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GROUND-WATER RESOURCES OF THE SOUTHEASTERN SAN JUAN BASIN

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Abstract—The availability of ground water varies considerably among four hydrogeologic provinces recognized in the southeastern San Juan Basin: the Nacimiento Uplift, Hogback Belt, Chaco Slope and Central Basin. In the Nacimiento Uplift province, the main aquifer is the Madera Formation (Pennsylvanian), which yields water with a total-dissolved-solids (TDS) content of <400 ppm at a rate of <1–200 gpm. The main aquifer in the Hogback Belt is Quaternary alluvium/pediment gravels. Rugged terrain and steep dips make extraction of water from Mesozoic and Cenozoic strata there impractical. However, this province serves as the recharge area for the Chaco Slope and Central Basin. In the Chaco Slope province, Cretaceous sandstones typically yield water with TDS contents of >300–>10,000 ppm at a rate of 1–400 gpm. In the Central Basin province Tertiary sandstone units are the principal aquifers and are often artesian. Transmissivities on the order of 100 ft^2/d have been reported. Water from these aquifers may have TDS contents of >4000 ppm, with elevated iron and/or sulfate content being special problems. Significant deep water resources exist that have not yet been seriously explored.

INTRODUCTION

For purposes of this paper, the southeastern San Juan Basin is that region bounded by the Rio Arriba/Sandoval County line on the north, longitude 106°45′ on the east, latitude 35°30″ on the south and longitude 107°22′30″ on the west (Fig. 1). North to south this includes the region between the northern tip of the San Pedro Mountains and the northern part of the Puerco Fault Zone/Puerco Necks. East to west it includes the Nacimiento Mountains and lower country to the west, extending to the approximate longitude of Laguna.

The region is semiarid to arid. Average annual precipitation at Cuba is approximately 13 inches. Higher values typify the mountains to the east; lower values are common in the lowlands to the west. Most of the region is situated east of the Continental Divide and is drained by tributaries of the Rio Grande (Rio Puerco, Rio Salado). The northwestern corner of the study region lies in the Colorado River Basin and is drained by tributaries of the San Juan River (mainly Cañon Largo).

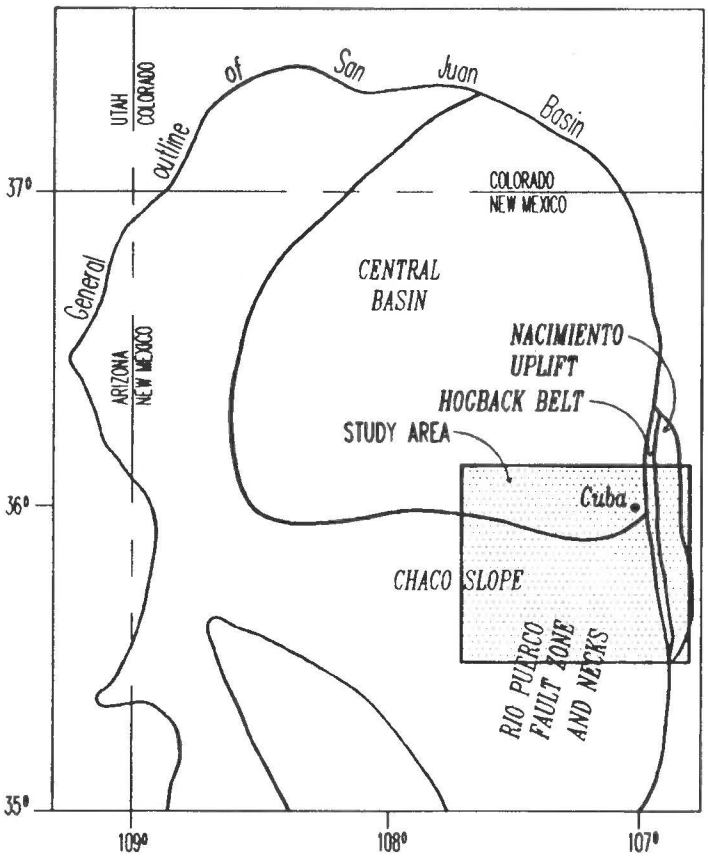

FIGURE 1. Location of study area and hydrogeologic provinces, southeastern San Juan Basin.

The potential for ground-water supplies varies considerably among four distinct hydrogeologic provinces recognized in the region: the Nacimiento Uplift, Hogback Belt, Chaco Slope and Central Basin (Fig. 1). The purpose of this paper is to give an overview of the contrasting hydrogeology and water resources in each of these provinces.

Several previous works have increased our understanding of the hydrology of the region and provide the basis for this overview. Basinwide hydrologic studies include those by Berry (1959) and Stone et al. (1983). Baltz and West (1967) and Brimhall (1973) investigated the water-resource potential of the Tertiary deposits of the Central Basin. Renick (1931), Bushman and Foster (1957) and Anderholm (1979) documented hydrologic conditions near Cuba. Craigg (1980) and Craigg and Stone (1983) addressed the hydrogeology in the southwestern part of the study region. As this overview is necessarily general, the reader is referred to these previous works for details on any area of special interest.

NACIMIENTO UPLIFT

The Nacimiento Uplift province is the mountainous area lying east of the Nacimiento Fault and forming the eastern margin of the San Juan Basin in this vicinity (Fig. 1). Anderholm (1979) called this province the San Pedro Mountains after the topographic feature by that name in the Cuba area. As this paper covers a larger area, a more regionally appropriate name is applied. This province is distinguished by its high elevation (8000–10,000 ft) and the presence of Paleozoic and Precambrian rocks at the surface.

The main aquifer is the Madera Formation of Pennsylvanian age (Table 1). Water is derived mainly from springs that have been developed for stock and domestic purposes (Anderholm, 1979). Although the water level in the province has not been mapped, owing to the lack of wells, flow direction is presumably away from the mountains in all directions. Water from the Madera is of the calcium-bicarbonate type, as might be expected from its limestone composition. The Precambrian rocks are fractured and should contain water, but, like the Madera, they have not been tested by drilling.

HOGBACK BELT

The Hogback Belt province corresponds to the narrow band of nearly vertical to slightly overturned Mesozoic and Cenozoic strata situated just west of the Nacimiento Uplift (Fig. 1). It is distinguished by its rugged terrain and steeply dipping beds. Elevations are transitional between those of the mountains and adjacent lowlands. Anderholm (1979) first recognized this province in the Cuba area. His definition

TABLE 1. Summary of ground-water resources, southeastern San Juan Basin.

Hydrogeologic Provinces	Main Aquifers	Aquifer Thickness (ft)	Yield (gpm)	TDS (ppm)
Hogback Belt	Quaternary alluvium/ pediment gravels	0–140	3–26	<600
Central Basin	Tertiary sandstones	10–200	15–20	<300 – >4,000
Chaco Slope	Cretaceous sandstones	10–150	1–400	<300 – >10,000
Nacimiento Uplift	Madera Fm. (Pennsylvanian)	400–1,550	<1–200	<400

was broader than employed here, however, and the nearly horizontal Tertiary strata making up the western part of his Hogback Belt would here be assigned to the Central Basin.

The Hogback Belt serves the important function of recharge area for aquifers of the Chaco Slope and Central Basin provinces. The more permeable rocks contain fresh water derived from runoff of rain and snow from the Nacimiento Mountains. However, the rugged terrain and steep dips make the extraction of this water impractical.

The main aquifer in this province is therefore the alluvium in stream valleys cut through the hogbacks and pediment gravels deposited atop the upturned strata (Table 1). Fortunately this province is small and suitable water supplies can be found in adjacent areas.

CHACO SLOPE

The Chaco Slope province is the area of gently dipping Cretaceous sandstone and shale units lying west of the Hogback Belt and south of the Central Basin (Fig. 1). It is distinguished by its cuesta or mesa and valley topography and northwesterly regional dips. This province includes the northern part of the Puerco Fault Zone/Puerco Necks area. Strata are offset by a series of northeast-trending, high-angle, normal faults, downdropped to the west (Craigg, 1980). Although displacement may be on the order of 50–150 ft, rock units are not always completely offset and ground-water flow is not totally interrupted.

The main aquifers are the sandstones (Table 1). Semiconfined conditions prevail and two flowing wells produce water from depths of 600 and 1200 ft in the Gallup Sandstone (Craigg and Stone, 1983). Springs commonly issue from sandstone/shale contacts and fractures. Ground-water flow directions are similar for the various sandstones—toward streams that serve as local discharge areas. Transmissivities of the Cretaceous sandstones are on the order of 10^{-4}–10^{-1} ft^2/d (Craigg and Stone, 1983).

Waters are of the sodium-bicarbonate or sodium-sulfate type. The sodium comes from clay in the matrix of the sandstone or in adjacent shale units. The sulfate content of water from the coal measures is related to the breakdown of iron-sulfide minerals and organic materials.

Ground water should also be available in this province below the Mancos Shale, especially in the Dakota Sandstone and underlying Morrison Formation. There is little information on these units owing to their great depth over most of the area. Where they lie near the surface in the southeastern part of the province, they may provide useful supplies. Sandstones of the Westwater Canyon and Jackpile Members are the best targets in the Morrison Formation. Shomaker and Stone (1976) gave characteristics of potential aquifers for use in coalfields such as those on the Chaco Slope. Water from the Dakota may be of poor quality, based on analyses elsewhere in the basin (Stone et al., 1983).

CENTRAL BASIN

The Central Basin province includes the area of nearly horizontal Tertiary strata lying west of the Hogback Belt and north of the Chaco Slope (Fig. 1). It is distinguished by its badlands or dissected plateau topography. The Tertiary sequence is very thick and characterized by alternating coarse and fine clastic rock types. More specifically, it includes the Llaves, Regina and Cuba Mesa Members of the San Jose Formation, the Nacimiento Formation, and the Ojo Alamo Sandstone, in descending order.

Low precipitation, together with the occurrence of shale at the surface over much of the area, result in low recharge. Nonetheless, the sandstones do store considerable quantities of ground water. The Cuba Mesa Member of the San Jose Formation is an important aquifer, especially near its outcrop, although waters have an elevated iron content in places (Anderholm, 1979). The excessive thickness of the overlying Regina Member mudstones (>1000 ft) has discouraged drilling to the Cuba Mesa elsewhere. The Nacimiento Formation is generally not an important aquifer, due to its fine texture. However, sandstone bodies within this unit locally produce useful amounts of water (Brimhall, 1973). The Ojo Alamo Sandstone is coarse grained and quite productive, especially at Cuba, where it lies near the surface (Anderholm, 1979). Where overlain by the Nacimiento, water in the Ojo Alamo is confined and flowing wells have been reported. Transmissivity of the Ojo Alamo is on the order of 10^{-1}–10^{-2} ft^2/d (Brimhall, 1973). Water from the Ojo Alamo has an elevated sulfate content, even close to recharge areas (Anderholm, 1979). Ground-water flow direction in this province is northwesterly west of the Continental Divide and southeasterly east of the Divide.

CONCLUSIONS

A few conclusions are possible from this general overview.

1. Water-resource availability in the southeastern San Juan Basin varies considerably with hydrogeologic setting. As the Paleozoic/Precambrian, Mesozoic and Cenozoic rocks differ in composition and texture, so do their abilities to store and transmit ground water.
2. Water quality in the region also varies with rock type and setting. The freshest water is found in carbonate rocks near recharge areas, whereas the poorest water is associated with sandstone aquifers interbedded with shales.
3. Based on existing wells and supplies, one might conclude that water resources are limited in the southeastern San Juan Basin. However, previous studies suggest that significant water resources lie deeper than exploration efforts have penetrated to date. Although the development of such resources would no doubt be rewarding, the costs associated with such a program clearly exceed the local financial resources. Perhaps some government assistance is possible, especially for municipal supplies.

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