PRELIMINARY DELINEATION AND DESCRIPTION OF THE REGIONAL AQUIFERS OF TENNESSEE--BASAL SANDSTONE WEST OF THE VALLEY AND RIDGE PROVINCE

J.V. Brahana, Michael W. Bradley, Jo Ann Macy, and Dolores Mulderink

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI)

For the convenience of readers who may want to use International System of Units (SI), the data may be converted by using the following factors:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallons per minute (gal/min)	0.004	cubic meters per minute (m^3/min)

National Geodetic Vertical Datum of 1929 (NGVD of 1929: A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

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ABSTRACT

The basal sandstone is a poorly sorted, well indurated sandstone, which lies below the Conasauga Group and above the Precambrian crystalline rocks. It is an unknown resource defined by limited data, with only 14 data points (wells) for the entire State of Tennessee. The basal sandstone is thought to occur throughout most of the State west of the Valley and Ridge province at depths of generally more than 5,500 feet below land surface. The basal sandstone probably does not receive significant vertical recharge because the sandstone is overlain by such a thick sequence of flat-lying, low-porosity lower Paleozoic carbonates and shales. Data from two sites indicate that the rocks of the basal sandstone have relatively low porosity and permeability.

The concentrations of dissolved solids in water from the basal sandstone range from less than 40,000 milligrams per liter to more than 200,000 milligrams per liter. The basal sandstone is not being used as a source of drinking water because of its great depth, the presence of shallower sources of drinking water, and possible concentrations of more than 10,000 milligrams per liter dissolved solids throughout its area of occurrence.

INTRODUCTION

The Safe Drinking Water Act (Public Law 93-523) includes provisions for the protection of underground sources of drinking water. Part C of the Act authorizes the Environmental Protection Agency (EPA) to establish regulations to insure that underground injection of contaminants will not endanger existing or potential sources of drinking water. As developed by EPA, the regulations require that all underground sources of drinking water with less than 10,000 milligrams per liter (mg/L) dissolved solids that contain hydrocarbon, mineral, or geothermal resources be designated for protection whether or not they are currently being used as a source of drinking water.

The geologic formations of Tennessee (Miller, 1974) have been combined into eight major regional aquifers. Aquifers are delineated on a regional basis and are characterized by a unique set of hydrologic conditions and water quality.

The purpose of this report is to describe the formations that comprise the Cambrian basal sandstone west of the Valley and Ridge province and to delineate water-quality zones within the basal sandstone.

This report on the basal sandstone provides generalized information on (1) the areal and stratigraphic occurrence, (2) dissolved-solids concentration of the ground water, (3) the hydraulic character, and (4) the areas of known ground-water contamination in the stratigraphic section from the base of the Conasauga Group to the top of the Precambrian crystalline rocks. Formation names and physiography used in this report are those of the Tennessee Division of Geology (Miller, 1974) and do not necessarily follow the usage of the U.S. Geological Survey.

GEOLOGY

The basal sandstone is thought to occur throughout most of the State west of the zone of thrust faulting that marks the western boundary of the Valley and Ridge province (fig. 1). The formations that comprise the basal sandstone are also found in the Valley and Ridge province east of the area described in this report but are not included here. The formations in the Valley and Ridge have been intensely folded and faulted and because of this deformation are part of a separate system.

The primary rock type of the basal sandstone is sandstone; minor carbonates have been noted at some locations and, in fact, may be part of the overlying confining layer. Drilling records and the deep geophysical logs that exist indicate the thickness of the basal sandstone averages about 200 to 400 feet. However, the basal sandstone appears to be absent in several locations. The basal sandstone is a tan to light gray, fine- to coarse-grained rock that is poorly sorted and well indurated. Interbeds of dark gray to brown dolomite are present. Major geohydrologic characteristics of the basal sandstone are described in table 1. The basal sandstone is defined by only 14 wells drilled for energy or mineral exploration, or for deep waste disposal (table 2).

Overlying the basal sandstone is the Conasauga Group and its equivalents. The Conasauga Group is composed of light- to medium-gray limestone with minor amounts of gray to green impermeable shale (Warner, 1972; Geraghty and Miller, 1978). Driller's records, resistivity logs, and gamma ray logs indicate that the limestone of the Conasauga and Rome contains increasing amounts of argillaceous material with depth. The configuration of the base of the Conasauga Group, which is equivalent to the top of the basal sandstone, is shown in figure 2.

The unit on which the basal sandstone rests is a granitic rock. It is assumed that below the weathered surface of this Precambrian basement the rocks have no effective porosity or permeability. Very little water is thought to exist below the basal sandstone. The configuration of the top of the basement granite is shown in figure 3.

Locations of lines of geohydrologic sections based on geophysical logs are presented in figures 2 and 3. The sections themselves are shown in figures 4 through 9. Because of the paucity of data, however, these sections are highly generalized.

HYDROLOGY

Hydrologic data for the basal sandstone is limited to that from the deep waste disposal wells in Maury and Humphreys Counties. Data from these wells indicate that, with the exception of a few thin zones, the basal sandstone is dense and has low porosity and permeability. An undocumented reference in a request to inject waste in Maury County indicated the basal sandstone has higher permeability in some zones than in others (Geraghty and Miller, 1978). Confining pressures at depths to which the basal sandstone occurs are expected to keep fractures and joints closed. Additionally, the thick beds of the overlying Conasauga and Knox Groups restrict vertical movement of water into or out of the sandstone. No water-level measurements exist from the basal sandstone. But based on the very tight nature of the formations and confinement from above and below, it is assumed that lateral flow in the basal sandstone is not significant. Ground-water occurrence in the basal sandstone is presented in a simplified and generalized manner in figure 10. Additional data are necessary to confirm or disprove this model.

WATER QUALITY

The basal sandstone is not currently being used as a source of drinking water within the state, nor has it been extensively explored as a source of minerals, oil, or gas. The only chemical analyses available at this time are from several drill stem tests, swab tests, and indirect analysis from geophysical logs made in conjunction with the drilling of the deep waste injection wells in Humphreys and Maury Counties (table 3 and fig. 11). The results of these tests are contradictory and, in fact, not one of the analysis reported can be confidently used to represent the general quality of the natural water in the basal sandstone. Inconsistencies in the data suggest that the values greater than 50,000 mg/L may be due to contaminants migrating from nearby disposal wells.

There are no records available indicating that the basal sandstone is used as a source of drinking water. This formation occurs at depths generally greater than 5,500 feet below land surface, and it has not been economically feasible to drill wells into the basal sandstone (with unknown water quality) when good quality drinking water can be found at much shallower depths.

CONTAMINATION

Three documented sites of contamination are known for the basal sandstone (fig. 11). All three sites are associated with deep injection wells in Humphreys and Maury Counties. These waste-injection wells are open to a thick stratigraphic section, from the lower part of the Knox Group to the Precambrian, and as best can be determined from existing data, the injected fluids have invaded the permeable zones throughout parts of the entire section. The areal extent of the injected waste in the basal sandstone is not known. Deep-well injection at these sites is discussed by Warner (1972), Resources Services Incorporated (1975), and (Geraghty and Miller (1978).

SUMMARY

The basal sandstone occurs in the subsurface probably throughout most of Tennessee west of the Valley and Ridge province. The basal sandstone is overlain by the Conasauga Group, a thick sequence of flat-lying, low-permeability lower Paleozoic carbonates and shales that acts as an upper confining layer for the basal sandstone. Precambrian granitic rocks underlie the basal sandstone and act as a lower confining layer.

Limited data indicate that with the exception of a few thin zones, the basal sandstone is dense and has low porosity and permeability.

Dissolved-solids concentrations in three water samples from the basal sandstone range from 38,500 to 201,800 mg/L. Interpretation of these data are subject to doubt, but suggests that values greater than 50,000 mg/L may be due to migration of contaminants from nearby disposal wells.

The basal sandstone is not currently being used as a source of drinking water nor has it been extensively explored for gas, oil, or minerals.

There are three documented sites of contamination of the basal sandstone. All are associated with deep injection wells. Study of existing data suggests that the injected fluids have invaded permeable zones throughout parts of the section exposed to the waste. The areal extent of this contamination is not known.

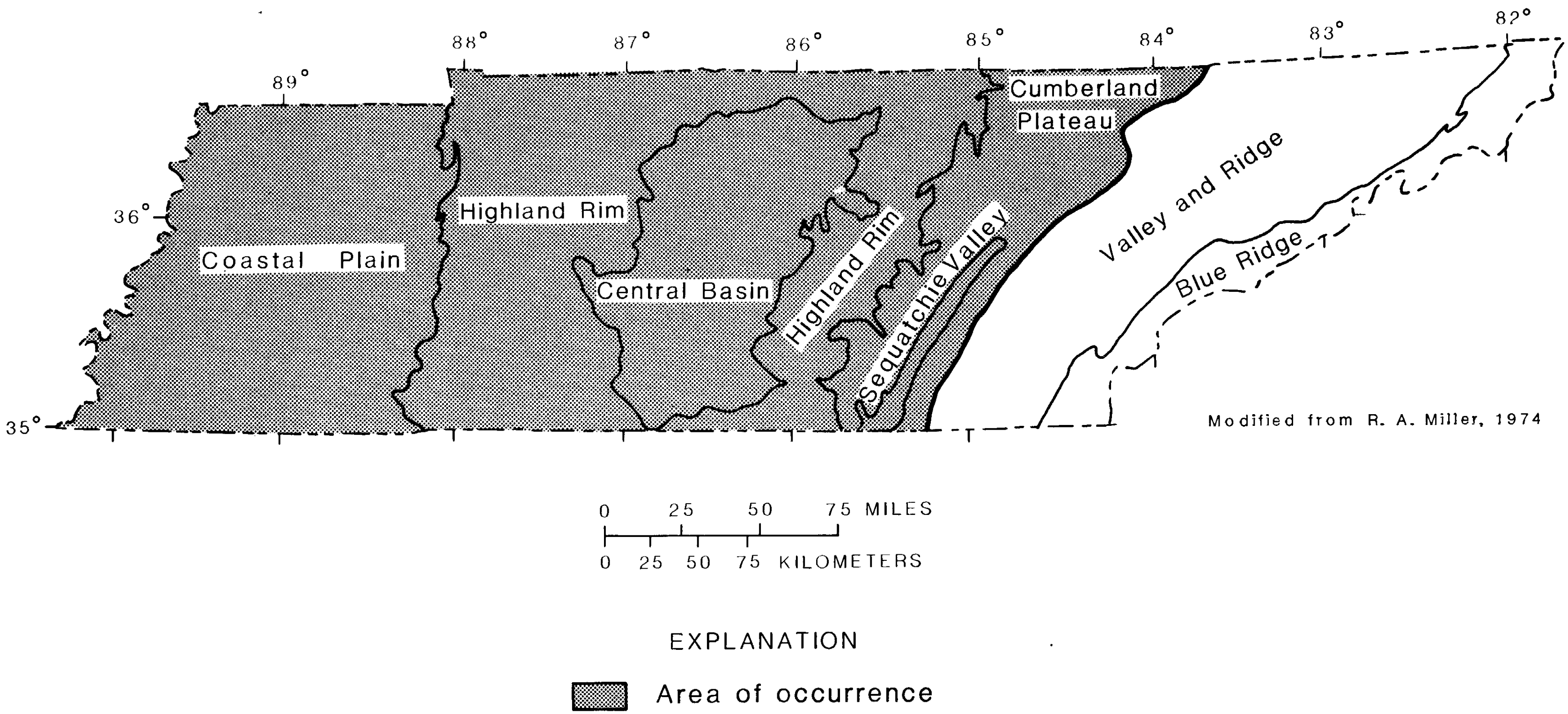


Figure 1.--Areal occurrence of the basal sandstone and physiographic provinces in Tennessee.

Table 1.--Geohydrology of the formations comprising the basal sandstone, and confining units

[Sources: Freeman (1953), Hardeman (1966), Miller (1974), unpublished consultants' reports and well logs on file with Tennessee Division of Geology]

SYSTEM	SERIES	STRATIGRAPHIC UNIT	GEOLOGIC DESCRIPTION	HYDROLOGIC SIGNIFICANCE		
				OCCURRENCE IN TENNESSEE	HYDROLOGIC CLASSIFICATION AND CHARACTER	YIELD
CAMBRIAN	Middle and Upper	Conasauga Group and equivalents	Shale, limestone, dolomite. Thickness from several hundred to more than 1,000 feet.	Thought to occur west of Valley and Ridge throughout most of State.	Confining unit. Not defined in subsurface. At depth, assumed to be very impermeable and nonporous.	Indirect geologic evidence suggests that most wells drilled in these rocks would yield very little water.
CAMBRIAN	Lower and Middle	Rome Formation and equivalents	Sandstone, siltstone, shale, dolomite, and limestone. Highly variable thickness from 0 to more than 500 feet.	Thought to occur in subsurface only. West of Valley and Ridge throughout most of the State.	Very low porosity and permeability. Very few data exists that describe the hydrologic character.	Indirect geologic evidence suggests that most wells drilled in these rocks would yield very little water.
CAMBRIAN	Lower and Middle	Unnamed basal sandstone	Sandstone, arkosic, that grades into weathered pockets of granite wash.	Known from drill holes throughout Tennessee west of the Valley and Ridge.	Porosity and permeability are low, but higher than either overlying or underlying rocks. Directly overlies crystalline rocks.	Unknown, but thought to be small. Dissolved-solid concentrations gen erally not expected to be below 10,000 million gallons per liter.
PRECAMBRIAN		Precambrian crystalline rocks	Granite, and other massive crystalline rocks. Part of crystalline basement. Thickness unknown.	Occurs at great depths beneath land surface. Does not outcrop east of Blue Ridge province.	Confining unit. Highly nonporous and impermeable. Because of great depths, water-bearing characteristics are assumed to be very poor. No direct data exist that define the hydrologic character of these rocks.	Indirect geologic evidence suggests that most wells drilled in these rocks would yield very little water.

Table 2.--Summary of selected wells in the basal sandstone

[*NP - Not penetrated. Well records are on file with the Tennessee Division of Geology, Nashville, Tennessee]

Well No.	Name	County	Depth to the top of the basal sandstone (feet below land surface)	Depth to the top of the Precambrian basement (feet below land surface)
1	California Co. E. W. Beelar No. 1	Giles	5570	5,640
17	Gordon Street Inc. R. Holden No. 1	Rutherford	5530	5,560
19	Atha and Indiana Farm Bureau Ketchen Coal Co. No. 1	Scott	7395	NP*
20	Big Chief H. H. Taylor No. 1	Gibson	6854	6,935
21	Stauffer Chem. Co. Fee (disposal) No. 1	Maury	6300	6,400
22	DuPont, Old Hickory Plant Fee No. 1	Davidson	5270	5,460
23	Ed Riley Oil Co. Louise Lanham No. 1	Morgan	7485	NP
24	DuPont, New Johnsonville Fee No. 2	Humphreys	7210	7,450
29	Amoco Prod. Co. R. S. Driver No. 1	DeKalb	5045	5,445
32	Stauffer Chem. Co. Fee No. 2	Maury	6330	6,420
34	Monitor Petroleum Gernt Est. No. 8	Fentress	6980	7,744
35	Amoco Prod. Co. J. J. Brothers No. 1	Coffee	5654	NP
38	Mobil Chemical Fee No. 1	Maury	6328	6,403
39	Ladd Petroleum Co. T. J. Kemmer No. 1	Cumberland	9960	10,110

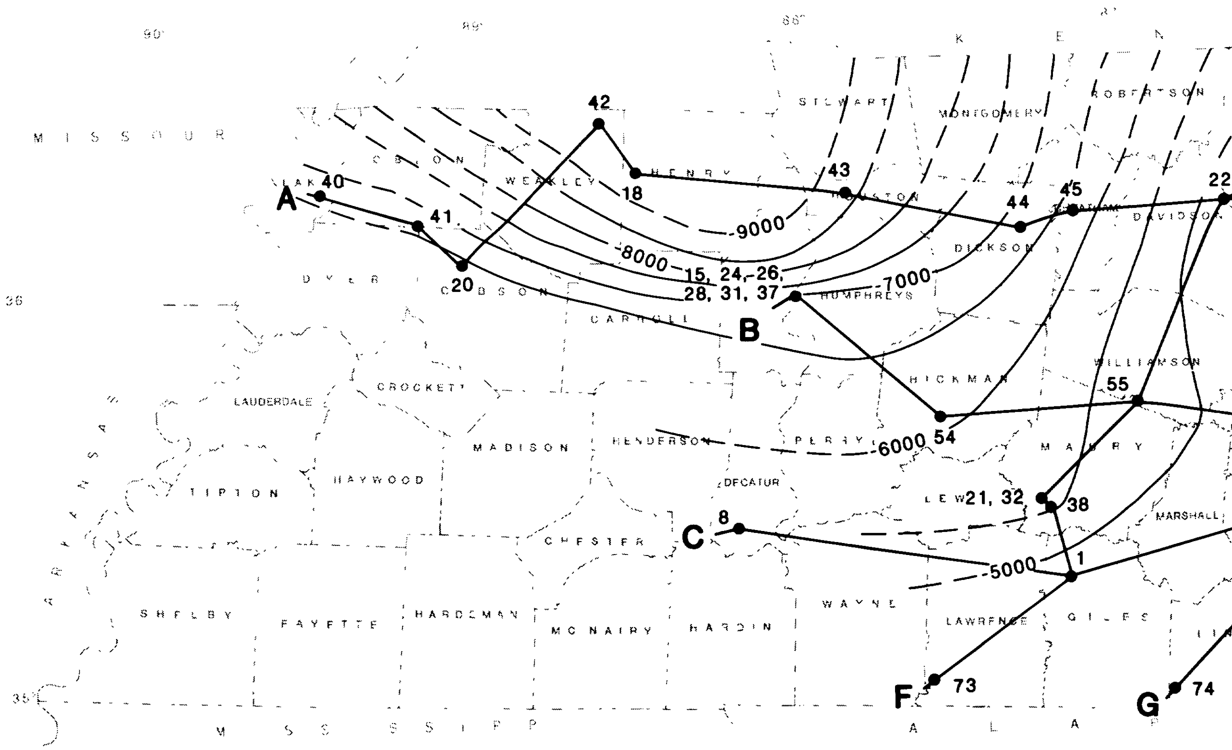
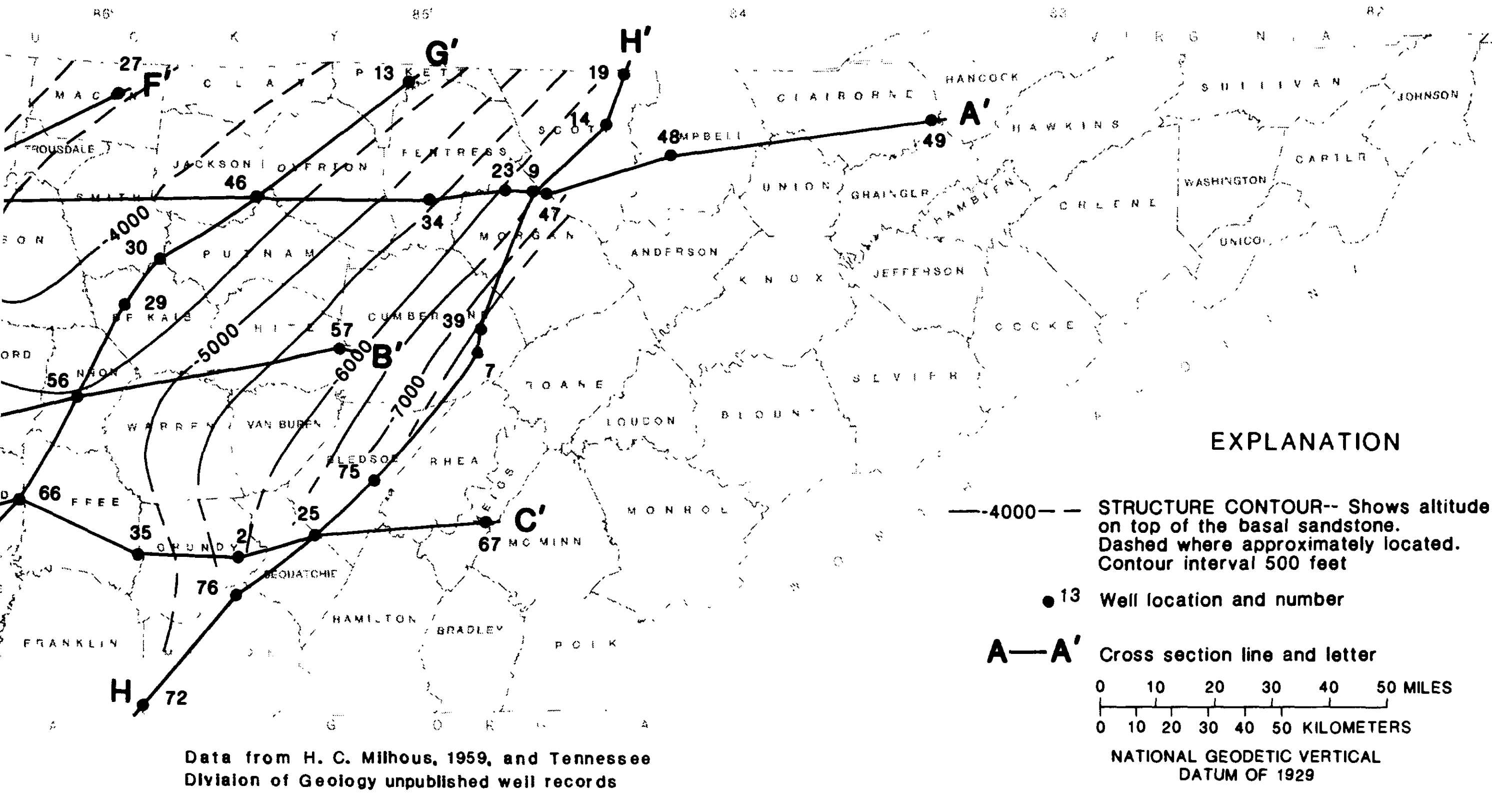
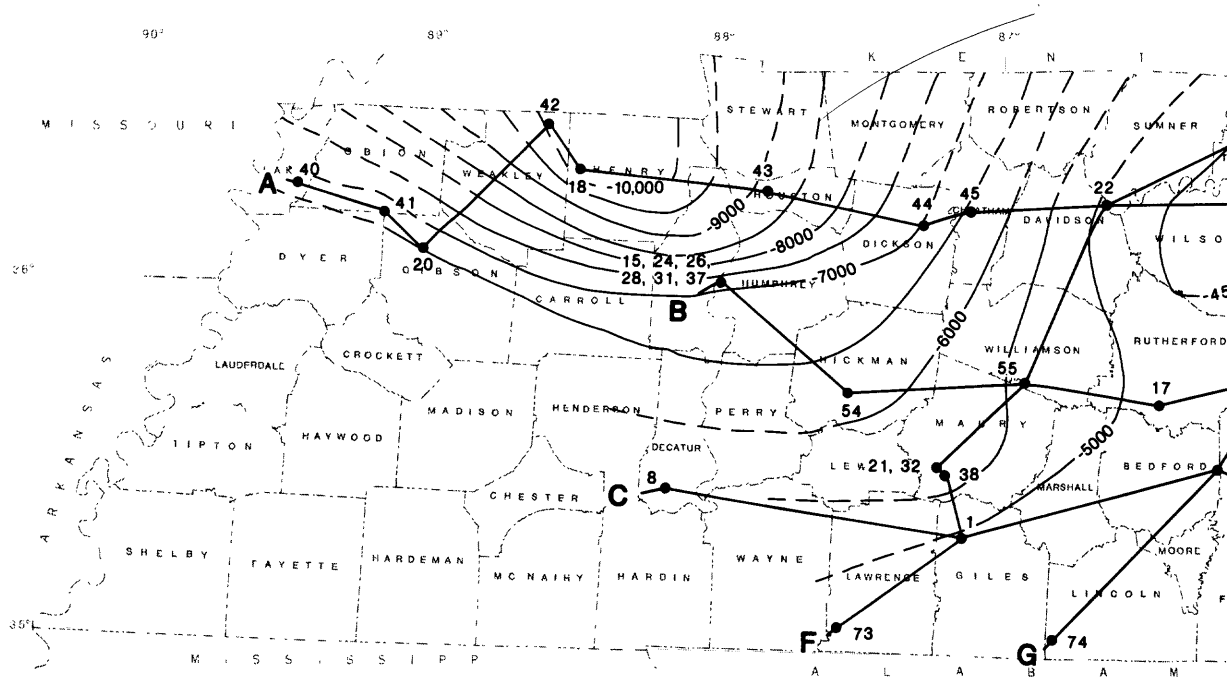


Figure 2.–Struc

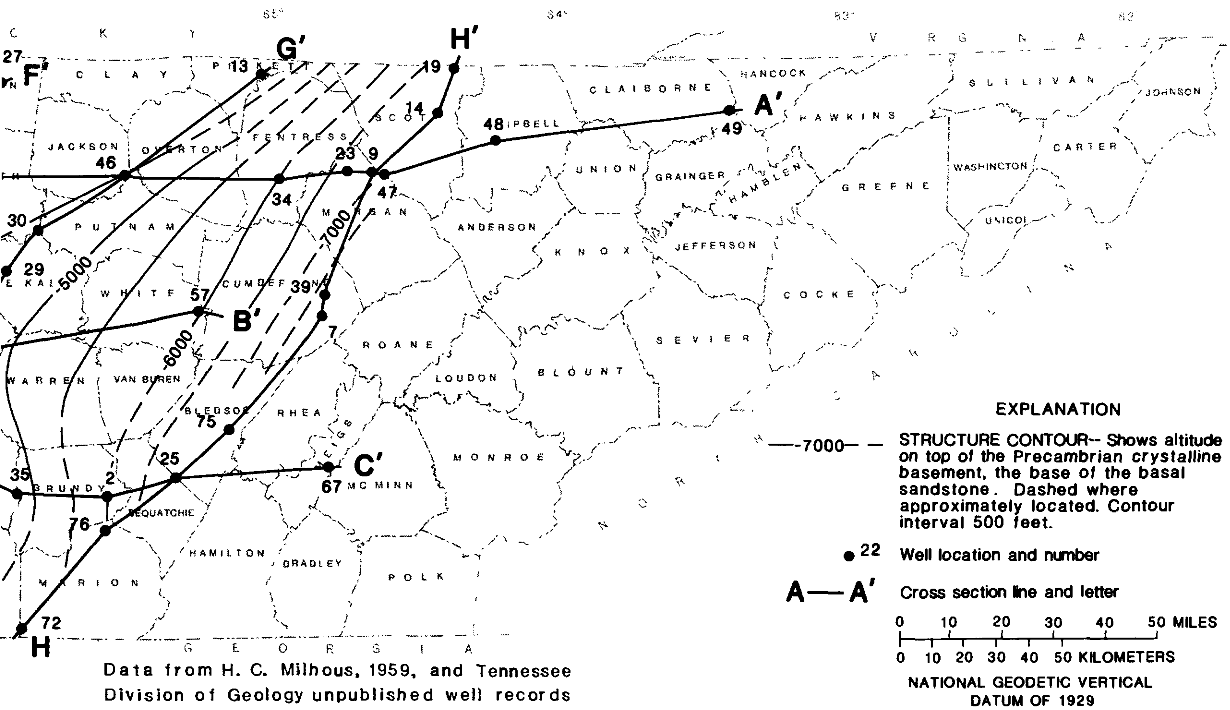


tours on top of the basal sandstone.

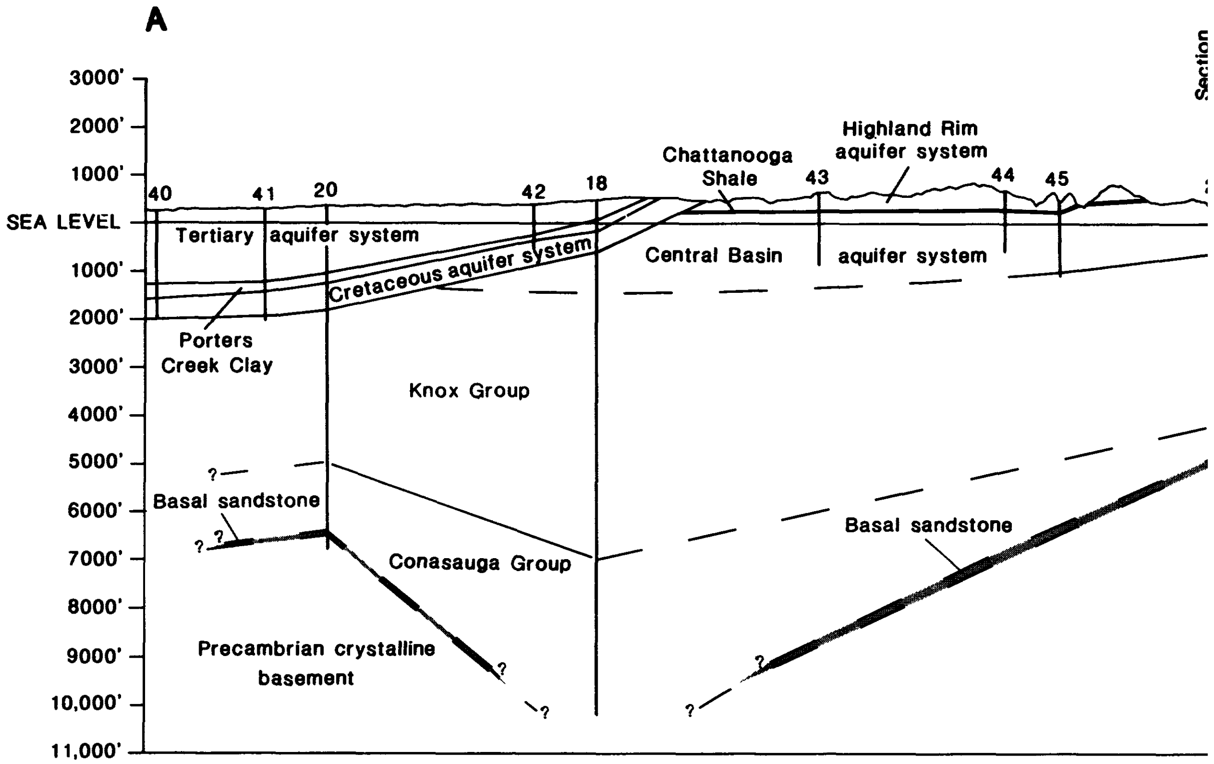


Base from U.S. Geological Survey State base map 1:1 000 000, 1957 revised 1973

Figure 3.--Structure conto



top of the Precambrian basement rocks.



EXPLANATION

22

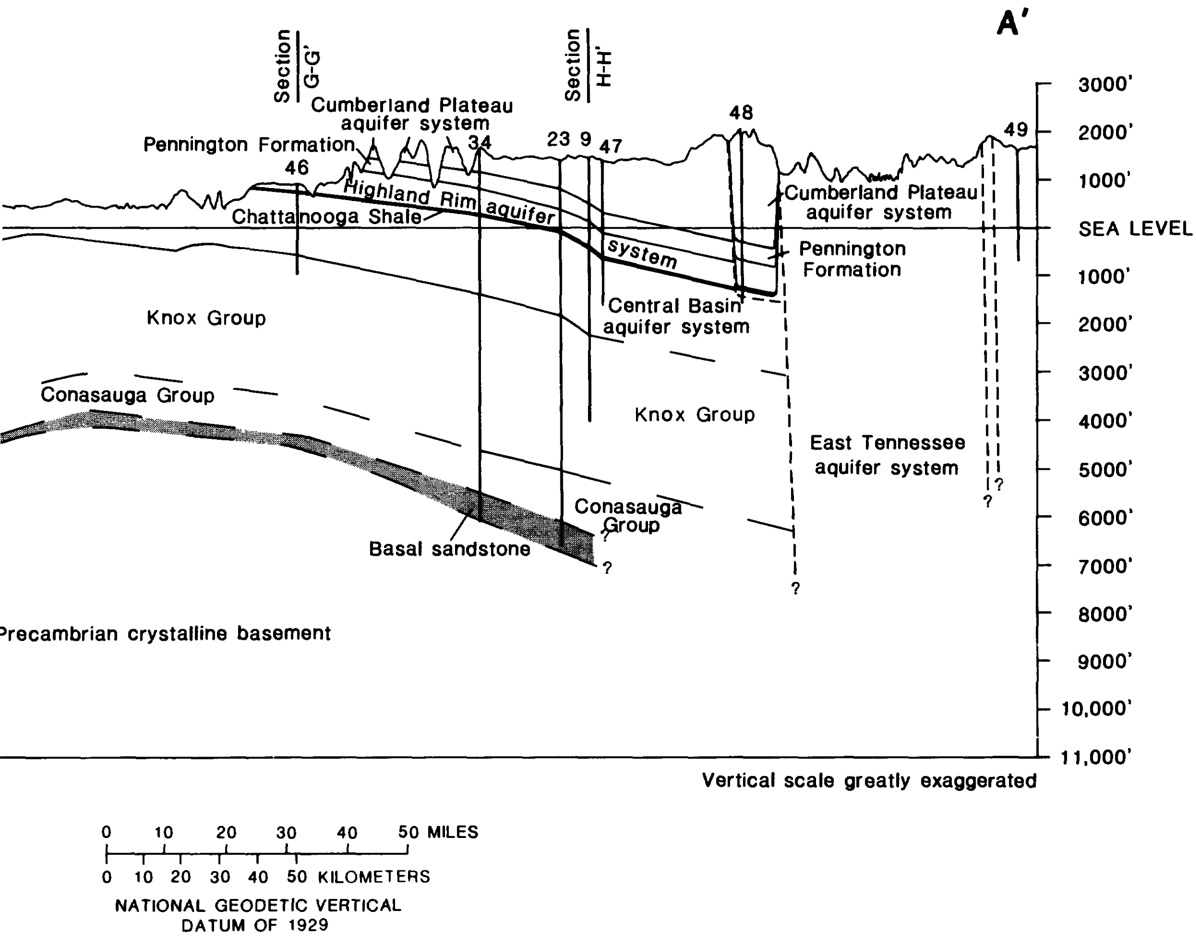
Well and number

Fault

DISSOLVED-SOLIDS CONCENTRATIONS, IN MILLIGRAMS PER LITER

Unknown
Estimated, greater than 10,000

Figure 4.-- Regionalized geohydrologic section showi



er quality in the basal sandstone along line A-A'.

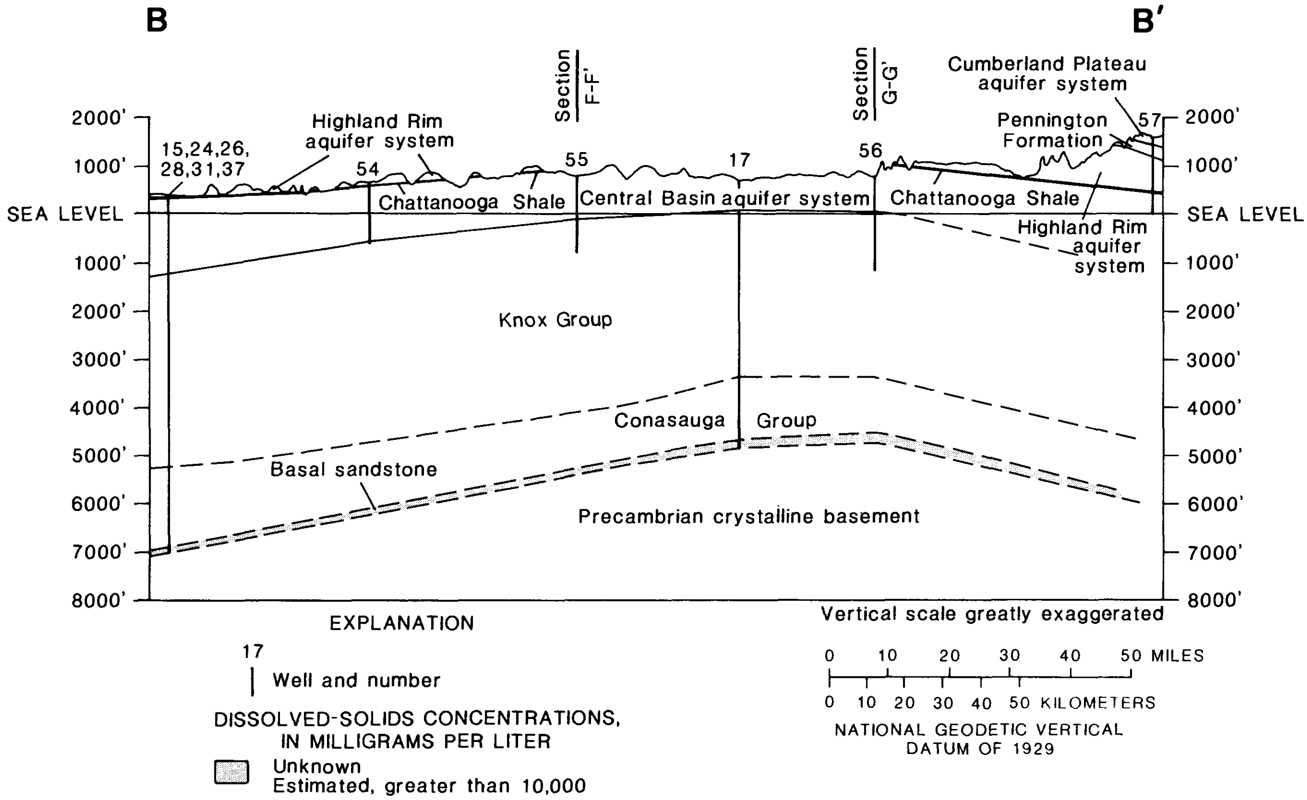


Figure 5.-- Regionalized geohydrologic section showing water quality in the basal sandstone along line B-B'.

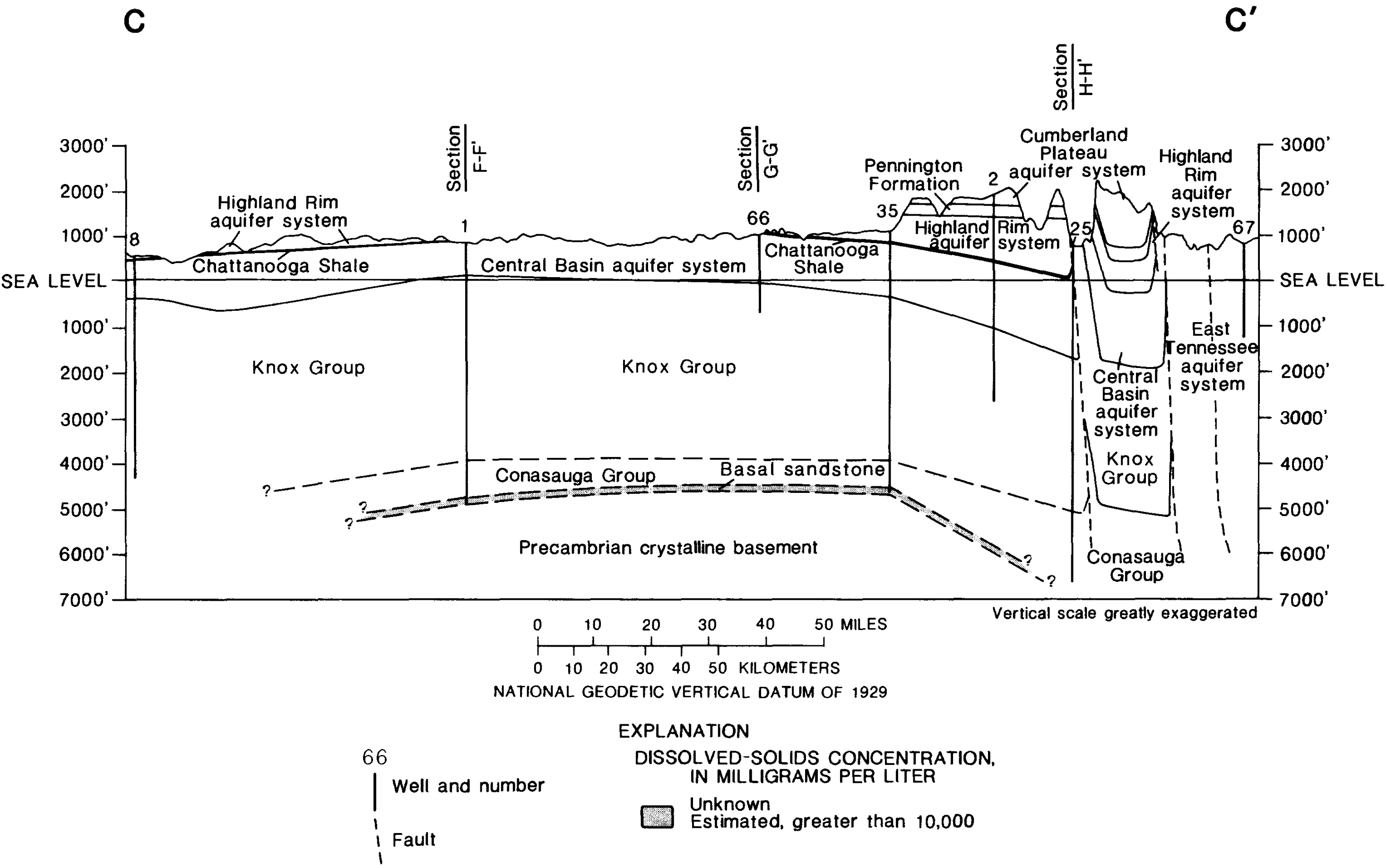


Figure 6.-- Regionalized geohydrologic section showing water quality in the basal sandstone along line C-C′.

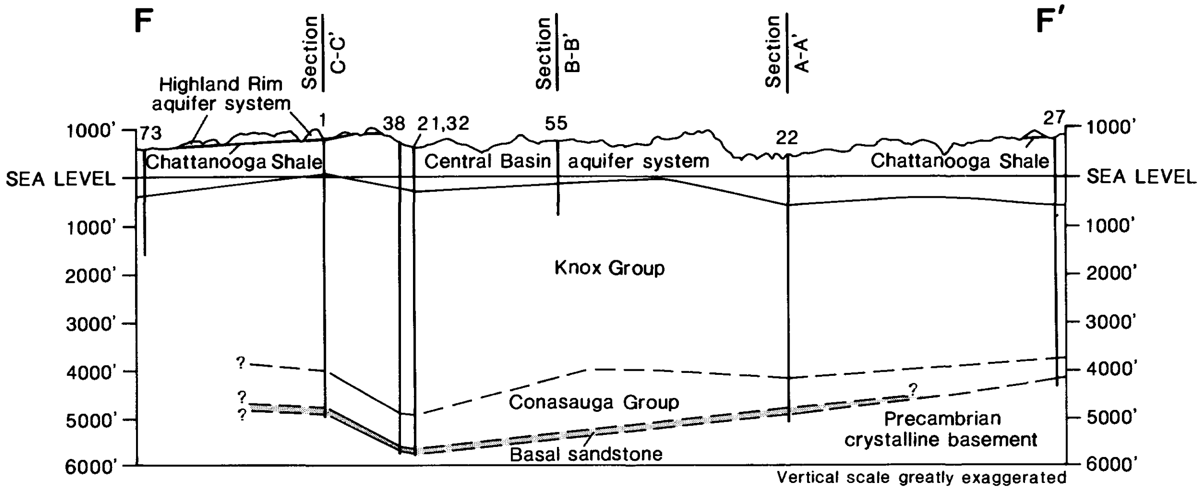


Figure 7.-- Regionalized geohydrologic section showing water quality in the basal sandstone along line F-F'.

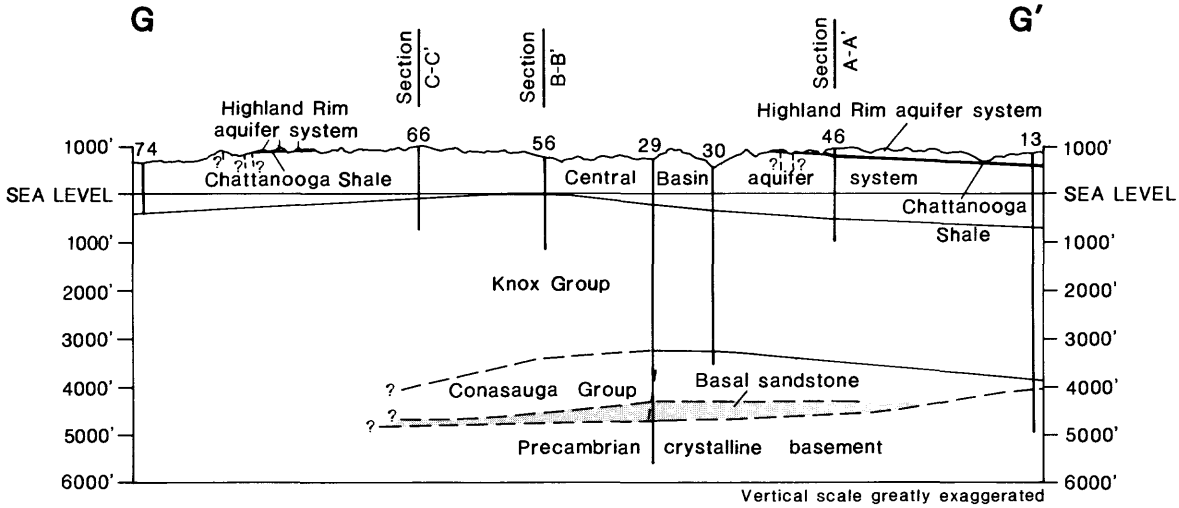


Figure 8.-- Regionalized geohydrologic section showing water quality in the basal sandstone along line G-G'.

0 10 20 30 40 50 MILES

0 10 20 30 40 50 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

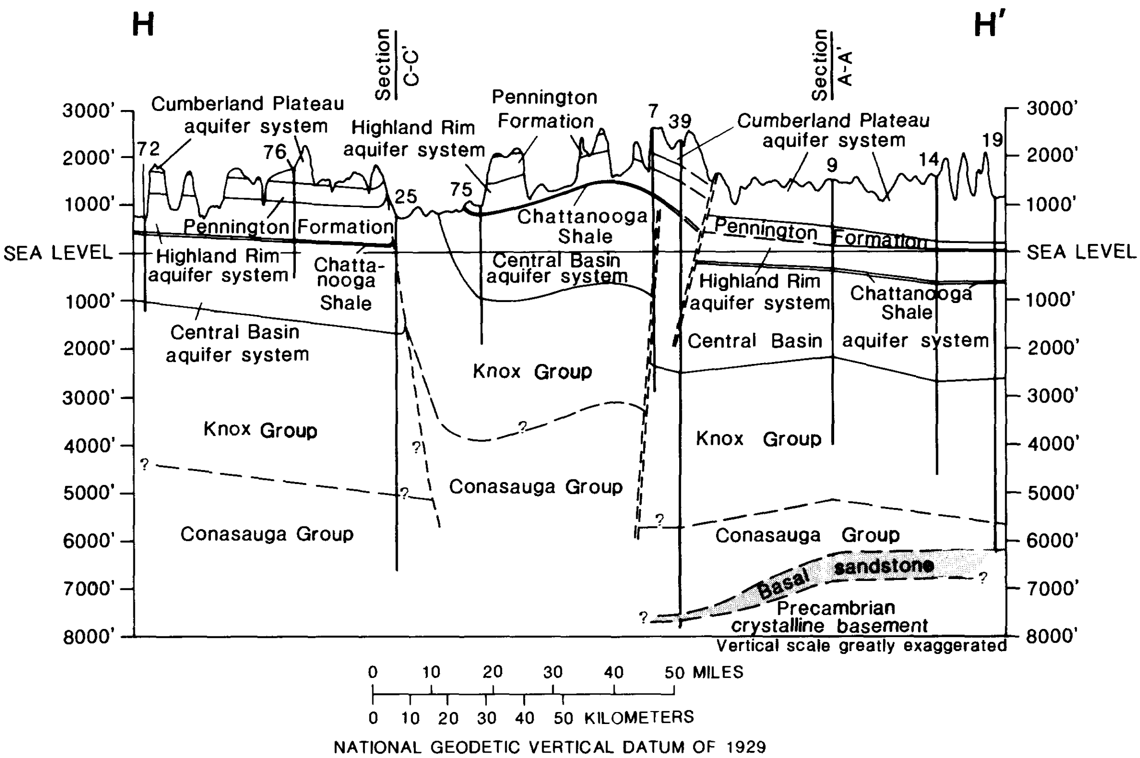
22 Well and number

Fault

DISSOLVED-SOLIDS CONCENTRATIONS, IN MILLIGRAMS PER LITER

Unknown

Estimated, greater than 10,000



EXPLANATION

7 Well and number

Fault

DISSOLVED-SOLIDS CONCENTRATIONS, IN MILLIGRAMS PER LITER

Unknown
Estimated, greater than 10,000

Figure 9.-- Regionalized geohydrologic section showing water quality in the basal sandstone along line H-H'.

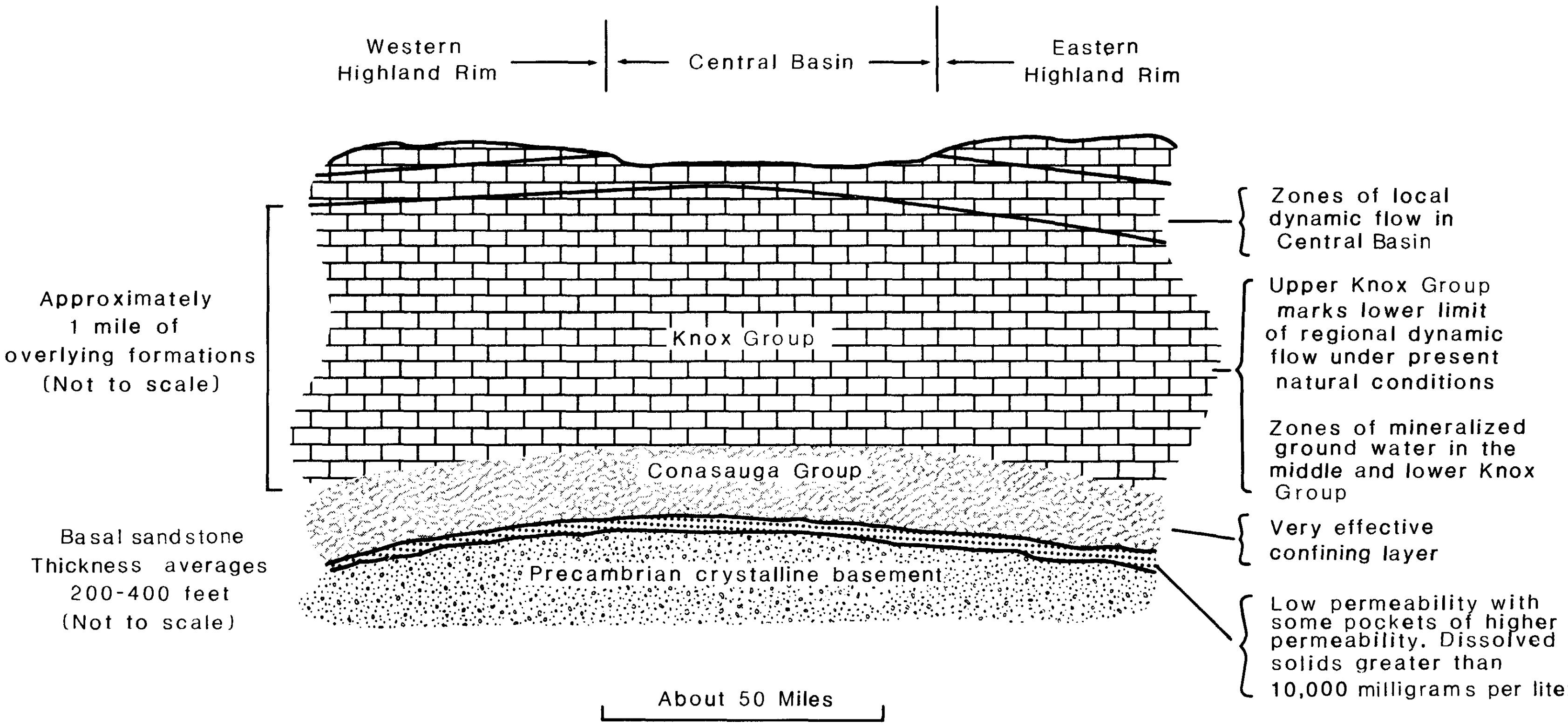


Figure 10.-- Conceptual model of ground-water occurrence in the basal sandstone.

Table 3.--Dissolved-solids concentrations in water from wells in the basal sandstone

[Data sources: a, Warner (1972); b, Geraghty and Miller (1978); c, Resources Services, Incorporated (1975). *, sampling interval includes more than one flow-contributing zone; **, Intercepted neutralized iron salts, which are by products of the injected wastes]

Site identification No.	Location	Depth, in feet	Water-bearing unit	Dissolved-solids concentrations, in milligrams per liter
1	New Johnsonville DuPont Humphreys County	6978-7447*	Conasauga Group- and Rome Formation Unnamed basal sand	[a] 99,034**
2	Mount Pleasant Stauffer Chemical Co. Maury County	6200	Rome Formation	[b] 38,500
3	Mount Pleasant Mobil Chemical Co. Maury County	6380-6413	Rome Formation	[c] 201,800

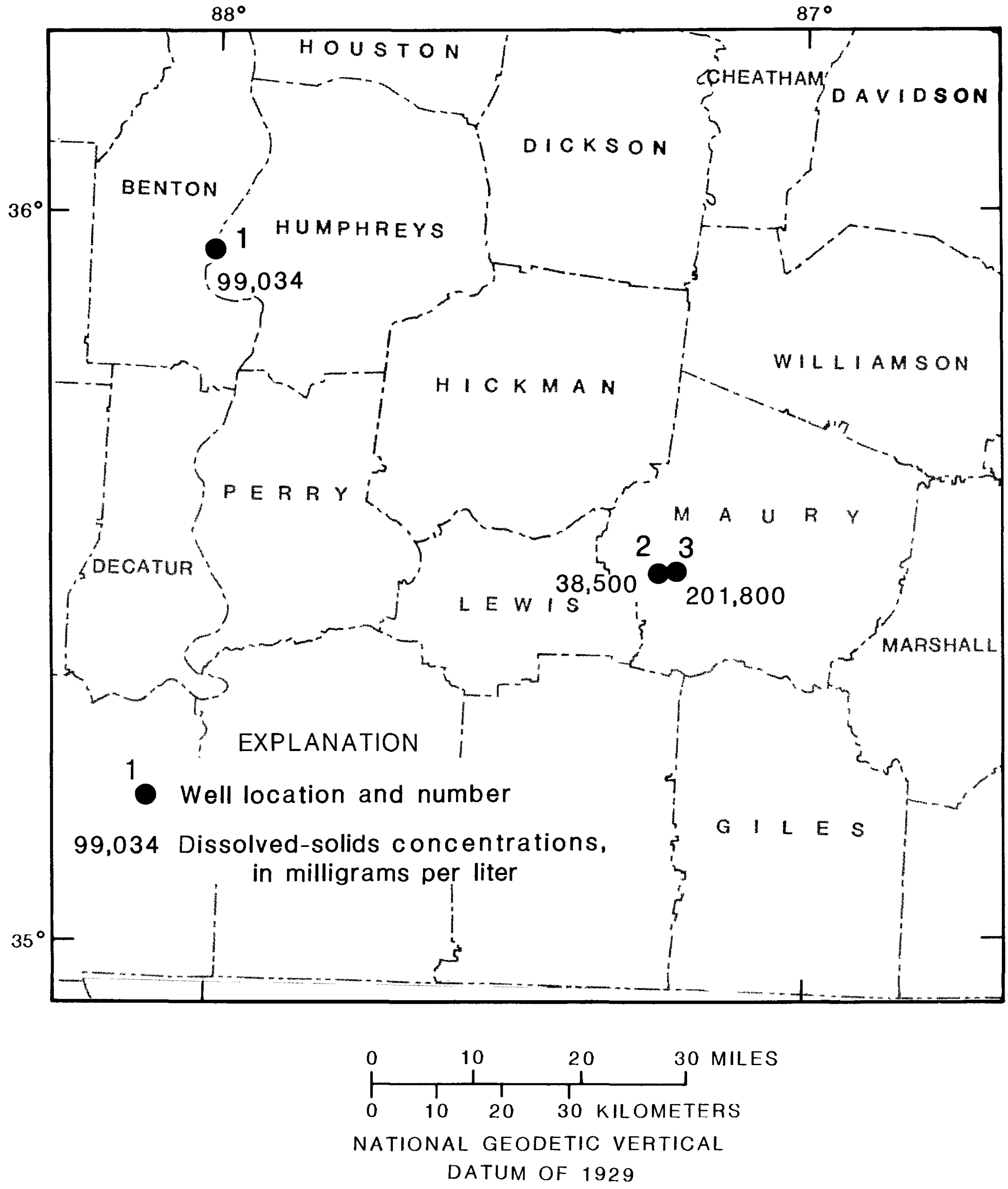


Figure 11.-- Location of injection wells in the basal sandstone and concentrations of dissolved solids.

SELECTED REFERENCES

Bloyd, R.M., Jr., 1974, Summary appraisals of the Nation's ground-water resources-Ohio Region: U.S. Geological Survey Professional Paper 813-A, 41 p.

Collins, A.G., 1975, Geochemistry of oilfield waters: New York, N.Y., Elsevier Scientific Publishing Company, 496 p.

Feth, J.H., and others, 1965, Preliminary map of conterminous United States showing depth to and quality of shallowest ground water containing more than 1,000 parts per million dissolved solids: U.S. Geological Survey Hydrologic Atlas HA-199, scale 1:3,168,000.

Freeman, L.B., 1953, Regional subsurface stratigraphy of the Cambrian and Ordovician in Kentucky and vicinity: Kentucky Geological Survey Bulletin 12, 352 p.

Geraghty and Miller, 1978, Evaluation of deep-well disposal and other wastewater disposal alternatives at Mount Pleasant, Tennessee: Tampa, Florida, Geraghty and Miller, Inc., unpublished consultant's report, 47 p.

Krieger, R.A., Hatchett, J.L., and Poole, J.L., 1957, Preliminary survey of the saline-water resources of the United States: U.S. Geological Survey Water-Supply Paper 1374, 172 p.

Milhous, H.C., 1959, Well logs in Tennessee: Tennessee Divison of Geology Bulletin 62, 606 p.

Miller, R.A., 1974, The geologic history of Tennessee: Tennessee Division of Geology Bulletin 74, 63 p.

Resources Services, Inc., 1975, Injection wells 1-5, Stauffer Chemical Company Organic Plant, Mt. Pleasant, Tennessee: Worthington, Ohio, Consulting reports 1-5, 50 p.

Schlumberger Well Surveying Corp., 1958, Introduction to Schlumberger well logging: Schlumberger Document no. 8, 176 p.

Statler, H.T., Bloss, P., and Zurawski, R.P., 1975, Subsurface information catalog of Tennessee 1866-1974: Tennessee Division of Geology Bulletin 76, 146 p.

Warner, D.L., 1972, E.I. DuPont De Nemours and Company disposal well no. 1 New Johnsonville, Tennessee - Analysis of performance history: E.I. DuPont De Nemours Consulting Report, 75 p.

Zurawski, Ann, 1978, Summary appraisals of the Nation's ground-water resources--Tennessee region: U.S. Geological Survey Professional Paper 813 L, 35 p.

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