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Preliminary Investigation of the Ground-Water Resources of Baxter, Fulton, Izard and Sharp Counties, Arkansas

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A PRELIMINARY INVESTIGATION OF THE GROUND-WATER RESOURCES OF BAXTER, FULTON, IZARD AND SHARP COUNTIES, ARKANSAS

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ABSTRACT

One hundred and seventy-seven drillers' well reports were used to investigate the groundwater resources of Baxter, Fulton, Izard, and Sharp counties. The most widely utilized aquifer zone is composed of the Cotter and Jefferson City dolomites. The well depths range from 30 to 740 ft with a mean and median of 264 and 225 ft, respectively. The drillers' yield estimates range from 1 to 50 gpm with a mean of 12.0 gpm and a median of 10 gpm. The piezometric surface has an average hydraulic gradient of 9 ft/mile with groundwater discharge occurring along the Spring and White Rivers.

Overlying the Cotter-Jefferson City aquifer is the Powell Dolomite aquifer. Well depths range from 43 to 275 ft with a mean and median of 137 and 114 ft, respectively. Driller estimated yields range from 7 to 40 gpm with a mean and median of 18 and 15 gpm, respectively. The Everton Aquifer is composed of a complex series of interfingering sandstones and carbonate layers that may act collectively or individually as aquifers. Well depths in this aquifer range from 8 to 812 ft with a mean of 338 ft and a median of 500 ft. Yields range from 1 to 40 gpm with a mean and median of 11 and 7 gpm, respectively. The least productive and least utilized, but shallowest aquifer is the St. Peter Sandstone aquifer which has a depth range of 55 to 113 ft with a mean and median of 80 and 85 ft, respectively. The yield ranges from 1 to 20 gpm with a mean and median of 9 and 5 gpm, respectively.

The Spearman Rank Correlation procedure was used to compare well yields (gpm), well depth, regolith thickness, depth to water, and piezometric surface elevation of the Cotter-Jefferson City aquifer. At $\alpha = 0.1$, the following relationships were established: 1) greater yield at shallow well depths, 2) greater yield where the water table is closer to the surface, 3) thicker regolith in deeper wells, and thicker regolith with increased depth to water. These correlations indicate the strong control on water movement by fractures in the aquifer, and "closing off" of fractures at depth, and the control of regolith thickness by depth to water rather than fracture proximity.

INTRODUCTION

Ground water is the primary source of water used by rural residents and small communities in northern Arkansas. Unfortunately, the number of ground water investigations in this area are extremely sparce. An early listing of some ground-water wells in northern Arkansas was made by Branner (1937) without any hydrogeologic interpretations. A very generalized statement of ground-water resources in Arkansas was made by Baker (1955). Lamonds (1972) performed a reconnaissance survey of northern Arkansas using limited data to produce piezometric surface maps for the Roubidoux Formation and Gunter Sandstone Member of the Gasconade Formation. Several University of Arkansas hydrologic theses have been written, but they have dealt almost exclusively with the Boone-St. Joe aquifer in the Fayetteville area. Ogden et al., (1979) have investigated deeper aquifers of Carroll, Madison, and Boone counties. A preliminary study similar in scope to this investigation of the ground-water resources of northern Searcy County recently has been prepared by Goodman and Ogden (1980).

This paper will present the preliminary results of a ground water reconnaissance survey of a four county area of north-central Arkansas where Ordovician carbonate and sandstone aquifers are widely utilized. The purposes of the paper are to: 1) define the aquifers, 2) determine ranges in yield and depths for the aquifers, 3) produce a piezometric surface map for the Cotter-Jefferson City carbonate aquifer, and 4) statistically compare aquifer and well properties.

LOCATION AND GEOLOGY

The study area is located in Baxter, Fulton, Izard, and Sharp counties of northern Arkansas (Fig. 1). The area is exclusively within the Salem Physiographic Province with Ordovician strata cropping out on the surface (Fig. 2). The strata dip gently southward along the southern flank of the Ozark Dome. The study area is relatively free of structural deformation with normal faults cutting the strata in a few areas. An extensive, but subdued, karst topography of many caves, dolines, and springs exist in the carbonate formations.

METHODS AND MATERIALS

Drillers' logs from 1970 to 1979 were acquired from the Arkansas Geological Commission for the four counties. One hundred and nine wells were accurately plotted on 7.5 minute topographic quadrangles using drillers' locations and county platt books. In this way, well top elevations and hence the elevation of the static water levels could be determined using water level information on the logs. The aquifer (producing horizon) of each well was determined from the geologic maps of the area in conjunction with the depth, producing zone, and gross lithologic log given on the drillers' well reports. Other information utilized from these reports was the estimated yield in gallons per minute (gpm) and regolith thickness.

The Spearman-Rank Correlation Coefficient Test of the Statistical

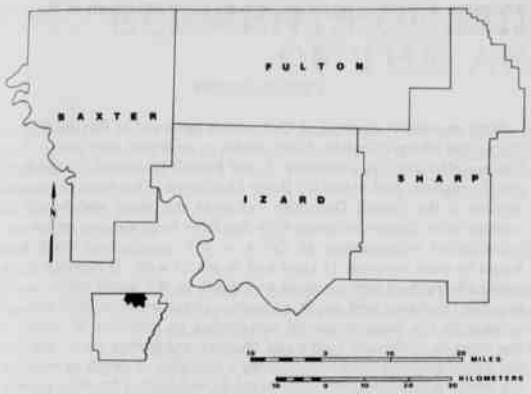

Figure 1. Location of study area.

SYSTEM	STAGE	FORMATION	THICKNESS (in ft.)	GENERAL ROCK TYPE
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 showing Ordovician formations of the study area (modified after Caplan, 1954, 1957).

Analysis System (Barr et al., 1976) was used to determine if relationships exists between various well and aquifer characteristics. The parameters compared were: 1) well depth, 2) depth to water, 3) regolith thickness, 4) yield (gpm), and 5) piezometric surface level (ft above sea leve).

RESULTS

Four aquifer zones above the Roubidoux are utilized by residents in the study area. The aquifer zones can be distinguished from marker horizons on the drillers' logs combined with the known surface geology, expected thicknesses of formations, and well depth. The shallowest of these Ordovician aquifers is the St. Peter Sandstone. This aquifer is the least utilized with producing wells located only in Sharp and Izard counties. The aquifer is unconfined, when exposed at the surface, but is confined when at depth. The St. Peter aquifer is also the least productive, having a range in yield from 1 to 20 gpm with a median and mean of 5 and 9 gpm, respectively (Table 1). Depth of wells producing from the St. Peter range from 35 to 113 feet with a mean and median of 80 and 85 feet, respectively (Table 1). The St. Peter Sandstone was included in the Evermore aquifer zone defined in northwest Arkansas by Ogden et al. (1979) due to its thinness or absence.

A second important aquifer is the Everton which is a carbonate and sandstone sequence underlying the St. Peter. The Everton Aquifer is slightly more productive than the St. Peter. It has a range in yield of 1 to 40 gpm with a median and mean of 7 and 11 gpm, respectively. Although more productive, the mean and median depth to water is considerably larger for the Everton than for the St. Peter. Well depths range from 80 to 812 feet with a mean and median depth of 338 and 500 feet, respectively (Table 1).

The Everton Formation is a complex aquifer zone composed of several water producing horizons separated by aquicludes. Everton sandstones and carbonates can occur as unconfined aquifers, when exposed at the surface, or confined conditions at depth. In general, the sandstones are tighter and less productive than the carbonates.

Below the Everton is the Powell Dolomite, the third major aquifer in the study area. The Powell is generally the most productive of the four aquifers. Well yields in this aquifer range from 7 to 40 gpm with a median of 15 gpm and a mean of 18 gpm. The depth of the wells ranges from 43 to 275 feet with a median and mean of 114 and 137 feet, respectively (Table 1). This aquifer is generally unconfined when exposed at the surface.

The Powell Dolomite increases in thickness in a southeastern direction across Arkansas (Caplan, 1957). Along the Arkansas-Missouri border, where the Powell is absent or thin, it does not act as an aquifer. In Marion County, the Powell is an independent aquifer in a few areas, but generally east of Marion and Searcy counties it cannot be distinguished on the drillers' lithologic logs from the underlying Cotter.

The Cotter and Jefferson City Dolomites, which are indistinguishable on the drillers' lithologic logs, make up the fourth major aquifer zone. This aquifer is the most widely utilized in the study area, especially where it is exposed in the northern portions of Baxter, Fulton, and Sharp counties. The wells range in yield from 1 to 50 gpm with a mean and median of 12.0 and 10.0 gpm, respectively. Depth of the wells range from 50 to 740 feet with a median and mean of 225

Table 1. Range, mean, and median of depth and yield of aquifers within the study area.

Aquifer	Depth (ft)			Yield (gpm)		
	Range	Median	Mean	Range	Median	Mean
St. Peter	35-113	85	80	1-20	5	9
Everton	80-812	500	338	1-40	7	11
Powell	43-275	114	137	7-40	15	18
Cotter-Jefferson City	50-746	225	264	1-50	10	12

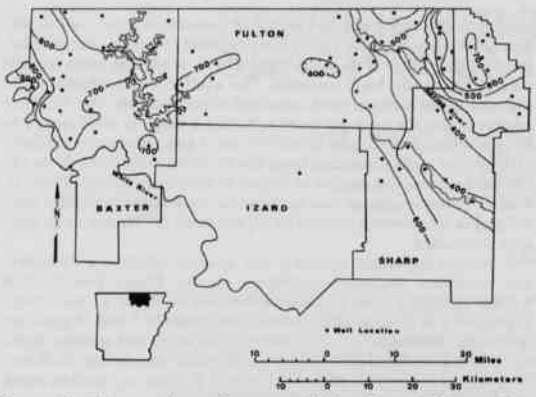

Figure 3. Piezometric surface map of the Cotter-Jefferson City Aquifer.

and 264 feet, respectively (Table 1). This aquifer generally is confined, but unconfined conditions occur locally.

A piezometric surface map was made for the Cotter-Jefferson City aquifer since 79 of the 109 plotted wells were within this aquifer (Fig. 3). Insufficient data exist for constructing piezometric surface maps of the other aquifers. The average hydraulic gradient for the aquifer is 9 ft/mile with water movement being generally southwest. The map indicates that aquifer discharge occurs along the White River in western Baxter County and along the Spring River in eastern Fulton and Sharp counties (Fig. 3).

STATISTICAL

The statistical relationships among well depth, regolith thickness, piezometric level, yield (gpm), and depth to the water table were determined from the hydrologic data compiled from drillers' well reports in the study area for the Cotter-Jefferson City aquifer. Comparisons were made using the Spearman Rank Correlation Coefficient (Siegel, 1956) and the aid of computer SAS (Barr et al., 1976) procedures.

Information was obtained from 177 drillers' reports. A comparison between yield and depth of well showed greater yield at shallow well depths at an $\alpha = 0.1$ significance level. A significant relationship at an $\alpha = 0.1$ probability also exists between yield and depth to the water table. Greater yield is found where the water table is closer to the surface. These correlations indicate the strong control on ground water movement by solutionally enlarged fractures at shallow depths in the aquifer and the tightening of fractures at depth due to greater lithostatic pressure. Thicker regolith was also found to be correlated with deeper wells and as the depth to water increases so does the regolith thickness. Although not statistically related, an inverse trend showing less yield among thicker regolith zones was found. These three trends suggest that there is not a significant difference in the thickness of regolith on or off fractures, but that regolith thickness is related to depth of weathering, which is a function of depth to the water table. Thicker regolith is found where it is deeper to the water table since weathering processes operate more effectively in the zone of aeration.

CONCLUSIONS

Four important aquifers of Ordovician age exist in Baxter, Fulton, Izard, and Sharp counties. From oldest to youngest they are: 1) the Cotter-Jefferson City Dolomite, 2) the Powell Dolomite, 3) the Everton Formation, and 4) the St. Peter Sandstone. The most productive aquifer is the Powell Dolomite, whereas the most widely utilized aquifer in the Cotter-Jefferson City due to its large surface exposure.

Statistical relationships at the $\alpha = 0.1$ significance level were found to exist between 1) yield and depth of well, 2) regolith thickness and depth of well, 3) yield and depth to the water table, and 4) regolith thickness and depth to water. These relationships strongly emphasize the importance of weathering by solution in enlarging fractures in carbonate rocks and thereby enhancing yield, but that the actual regolith thickness is more a function of depth of weathering which is more controlled by depth to water than fracture proximity.

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