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ARKANSAS SOIL AND WATER CONSERVATION COMMISSION
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POTENTIOMETRIC SURFACE OF THE OZARK AQUIFER IN NORTHERN ARKANSAS, 1995

Water-Resources Investigations Report 98-4000

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

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ABSTRACT

The Ozark aquifer in northern Arkansas is comprised of dolostones, limestones, sandstones, and shales of Late Cambrian to Middle Devonian age, and ranges in thickness from approximately 1,100 feet to more than 4,000 feet. Hydrologically, the aquifer is complex, characterized by discrete and diffuse flow components with large spatial variations in porosity and permeability. Regionally, the flow within the aquifer is to the south and southeast in the eastern and central part of the study area and to the northwest and north in the western part of the study area.

Within Arkansas, the potentiometric-surface map based on October-December 1995 data indicates maximum water-level altitudes of greater than 1,300 feet in Boone, Carroll, and Madison Counties and minimum water-level altitudes of less than 400 feet in Independence, Izard, Lawrence, Randolph, Sharp, and Stone Counties. Comparing the 1995 potentiometric-surface map with a predevelopment potentiometric-surface map (Imes, 1990), indicates general agreement between the two surfaces except in parts of Benton and Sharp Counties. Water-level differences could be attributed to differences in the time of year in which the water-level data were collected, differences in pumping conditions just prior to a water-level measurement, differences in interpretation resulting (in part) from greater number of water-level measurements used for this report than for Imes (1990), or erroneous water-level data.

INTRODUCTION

The Ozark aquifer is the largest aquifer, both in area of outcrop and thickness, and the most important source of freshwater in the Ozark Plateaus physiographic province, supplying water to large areas of northern Arkansas, southern Missouri, northeastern Oklahoma, and southeastern Kansas. A good understanding of water levels and trends in this heavily-used aquifer is important for continued use, planning, management, and assessment of anthropogenic and other impacts on aquifer viability.

The potentiometric surface of the Ozark aquifer within the Ozark Plateaus physiographic province of northern Arkansas (fig. 1) has been investigated by the U.S. Geological Survey (USGS) in cooperation with the Arkansas Soil and Water Conservation Commission and the Arkansas Geological Commission. The study is part of an ongoing effort by the three agencies to monitor ground-water levels in Arkansas' major aquifers.

The study area includes all Arkansas counties lying completely or partially within the Ozark Plateaus Province of the Interior Highlands major physiographic division (Fenneman, 1938). The study area is bounded on the north by Missouri, on the west by Oklahoma, on the east by the Mississippi Alluvial Plain, and on the south by the Ouachita Province (fig. 1).

The potentiometric-surface map presented in this report was prepared from ground-water level data collected by the USGS from October-December 1995 and supplemental data collected in the fall seasons of 1990-94. Additionally, streambed altitudes in areas where the aquifer is unconfined and hydraulically connected to the surface were used as bounding (maximum ground-water level) values.

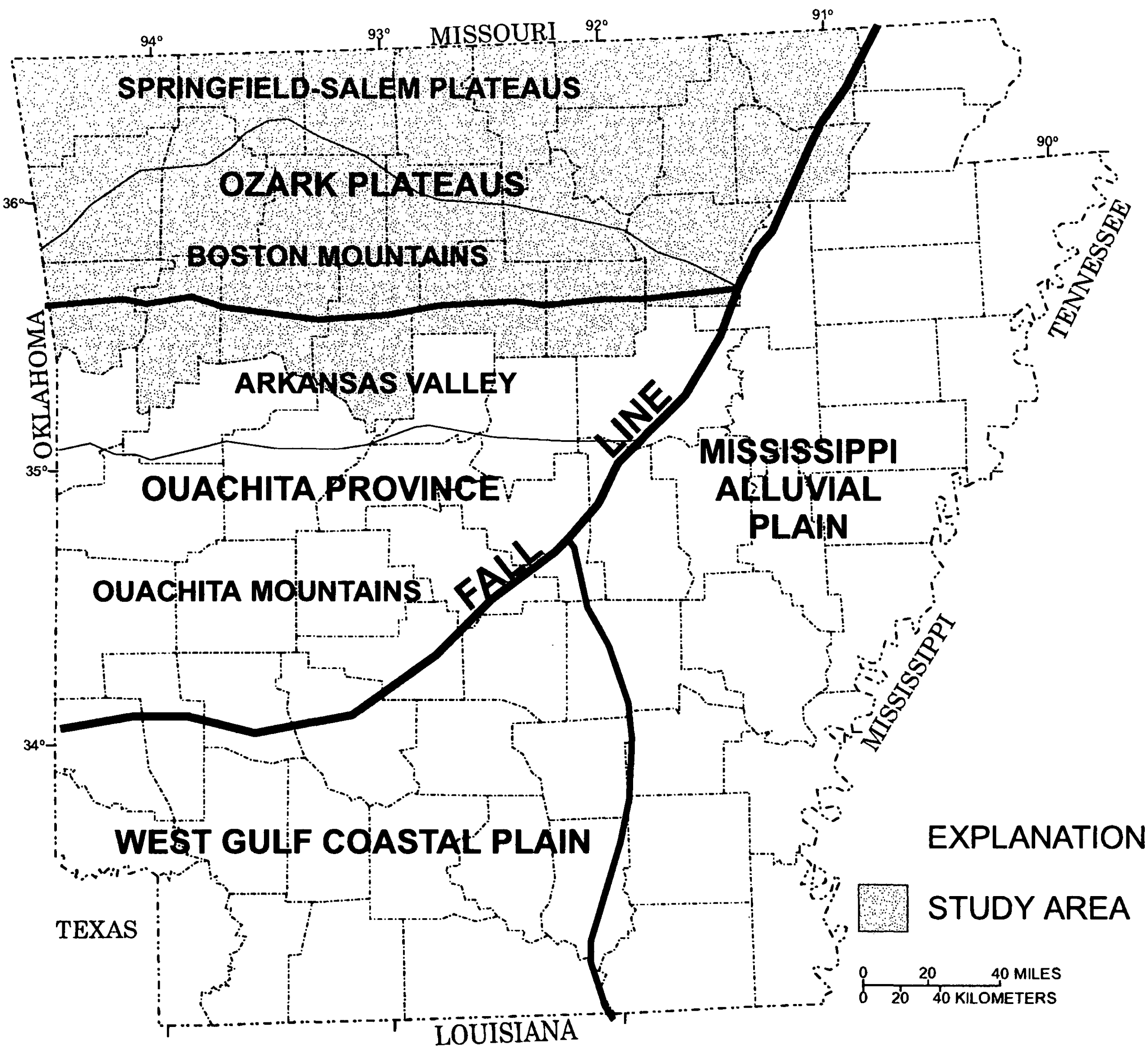

Figure 1. Location of study area.

AQUIFER DESCRIPTION

The Ozark Plateaus aquifer system (fig. 2) is in and adjacent to the Ozark Plateaus physiographic province and may be divided into five major units based on relative rock permeability and well yields. These units outcrop in a concentric pattern centered on and dipping away from the St. Francois Mountains of Missouri. The boundaries between these units do not always conform to geologic time divisions or formation boundaries, but were chosen to delineate groups of rocks having similar hydrologic properties. These geohydrologic units consist of rocks that range in age from Cambrian to Mississippian and are the St. Francois aquifer, St. Francois confining unit, Ozark aquifer, Ozark confining unit, and Springfield aquifer (Imes and Emmett, 1994).

The Ozark aquifer in Arkansas is composed of dolostones, limestones, sandstones, and shales of Late Cambrian to Middle Devonian age (table 1) and ranges in thickness from approximately 1,100 feet (ft) in the northwestern corner of the State to more than 4,000 ft in the south-central portion of the State (Imes, 1990). Most wells completed in the aquifer yield between 50 to 100 gallons per minute (gal/min) although some wells may yield as much as 600 gal/min (Imes and Emmett, 1994; Adamski and others, 1995).

The geohydrology of the Ozark aquifer is complex, consisting of a combination of discrete and diffuse flow components resulting from spatial variations in regolith thickness, faults, the presence of chert nodules, lithology, and cementation. Primary porosity and permeability are low for most rock units of the aquifer, although secondary porosity and permeability resulting from fracturing and dissolution of the carbonate rocks is spatially variable and ranges from moderate to large (Adamski, 1996). Hydraulic conductivity ranges from 1×10^{-8} feet per second (ft/s) to more than 1×10^{-3} ft/s (Imes and Emmett, 1994). The principal recharge area for the aquifer is in central and south-central Missouri and north-central Arkansas, where the aquifer is hydraulically connected to the surface and the potentiometric surface mimics the land-surface topography.

The Ozark aquifer is underlain by the St. Francois confining unit (the top geologic unit of which is the Doe Run Dolomite) (table 1). The aquifer is exposed in much of southern and central Missouri and northern Arkansas (fig. 2) where the gradual uplift of the Ozark dome and erosion of younger rocks has formed a deeply dissected, rugged topography that comprises the aquifer's primary recharge area. The aquifer is overlain in the southern and western portion of the study area by the Ozark confining unit (geologic unit is the Chattanooga Shale) (table 1). Within the Mississippi Alluvial Plain, east and southeast of the outcrop area (figs. 1 and 2), younger rocks of the Ozark aquifer have been removed by erosion and, subsequently, overlain by thick deposits of Cretaceous-, Tertiary-, and Quaternary-age sediments. Within this portion of the Mississippi Alluvial Plain, major rivers receive substantial discharge from the adjacent Ozark aquifer (Mesko and Imes, 1995).

Beneath the Mississippi Alluvial Plain (fig. 1), the rocks comprising the Ozark aquifer dip regionally at about 45 feet per mile (ft/mi)in a southeasterly direction. In the northern portion of the study area, the rocks comprising the Ozark aquifer dip regionally at about 26 ft/mi southward, increasing to 175 ft/mi or more as the aquifer approaches the southern boundary of the Ozark Plateaus physiographic province (Imes, 1990). As the regional dip carries the aquifer deeper into the subsurface with thicker sequences of overlaying Mississippian and younger rocks, the depth at which the aquifer is encountered increases to greater than 2,000 in the southern portion of the study area. Additionally, water quality is affected by increasing amounts of dissolved solids, fluoride, sulfide, and radium as water moves down dip, away from recharge areas (Imes and Emmett, 1994). The combination of depth to water and decreasing water quality limits the viability of the Ozark aquifer as an economic source of water in the southernmost portion of the study area.

POTENTIOMETRIC-SURFACE MAP

The potentiometric-surface map (plate 1) indicates the altitude to which water levels would rise in tightly cased wells completed in the Ozark aquifer. Water levels were measured to the nearest 0.01 ft from a measuring point of known altitude using a graduated steel tape or electronic water-level indicator. In some instances, when measuring deep, sealed, municipal or industrial wells, water-level measurements were obtained from built in air-line systems. The potentiometric surface was contoured using the measured water-level data from 1995 and supplemented with data from the previous fall seasons of 1990-95. Additional bounding values were used where the Ozark aquifer is exposed at the surface. Land-surface contours from a 1:500,000 scale topographic map of Arkansas were considered to prevent contours from crossing streams at inappropriate locations and to

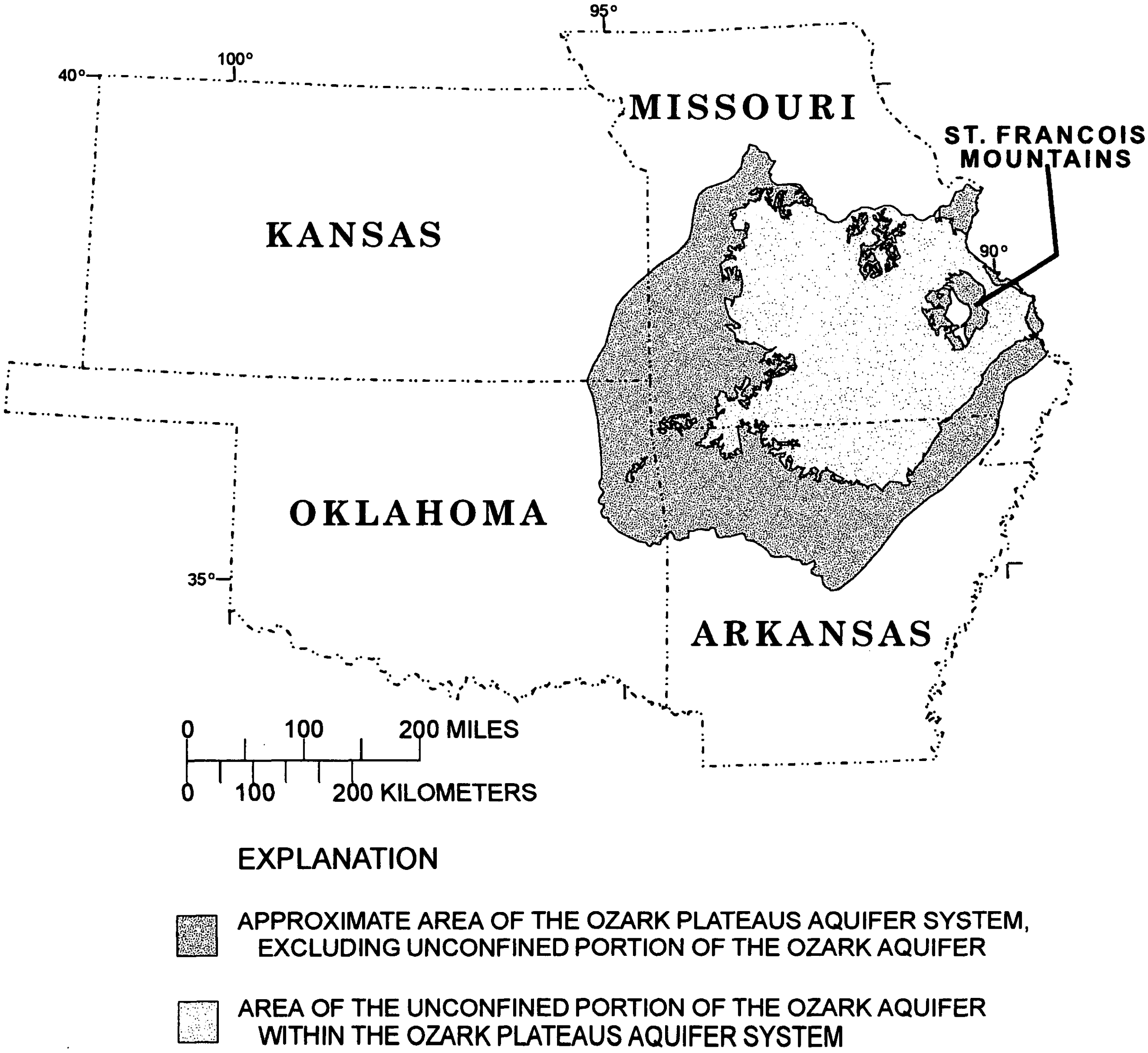

Figure 2. Location of Ozark Plateaus aquifer system (modified from Imes, 1990).

Table 1. Stratigraphic column with descriptions of lithologic and geohydrologic properties of the Ozark aquifer and adjacent confining units within Arkansas (modified from Lamonds, 1972; Imes and Smith, 1990)

ERA	PERIOD	GEOLOGIC UNIT	GEOHYDROLOGIC UNIT	LITHOLOGY	THICKNESS (feet)	GEOHYDROLOGY
Paleozoic	Devonian	Chattanooga Shale	Ozark confining unit	Shale unit that crops out in a narrow band that outlines the Ozark aquifer and is missing were the Ozark aquifer is exposed at the surface.	0 - 200	Unit is relatively impermeable because of large shale content.
		Clifty Limestone	Ozark aquifer	Chert with lenses of limestone, dolostone and cherty sandstone.	0 - 250	The residual cherty rubble, weathered from cherty limestone and sandstone of the unit may yield 2 to 5 gallons per minute.
		Penters Chert				
	Silurian	Lafferty Limestone		Limestone, dolomite, sandstone, and minor amounts of shale	0 - 2,000	The limestones and dolomites commonly yield 5 to 10 gallons per minute from solution channels, bedding planes, and fractures. Similar yields may be obtained from the sandstone were it is porous or fractured. This unit contains many springs. Yields from springs and some wells may exceed 50 gallons per minute.
		St. Clair Limestone				
		Brassfield Limestone				
	Ordovician	Cason Shale				
		Fernvale Limestone				
		Kimmswick Limestone				
		Plattin Limestone				
		Joachim Dolomite				
		St. Peter Sandstone				
		Everton Formation				
		Smithville Formation		Dolomite, dolomitic limestone, and minor amounts of sandstone and shale.	100 - 1,000	The solution channels and fractures in the dolomite and dolomitic limestone commonly yield 5 to 10 gallons per minute. Wells that tap large solution channels may yield more than 50 gallons per minute, but large yields are uncommon. This unit yields water to several large springs.
		Powell Dolomite				
		Cotter Dolomite				
		Jefferson City Dolomite				
		Roubidoux Formation		Sandstone and sandy dolomite. Not exposed in Arkansas.	100 - 250	Yields of as much as 450 gallons per minute may be obtained from some wells, but yields are highly variable and generally average less than 150 gallons per minute.
		Gasconade Dolomite		Dolomite, sandy dolomite, and sandstone. Not exposed in Arkansas.	350 - 650	The most productive water-bearing part of this unit is the Van Buren Formation. Wells that tap into this sandstone commonly yield 150 to 300 gallons per minute and may yield as much as 500 gallons per minute.
		Van Buren Formation				
	Cambrian	Eminence Dolomite				
		Potosi Dolomite				
		Doe Run Dolomite	St. Francois confining unit	Shale and shaley dolostone, siltstone, and limestone conglomerate. Shales present both as distinct beds and disseminated throughout dolomite matrix. Not exposed in Arkansas.	0 - 750	Permeability is minimal to moderate. Unit is more permeable were transected by fault and fracture zones.
		Derby Dolomite				
		Davis Formation				

reflect the general land-surface topography where appropriate (U.S. Geological Survey, 1990).

The extent of the potentiometric-surface contouring presented on plate 1 covers approximately half the defined study area. As discussed earlier, the Ozark aquifer within the southern portion of the study area is not a viable source of water. Therefore, few wells have been installed and no data are available for contouring purposes.

The potentiometric-surface map indicates maximum water-level altitudes of greater than 1,300 ft in Boone, Carroll, and Madison Counties. The water-level altitudes in these areas are reflective of the influence of the land-surface topography and not the regional flow pattern of the aquifer. Minimum water-level altitudes of less than 400 ft are mapped along the eastern and southeastern part of the study area in Independence, Izard, Lawrence, Randolph, Sharp, and Stone Counties.

A comparison of the predevelopment potentiometric surface (Imes, 1990) and the 1995 potentiometric surface presented in this report indicates general agreement between the two surfaces with the exception of two areas. Apparent rises in water-level altitudes of greater than 100 ft are indicated in northern and western Benton County and in southern Sharp County. Water-level differences could be attributed to differences in the time of year in which the water-level data were collected, differences in pumping conditions just prior to a water-level measurement, differences in interpretation resulting (in part) from greater number of water-level measurements used for this report than for Imes (1990), or erroneous water-level data.

The potentiometric-surface map reflects the general ground-water flow patterns within the Ozark aquifer, with movement being perpendicular to the contours in the direction of the hydraulic gradient. The regional direction of ground-water flow is to the south and southeast in the eastern and central part of Arkansas and to the northwest and north in the western portion of Arkansas, except in areas where the unconfined part of the aquifer is hydraulically connected to the surface. In these areas, the flow is affected more by local topography (flowing from high elevations toward stream valleys).

SUMMARY

In the fall of 1995, ground-water levels of the Ozark aquifer in northern Arkansas were investigated, mapped, and contoured. The product of this investigation was a potentiometric-surface map of the Arkansas portion of the Ozark aquifer. The Ozark aquifer in northern Arkansas is composed of dolostones, limestones, sandstones, and shales of Late Cambrian to Middle Devonian age which dip, regionally to the south and southeast away from the St. Francois Mountains of Missouri. Hydrologically, the aquifer is complex, characterized by discrete and diffuse flow components with large spatial variations in porosity and permeability. The principal recharge area for the aquifer is in central and south-central Missouri and north-central Arkansas, where the aquifer is hydraulically connected to the surface.

The 1995 potentiometric-surface map of the Ozark aquifer in northern Arkansas indicates maximum water-level altitudes of greater than 1,300 ft in Boone, Carroll and Madison Counties, and minimum altitudes of less than 400 ft in Independence, Izard, Lawrence, Randolph, Sharp, and Stone Counties. The regional direction of ground-water flow is generally to the south and southeast in the eastern half of the study area and to the northwest and north in the western half of the study area except in areas where the aquifer is unconfined. In these areas, the potentiometric surface mimics the land-surface topography. Comparing the 1995 potentiometric-surface map with a predevelopment potentiometric-surface map (Imes, 1990), indicates relatively good agreement between the two surfaces except in Benton and Sharp Counties. Water-level differences could be attributed to differences in the time of year in which the water-level data were collected, differences in pumping conditions just prior to a water-level measurement, differences in interpretation resulting (in part) from greater number of water-level measurements used for this report than for Imes (1990), or erroneous water-level data.

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