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Preliminary Investigation of the Ground-Water Resources of Northern Searcy County, Arkansas

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A PRELIMINARY INVESTIGATION OF THE GROUND-WATER RESOURCES OF NORTHERN SEARCY COUNTY, ARKANSAS

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ABSTRACT

Two aquifers are extensively used by residents of small communities and rural areas in northern Searcy County, Arkansas. The Mississippian Boone-St. Joe aquifer is generally the less productive and the shallower of the two. Ground-water yields for the Boone-St. Joe range from 0.5 to 75 gpm with a median yield of 5 and a mean of 9.8 gpm. Well depths range from 100 to 754 feet with a median depth of 350 feet and a mean of 360 feet. Confined conditions are indicated by the greater depths, whereas the Boone-St. Joe aquifer is unconfined when exposed at the surface.

Underlying the Boone-St. Joe aquifer is an aquifer zone composed of sands, sandy limestones, and/or dolomitic limestones below the Chattanooga Shale and above and including the Everton Formation. This aquifer can be composed of one or more of the following units: upper Everton, St. Peter, Clifty, Sylamore, Lafferty, St. Clair and/or Plattin. The range in yields for this aquifer is 1 to 80 gpm with a median yield of 9 and a mean of 17 gpm. Well depths range from 200 to 875 feet with a median and mean depth of 570 feet.

A statistical correlation was found among well yields (gpm), regolith thickness, depth of well, and cave intersection by the well. The results indicate that greater yields can be obtained in areas of thicker regolith. Cave presence was also found to enhance yields. A strong relationship between cave presence and deeper regolith was observed. These three relationships demonstrate increased weathering, and thus water flow along fractures. The effect of joints closing off at depth produced a strong relationship between shallower wells and greater yields within the Boone-St. Joe aquifer.

INTRODUCTION

Ground water is the most important source of domestic-use water in rural areas and communities in northern Searcy County, Arkansas, but little is known about its occurrence and movement. Few detailed hydrogeologic reports have been written about Searcy County, although numerous studies have been made concerning formations dealt with in this report in other areas of the state. Isopachous and structural contour maps of some of the formations discussed in this report were made by Caplan (1957).

The purposes of this study are: (1) identification of aquifers, (2) determination of range of depths and yields of wells, (3) determination of direction(s) of ground-water movement from a piezometric surface map, and (4) investigation of statistical inter-relationships among depth of well, depth to water, yield, regolith thickness, and cave presence in a well to determine geologic controls.

LOCATION AND GEOLOGY

The study area has been confined to northern Searcy County, specifically north of township 14 and bounded east and west by Range 14 West and 18 West, respectively (Fig. 1). The southern boundary is marked by the Boston Mountain Escarpement. This area was selected to facilitate the general study of aquifers of the Springfield Plateau.

Mississippian, Devonian, Silurian and Ordovician rocks are exposed at the surface of northern Searcy County. The generalized stratigraphy of the study area is shown in Figure 2, although thinner and less common units are not represented. Unconformities are common in the sequence sometimes making it difficult to determine the exact formations present in a well.

The Boone Formation crops out through most of the study area. However, dissection by major stream systems has exposed Devonian, Silurian and Ordovician rocks locally. The rocks of the area dip

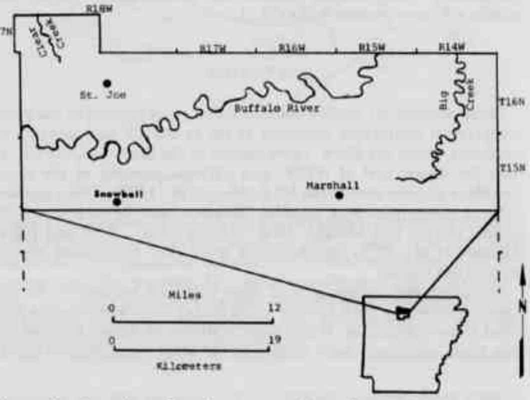

Figure 1. Location of study area, northern Searcy County, Arkansas.

gently on the southwestern flank of the Ozark Dome, with little deformation. A few normal faults are present, but they are believed to have only localized effect on the hydrogeology of the area. There is extensive karst developed in the carbonate rocks, specifically in the Boone and St. Joe limestones. Caves, springs, dolines and losing streams are common geomorphic features. Joints have been enlarged by solution, thus enhancing the porosity and permeability.

METHODS AND MATERIALS

Records of Searcy County water wells were obtained from the Arkansas Geologic Commission. It was possible from these to accurate-

SYSTEM	STAGE	FORMATION	THICKNESS (in ft.)	GENERAL ROCK TYPE
MISSISSIPPIAN	CHESTER	Pitkin	230-250	Limestone
		Fayetteville		
		Upper Member	30-55	Black shale
		Wedington Member	20-40	Sandstone
		Lower Member	260-280	Black shale
		Batesville	62-76	Sandstone
		Hindsville	0-12	Limestone
	MERAMEC	Ruddell	120-272	Shale
		Moorefield	25-199	Shale
	OSAGE	Boone	100-400	Cherty limestone
		St. Joe	0-100	Limestone
	KINDERHOOK	Bachelor	1-4	Green shale
		Chattanooga	0-38	Black shale
		Sylamore	2-5	Sandstone
DEVONIAN	MIDDLE DEVONIAN	Clifty	0-3	Sandy limestone
		Penters	0-91	Chert
SILURIAN	NIAGARAN	Lafferty	0-85	Limestone
		St. Clair	0-100	Limestone
	LOWER SIL.	Brassfield	0-26	Limestone
ORDOVICIAN	CINCINNATIAN	Cason	0-23	Shale
		Fernvale	0-125	Limestone
	MIDDLE ORDOVICIAN	Kimmswick	0-60	Limestone
		Plattin	0-240	Limestone
	LOWER ORDOVICIAN	Joachim	0-150	Dolomite
		St. Peter	0-175	Sandstone
		Everton	0-600	Dolomitic sandstone
		Black Rock	0-55	Dolomitic limestone
		Smithville	0-65	Limestone
		Powell	0-200	Dolomite
		Cotter	500+	Dolomite
		Jefferson City	300-400	Dolomite
		Roubidoux	135-190	Oolitic limestone
		Gasconade	100-200	Limestone

Figure 2. Generalized stratigraphy of northwest Arkansas (after Caplan, 1954).

ly locate 72 wells with the aid of driller directions, a county platt book, and topographic maps. From the gross lithologic log reported on each record, it was possible to determine the aquifer(s) that supplied water to each well. The occasional absence of formations due to unconformities and poor lithologic descriptions did not significantly hamper aquifer determination, as the aquifers are usually composed of more than one geologic formation that can be distinguished by marker horizons. Other information provided by the well records include: (1) depth to water, (2) driller's estimate of yield in gallons per minutes (gpm), (3) depth to bedrock, and (4) the presence of caves and their depth below land surface. With the aid of topographic maps, elevations of the well tops were determined with subsequent plotting of the static level control points of the piezometric surface map. The Spearman-Rank Correlation Coefficient test (Siegel, 1956) was then used to make preliminary tests among the following parameters: (1) well yield, (2) regolith thickness (depth to bedrock), (3) cave presence, and (4) total depth of well.

RESULTS

Two important aquifer zones were found to be extensively utilized by residents throughout northern Searcy County. The more shallow and extensively used aquifer is the Mississippian Boone-St. Joe limestone. This aquifer is generally the less productive of the two with a range in yield of 0.5 to 75 gpm but with a median and mean productivity of only 5 and 9.8 gpm, respectively (Table 1).

Table 1. Aquifer depth and yield ranges.

Aquifer	Depth (ft.) Range	Depth (ft.) Median	Depth (ft.) Mean	Yield (gpm) Range	Yield (gpm) Median	Yield (gpm) Mean
Boone - St. Joe	100-754	350	360	0.5-75	5.0	9.8
Sylamore - Everton	200-875	570	570	1.0-80	9.0	17

Total well depths drilled in the Boone-St. Joe aquifer range from 100 to 754 feet with a median and mean depth of 350 and 360 feet, respectively. While most of these depths represent wells in which drilling began in the Boone, the deepest wells represent drilling which began in upper Mississippian and Pennsylvanian rocks. Wells that penetrated the entire thickness of the Boone-St. Joe indicate that this aquifer achieves a maximum thickness of 423 feet in the southern part of the study area. The Boone-St. Joe aquifer is unconfined where exposed at the surface, but is confined where it is covered by younger strata.

A piezometric surface map for the Boone-St. Joe was prepared, which displays several hydrologic features (Fig. 3). The aquifer discharges along portions of the Buffalo River, Big Creek, and Clear Creek. The piezometric surfaces slope in a general southeastern direction with some northwesterly movement from drainage divides. The average hydraulic gradient of 75 feet per mile indicates rapid movement and drainage. A ground-water drainage divide is observed between the Buffalo River and Big Creek. Another drainage divide is observed northwest of St. Joe. A possible cone of depression appears to be developing in the town of Snowball where the aquifer is heavily utilized locally.

The next important aquifer zone is a group of sandstones, limestones, and dolomites below the Chattanooga Shale (where present) or below the St. Joe where the Chattanooga is missing. This aquifer zone generally consists of one or more of the following units: Sylamore Sandstone (upper Devonian), Clifty Limestone (Devonian), Lafferty Limestone (Silurian), St. Clair Limestone (Silurian), Plattin Limestone (middle Ordovician), St. Peter Sandstone (middle Ordovician), and/or Everton Formation (lower Ordovician). In this area, the units above the St. Peter are generally thin, unconformable and are undifferentiable from drillers' poor lithologic descriptions. The upper Everton is the most important formation within this aquifer zone, but the overlying units commonly contribute water to the wells. This aquifer zone has been termed collectively as the Evermore by Ogden et al. (1980).

This aquifer zone is considered a separate and distinct aquifer from the Boone-St. Joe, due to the presence of the Chattanooga Shale which acts as an aquiclude between the two aquifer zones. It confines the aquifer zone below it except where stream incision has exposed pre-Mississippian units. There is a distinct difference in head levels in neighboring wells utilizing the different aquifers. However, there is considerable hydrologic interaction among the different formations comprising the Sylamore-Everton which warrants their consideration as a single aquifer.

The range of yield for the Sylamore-Everton aquifer zone is 1 to 80 gpm with a median and mean range of 9 and 17 gpm, respectively. Well depths range from 200 to 875 feet with a median and mean depth of 570 feet (Table 1). These well depths commonly penetrated some of the Boone-St. Joe, as most drilling was initiated on the Springfield Plateau which is formed by the Boone Formation. No wells examined were observed to penetrate the entire thickness of the Everton. Often, yields in this aquifer zone reflect some contribution of water from the Boone-St. Joe through fractures in the Chattanooga, but this contribution is considered negligible as drilling would have ceased before the Sylamore-Everton was penetrated.

A piezometric surface map was not prepared for this aquifer zone as the authors feel that data obtained in this study was insufficient to do so. However, a map of static water levels and well locations has been prepared (Fig. 4). This shows, however, an erratic occurrence of head levels which is due to the productive potential and occurrence, or lack thereof, of the interacting units above the Everton. A vague easterly trend of movement is indicated by the map and is supported by observations of the authors of the Sylamore-Everton in Marion County (due north of the study area) where plotted well density is greater. Ground-water movement there is toward the east where discharge occurs along portions of the White River.

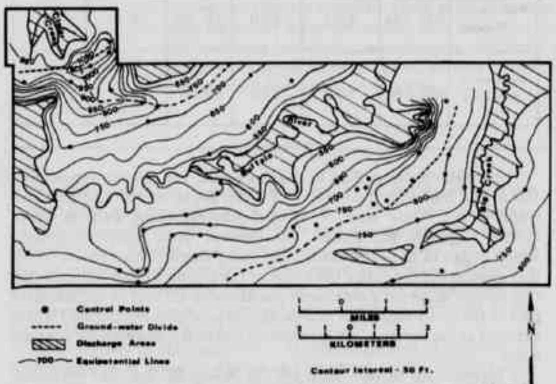

Figure 3. Piezometric surface map of the St. Joe-Boone Aquifer Zone.

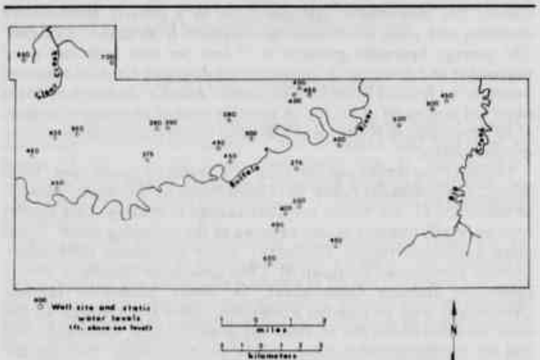

Figure 4. Static water levels of the Everton-Sylamore Aquifer Zone.

STATISTICAL RELATIONSHIPS

The relationships among yield, regolith thickness, depth of well and the presence of caves were determined from the hydrologic data found on the well driller reports to determine some of the geologic controls on well yield. The Spearman-Rank Correlation Coefficient test was used for the comparisons with the aid of computer SAS procedures (Barr et al., 1976).

The first relationship tested was between well water yield, as estimated by drillers, and regolith thickness. Regolith thicknesses on the Boone-St. Joe aquifer ranged from 3 to 121 feet with a median and mean of 17 and 27 feet, respectively. Thicknesses of regolith for wells in the Sylamore-Everton aquifer zone range from 4 to 100 feet with a median and mean of 20 and 25 feet, respectively, but usually these regolith values reflect weathering of the Boone and St. Joe limestones. The data of each aquifer were correlated both individually and collectively and the same resultant alpha significance level in both cases was obtained. The results show a linear relationship at an alpha = .001 probability level, indicating that higher well yields are obtained when wells are drilled in areas of thick regolith. In carbonate rocks, weathering is deeper along fractures, creating an irregular regolith-bedrock contact known as pinnacles and cutters (Sweeting, 1973). Fracture enlargement by solution as well as joint expansion by unloading of overburden creates a zone of increased permeability through which ground water can move more readily, thus yielding greater quantities of water to the well (Fig. 5). Therefore, the thicker regolith areas accurately indicate zones of fracture enlargement. Lattman and Parizek (1964) have found greater yields along photo-lineaments that are believed to represent fracture zones. It is possible that, by delineating zones of greater regolith thickness, greater yielding wells can be located. Ogden et al. (1980) found a similar relationship in northwest Arkansas.

It was also found that in the Boone-St. Joe aquifer, shallower wells have greater yields (alpha = .04). This is due to closing off of fractures at depth since the influence of weathering and unloading decreases with depth (Davis and DeWeist, 1967).

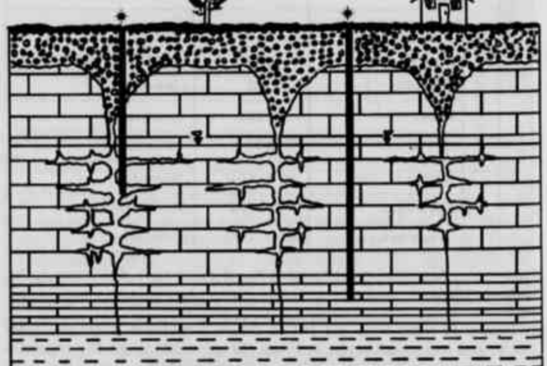

Figure 5. Diagrammatic representation of the relationship of pinnacles and cutters to fracture zones and regolith thickness.

A relationship was found between greater yields and cave presence in a well. This relationship was not due to water-filled cavities as the water table was generally below the level of the intersected cave. Caves commonly are oriented along joints and fractures (Barlow and Ogden, 1978). Therefore, wells intersecting caves are also likely to be intersecting these zones of weakness along which water can more easily migrate. Lattman and Parizek (1976) also found that more caves are intersected by wells drilled on fractures. This hypothesis is supported by the observation that thicker regolith was also found to be an indicator of cave presence in the subsurface. All wells that penetrated caves in northern Searcy County were drilled on thicker regolith (generally greater than 15 ft.). However, the number of wells drilled on thicker regolith that did not penetrate caves outnumber those that did three to one. Therefore, deeper regolith is considered to be merely one indicator and not proof of cave presence in the subsurface.

CONCLUSION

Two important aquifers representing combinations of pre-Pennsylvanian geologic formations are found to be utilized extensively by residents and communities in northern Searcy County. The Boone-St. Joe limestone aquifer is shallower, but less productive, than the Sylamore-Everton sandstone aquifer zone. More wells obtain water from the Boone-St. Joe aquifer, but when greater production is needed, the deeper Sylamore-upper Everton aquifer zone is utilized. This deeper aquifer is more commonly used by communities and the poultry industry.

Statistical correlations show that greater yields can be obtained where thicker regolith exists as concluded by Ogden et al. (1980). Thicker regolith zones are believed to represent zones of fractures enlarged by solution and along which water can be more easily transmitted. Caves are more often intersected by wells drilled in areas of thicker regolith, and wells intersecting caves have greater yields. This further substantiates the hypothesis of there being thicker regolith along fractures, since caves form by the solution of limestone along such zones of weakness.

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