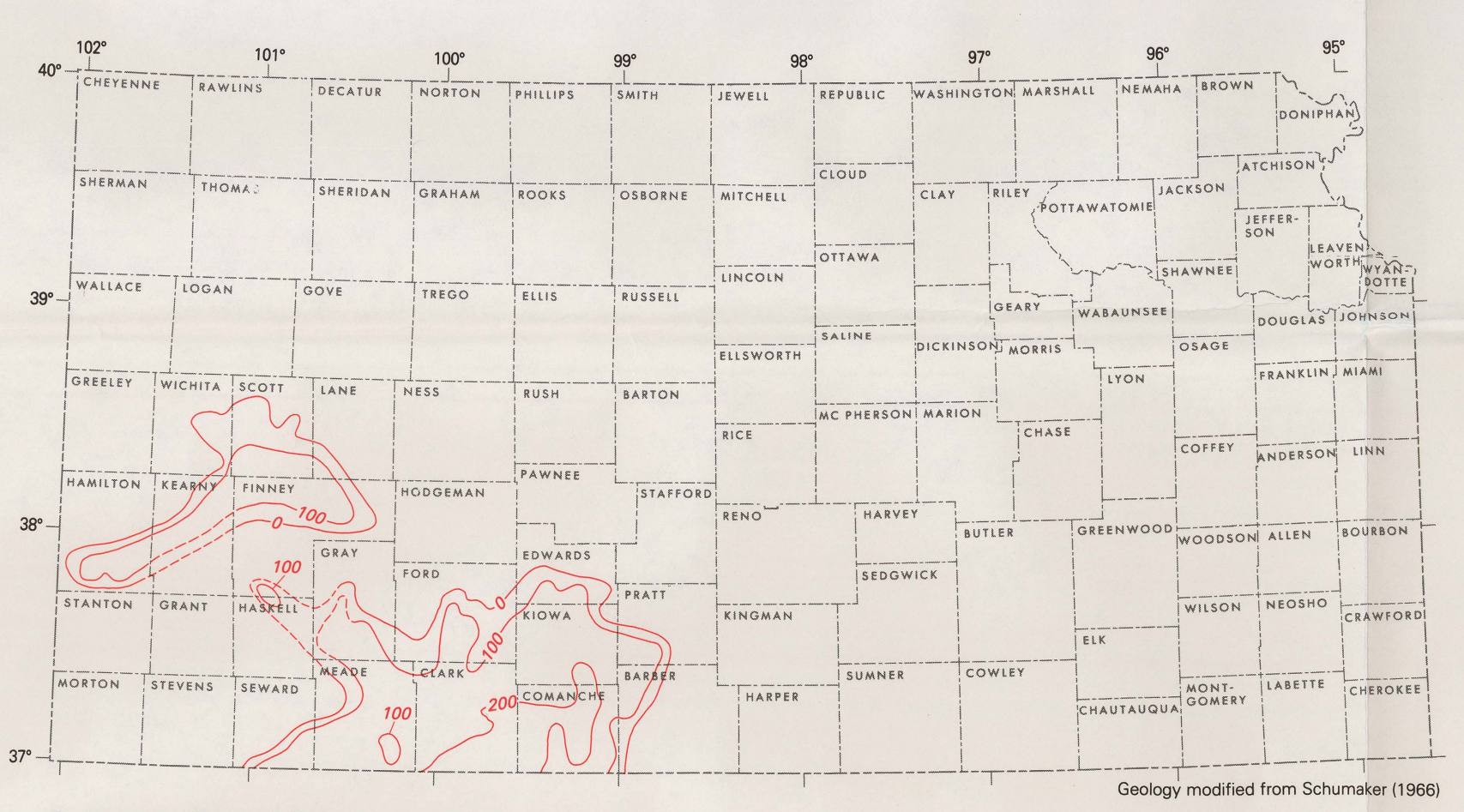
The middle salt unit occurs in the Ninnescah Shale of the Sumner Group (fig. 8 and table 1). The salt unit in the Ninnescah Shale (fig. 9B) also occurs in two separate areas. The larger area is centered in Clark and Comanche Counties and has a maximum thickness of about 200 feet. The smaller area in west-central Kansas has a maximum thickness of about 100 feet.

The lowest major salt unit in the confining system is the Hutchinson Salt Member of the Wellington Formation of the Sumner Group (fig. 8 and table 1). This salt unit is present in about one-third of central and western Kansas. Maximum thickness of the unit is about 500 feet along the Kansas-Oklahoma State line in Barber, Clark, Comanche, Kiowa, and Pratt Counties (fig. 9C). Dissolution is active along the eastern edge of the Hutchinson Salt Member where the unit is near the land surface (Watney and Paul, 1980; Gogel, 1981). This unit appears to be unaffected by dissolution along the western edge. The salt in this lowest major unit is comparatively pure and is commercially mined in Central Kansas (Bayne, 1972).



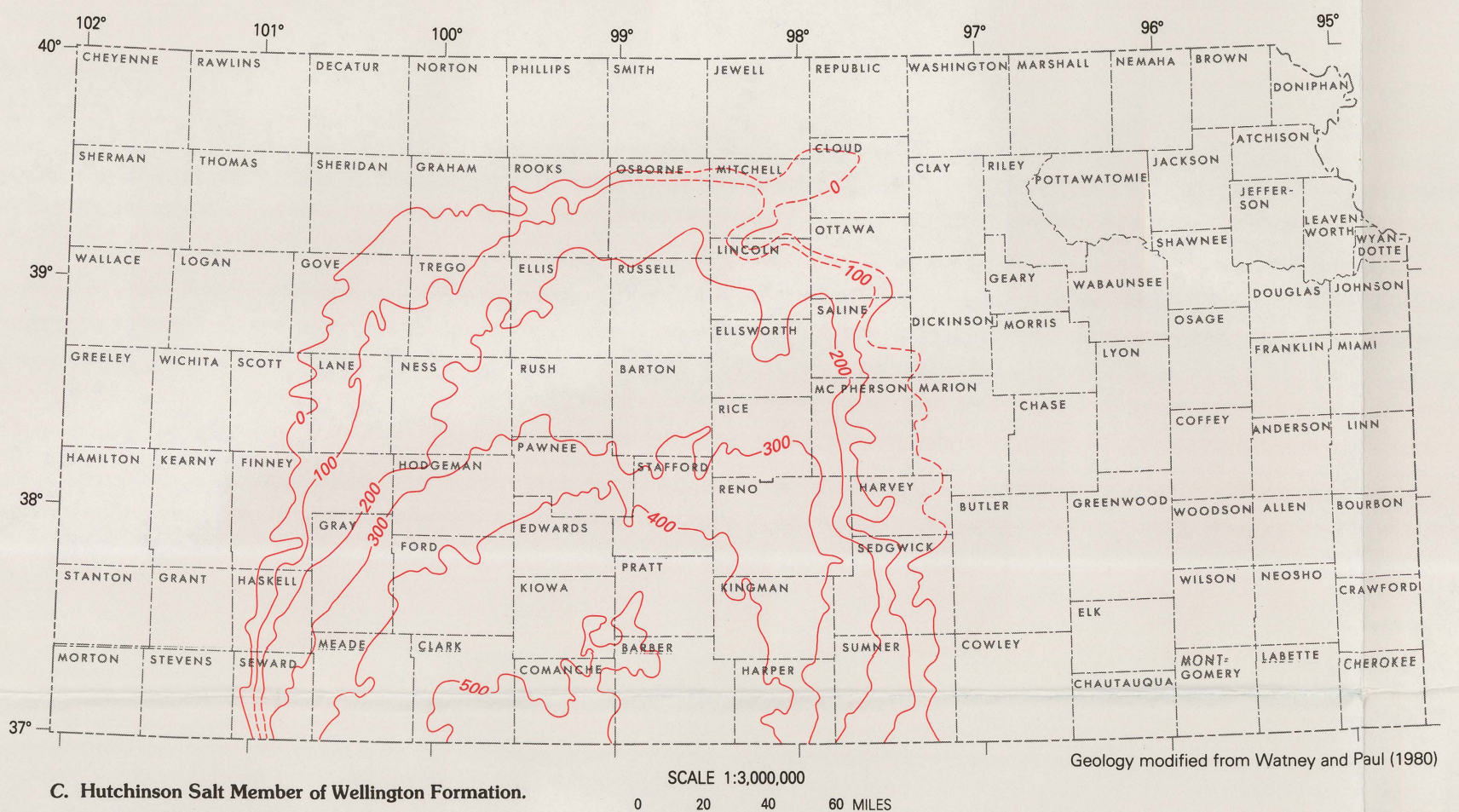
Geology modified from Schumaker (1966)

A. Salt unit in Flowerpot Shale.



Geology modified from Schumaker (1966)

B. Salt unit in Ninnescah Shale.



Geology modified from Watney and Paul (1980)

C. Hutchinson Salt Member of Wellington Formation.

SCALE 1:3,000,000
0 20 40 60 MILES
0 20 40 60 KILOMETERS

EXPLANATION

—100- - - LINE OF EQUAL THICKNESS OF SALT UNIT—Dashed where approximately located. Interval 100 feet

FIGURE 9.—Geohydrologic map showing thickness of major salt units in lower unit.

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GEOHYDROLOGIC SYSTEMS IN KANSAS—PHYSICAL FRAMEWORK OF THE WESTERN INTERIOR PLAINS CONFINING SYSTEM

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1992