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WATER-BEARING CHARACTERISTICS OF GEOLOGIC FORMATIONS IN NORTHEASTERN NEW MEXICO–SOUTHEASTERN COLORADO

L. CLAY KILMER
Geohydrology Associates, Inc., 4015-A Carlisle NE, Albuquerque, New Mexico 87107

Abstract—The oldest geologic units having some potential for utilization as aquifers in the guidebook study area are clastics of Permian and Pennsylvanian age exposed in the Sangre de Cristo uplift and present at depth in most of northeastern New Mexico. The Glorieta Sandstone of Permian age exposed on the east flank of the Sangre de Cristo uplift may have some potential for utilization. The Santa Rosa Formation of Triassic age is an aquifer locally, in Guadalupe County, New Mexico. The Chinle Formation of Triassic age yields small amounts of water locally to wells in Harding and Union Counties, New Mexico, and in Baca County, Colorado. The Exeter/Entrada Sandstone of Jurassic age is a local aquifer in Harding, Union and Baca Counties. The Morrison Formation, also of Jurassic age, has a locally-occurring sandstone member which is an aquifer, but generally the formation does not yield adequate water to wells. The Cheyenne, Mesa Rica and Dakota sandstones, of Cretaceous age, are aquifers of local importance in all areas. The Ogallala Formation is a primary aquifer of the High Plains in the conference area. Volcanic flows and cinder deposits of Tertiary-Quaternary age in eastern Colfax, western Union and northeastern Harding Counties are local aquifers. Quaternary alluvial deposits are aquifers in many locations, particularly in the major drainages within the conference area.

INTRODUCTION

The purpose of this report is to provide general information about the availability of ground water in the region included in the field conference and to cite ground-water literature available for the area. The discussion is limited to only those rocks that are potentially useful as aquifers in the area of the conference.

Detailed lithologic descriptions and the stratigraphic relations of geologic formations are abundant in the literature. Many are also described in considerable detail in one or more papers in this guidebook. This paper is concerned mainly with the physical properties of the rocks as they relate to the occurrence of ground water. Each aquifer within a rock group is described in order of geologic age. The descriptions include lithology, thickness of saturated zones and water-bearing characteristics. Where available, hydraulic parameters are given. The water-quality information is described in terms of electrical conductivity as an indicator of overall salinity. A specific conductance of 1,000 micromhos contains approximately 600 ppm (parts per million) total dissolved solids. In general, water having a specific conductance over 1,600 (1,000 ppm) is not considered suitable for human consumption.

Normally, aquifers which contain significant recoverable quantities of potable water are found at relatively shallow depths, generally less than 2,000 ft (610 m) below the land surface. The salinity of ground water commonly increases at greater depths. The clastic rocks at depths over 2,000 ft (610 m) generally are compacted and less porous, and thus have less ability to yield water to wells.

The rocks that are currently or potentially useful as aquifers in northeastern New Mexico are no older than Permian. The area is dominated by rock exposures dating from Triassic to Recent. Therefore, this discussion of the characteristics of the water-bearing geologic formations will provide only a cursory treatment of the units older than Triassic.

AQUIFERS OF PRE-TRIASSIC AGE

Permo-Pennsylvanian clastics

The Paleozoic section in the area of the Sangre de Cristo uplift is composed largely of thick deposits of immature arkosic sand, gravel and silt with minor amounts of limestone and shale. The Sandia, the Madera, the Sangre de Cristo, the Abo and the Yeso formations of Pennsylvanian and Permian age comprise this clastic section (Lessard and Bejnar, 1976).

The combined thickness of this section reaches several thousand ft (Dane and Bachman, 1965). The Sandia, Madera and Sangre de Cristo formations do not crop out in the area. They probably occur in the deep subsurface, but nowhere in the area visited by the conference are they known to provide potable water to wells. Likewise, the Abo and Yeso formations are not known to produce potable water to wells in the conference area, although they do produce small quantities of water to the south and west (Table 1) (Griggs and Hendrickson, 1951, pp. 38–45).

Glorieta Sandstone

The Glorieta Sandstone is exposed in a few small areas on the east flank of the Sangre de Cristo uplift north of Las Vegas. The Glorieta is a yellow-gray to grayish-orange quartzarenite with well-rounded quartz grains (Baltz and Bachman, 1956). The sandstone is well-cemented to friable.

The thickness of the Glorieta Sandstone reaches 220 ft (67 m) in Kearny's Gap south of Las Vegas (Baltz and Bachman, 1956), and a lithologic log of a carbon dioxide gas well in the Bueyeros gas field, Harding County, indicates that the Glorieta in that area is about 100 ft (30 m) thick at a depth of about 1,400 ft (427 m) (Foster and Jensen, 1972, p. 197). Wells this deep probably would produce brackish water in small quantities. However, where the sandstone is present at shallower depth and saturated, small to moderate quantities of potable water probably could be developed.

AQUIFERS OF TRIASSIC AGE

Santa Rosa Formation

The Santa Rosa Formation is well exposed along Highway 285 between Lamy and Clines Corners and along the Pecos River between Ft. Sumner and an area northwest of Watrous (Dane and Bachman, 1965). However, it is found only at depth in the conference area where it underlies the Chinle Formation.

The Santa Rosa Formation is a series of alternating lutites, arenites and rudites which are reddish-gray, yellowish-gray and olive-gray in color (Lessard and Bejnar, 1976). The thickness of the Santa Rosa Formation reaches 323 ft (98 m) in the Gallinas River Canyon.

It is unlikely that potable water could be developed in the Santa Rosa Formation anywhere in the conference area. The quality of water from the Santa Rosa is highly variable, ranging from 446 to 3,590 micromhos specific conductance in Guadalupe County (Dinwiddie and Clebsch, 1973, p. 6), and it is likely to be even poorer if found at depth in the conference area. In the area of Tucumcari, the Santa Rosa occurs at a depth of about 1,500 ft (457 m), and the water is not usable (Trauger and Bushman, 1961, p. 15).

TABLE 1. Generalized stratigraphic section and water-bearing characteristics of geologic formations in northeastern New Mexico and adjoining areas.

Aquifer or Formation	Thickness (feet)	Yield (gpm)	Transmissivity (gpd/ft)	Storage Coefficient	Specific Capacity (gpm/ft of drawdown)	Water Quality
Younger alluvium	20 (avg)	Up to 9 gpm in Quay Co.; 300 gpm near Capulin	Moderate	unknown	1-10	Fair to poor depending on recharge; from 452 to 3980 micromhos
Older alluvium	0-600	Up to 300	6620	unknown	1-5	Fair to poor; from 781 to 3840 micromhos
Volcanic rocks	0-50	Up to 1000	Low to high	unknown	0-36	Good to fair; from 86 to 935 micromhos
Ogallala	0-300	Up to 1600	3000 to 90,500	0.1048	1-30	Good to fair; from 326 to 820 micromhos
Greenhorn L.S.	0-62	Less than 10	Very low	unknown	Less than 0.5	Fair to poor; 448 to 5900 micromhos
Dakota-Mesa Rica-Purgatoire	0-300	Up to 400	3700 to 66,600	7×10^{-5}	0.5-5	Variable; from 40 to 5640 micromhos
Cheyenne	0-50	Up to 3000	Low to high	unknown	1-20	Moderately hard; from 370 to 1061 micromhos
Morrison	0-600	1 to 2	Low to moderate	unknown	Less than 1	Fair to poor; 813 to 2520 micromhos
Exeter/Entrada	0-300	Up to 600	630 to 5560	0.0002 to 0.144	0.5-5	Fair to poor; 540 to 3190 micromhos
Chinle-Dockum Group	1200	Up to 20	Very low	unknown	0.03-1	Poor; 906 to 5270 micromhos
Santa Rosa Sandstone	1-375	Up to 150 Less than 10 (avg)	Low	unknown	Less than 1	Fair to poor; 491 to 2640 micromhos
Glorieta Sandstone	0-220	Up to 15, locally more	Low	unknown	Less than 1	Potable where penetrated by wells at shallow depth
Permo-Pennsylvanian Clastics	3000+	Less than 10	Low	unknown	0-4.5	Probably non-potable in most of the conference area

Chinle and Redonda formations—Dockum Group

This discussion includes the Chinle and the Redonda formations of Griggs and Read (1959, p. 2006). The Chinle is exposed in the canyon of the Canadian River, in eastern Harding County and in Cimarron Canyon in Union County. It may be presumed to exist at depth under all the region encompassed by the field conference. The Chinle is a thick sequence of reddish-brown shale, siltstone and fine sandstone. This unit reaches a known thickness of 1,230 ft (375 m) in Quay County (Berkstresser and Mourant, 1966). Trauger and Bushman (1964, p. 16) indicate a probable maximum thickness of 1,500 ft (457 m) at the time of deposition in the Tucumcari basin. The formation thins northward. McLaughlin (1954, p. 18) reports the Chinle to be about 570 ft (174 m) thick in southeastern Baca County, Colorado.

The Chinle has been sparsely utilized as an aquifer in northeastern New Mexico due to low yields and commonly poor quality resulting from its fine texture. A few wells have been completed in the Chinle in Harding County in the valley of Ute and Tequesquite Creeks. Production is generally only adequate for stock supply (where available at all), but wells in Quay County reportedly have produced as much as 20 gpm (Berkstresser and Mourant, 1966). Such high yields probably were obtained from the middle sandstone (Cuervo) member. No wells in Harding County are known to have tapped this unit of the Chinle. The specific capacity of the Chinle at a well in sec. 11, T28N, R27E near Tucumcari was measured at about 0.03 gpm/ft (Trauger and Bushman, 1964, p. 16). Water from the Chinle is hard. Specific conductance ranges from 906 to 5,270 micromhos (Berkstresser and Mourant, 1966).

In southeastern Baca County, Colorado, the rock texture is very fine, with yields to wells being small. Quality is variable, with the best water coming from areas where the Chinle is overlain by Ogallala (McLaughlin, 1954).

Cooper and Davis (1967) and Trauger et al. (1986) cite the development of small quantities of water from the Chinle for stock and domestic wells in the Cimarron River valley in eastern Union County and in Harding County, New Mexico. The specific conductance of waters from these wells ranges from 1,280 to 2,670 micromhos, at best only marginally suitable for domestic use.

AQUIFERS OF JURASSIC AGE

Exeter/Entrada

The Exeter/Entrada Sandstone is a prominent ledge-forming sandstone well exposed on the margins of the Tucumcari basin in San Miguel and Guadalupe Counties and locally in Harding County. The formation also is exposed along the Cimarron River canyon in Union County, New Mexico, and southern Baca County, Colorado. Throughout the area the Exeter/Entrada Sandstone is described as a fine- to medium-grained quartzose sandstone.

In Baca County the Exeter/Entrada is described as a friable, cross-bedded, fine-grained quartz sand. The thickness of the Exeter/Entrada reaches 300 ft (91 m), but it is generally about 35 ft (11 m) thick (McLaughlin, 1954). The water from the Exeter/Entrada in this area is reported as hard but suitable for domestic and stock purposes.

In Harding County the Exeter/Entrada is also a crossbedded sand but generally is not much over 100 ft (30 m) thick. The yields to stock wells known to be completed in the Exeter/Entrada east of Bueyeros range from 1.5 gpm to 5 gpm. It is possible the Exeter/Entrada is the source of a good part of the water developed in a few irrigation wells in the vicinity of Rosebud. The quality of water from the Exeter/Entrada in this area is generally good.

Cooper and Davis (1967, p. 53) report Exeter/Entrada wells in Union County having artesian flows to 65 gpm, and pumping yields of 500–600 gpm along Tramperos Creek. The quality of the water from the Exeter/Entrada in this area ranges from 813 to 2,520 micromhos specific conductance.

In the western part of the Great Plains Province toward the eastern flank of the Sangre de Cristo uplift, the Exeter/Entrada can be utilized only in close proximity to outcrops where it may be reached at moderate drilling depths (Dinwiddie and Cooper, 1966, p. 76).

Hydraulic coefficients for the Exeter/Entrada are not available for production areas in the conference area. They have been determined for the unit in the Tucumcari area to the south. The transmissibilities of the sandstone in the Tucumcari municipal well fields range from 630 gpd/ft to 6,700 gpd/ft. Storage coefficients range from 0.0002 to 0.144 (Trauger and Bushman, 1964, pp. 48–63).

Morrison Formation

The Morrison Formation is a series of fine- to medium-grained clastics which is continuous across northeastern New Mexico. The Morrison crops out in the Canadian Escarpment and the valley of Ute Creek and its tributaries in eastern Harding County-southern Union County and the drainage basin of the Cimarron River in northern Union County (Dane and Bachman, 1965). In Union County the Morrison Formation has a locally occurring sandstone member in the upper section which may produce water of marginal quality in small quantities. Wells yield 1 to 2 gpm and specific conductance ranges from 813 to 2,520 micromhos (Cooper and Davis, 1967).

Morrison-Exeter/Entrada aquifer

According to Lappala (1973), the sandstones of the Morrison and the Exeter/Entrada form a single hydrologic unit in much of Union County. Although the combined saturated thickness is probably less than 50 ft (15 m), the aquifer system can maintain high yields where sufficient hydrostatic pressure exists. The City of Clayton wells no. 3 and 4 are completed in this aquifer unit. Most of the irrigation wells in southeastern Union County are multiple completions tapping the Morrison-Exeter/Entrada aquifer in addition to the overlying Ogallala aquifer. Where the Ogallala aquifer is not present, the Morrison-Exeter/Entrada produces moderate quantities of water for stock and domestic use. This aquifer unit may be the one supplying water to the irrigation wells near Rosebud, Harding County, but, in addition, the Ogallala may be a part of the system.

AQUIFERS OF CRETACEOUS AGE

Cheyenne-Mesa Rica-Dakota Sandstone sequence

The Tucumcari Shale, Mesa Rica Sandstone and Pajarito Shale sequence of beds was earlier referred to the Purgatoire Formation (Dobrovolny et al., 1946) but elevated to formational status by Griggs and Read (1959). Darton's geologic map of New Mexico (1928) lumped the Pajarito Shale and Mesa Rica with the Dakota Sandstone. The Cheyenne Sandstone was not recognized in New Mexico by earlier investigators.

Gage and Asquith (1977) thought the Mesa Rica might be a correlative of the Dakota Sandstone. Mateer (1985) reviewed the problem in a detailed discussion of pre-Graneros Cretaceous stratigraphy in the region. He concluded the Mesa Rica represents the fluvio-deltaic complex and the Dakota the marine sand interval of time-equivalent and contiguous beds. However, in the vicinity of Mosquero and Roy, beds of distinctly Dakota character overlie beds distinctly Mesa Rica, and are separated locally by shale beds identified by Wanek (1962) as the Pajarito. The question of the true relation of the Mesa Rica to the Dakota remains open.

Cheyenne Sandstone

The Cheyenne Sandstone Member of the Purgatoire Formation is an important aquifer in southeasern Colorado. This unit may have an equivalent in northeastern New Mexico. Trauger et al. (1972, p. 20) suggested that a distinctive clean white, 20–30-ft- (6–9-m)-thick sandstone well exposed at the base of the Mesa Rica Sandstone south of Mosquero might be a correlative to the Cheyenne. It also may be the unit seen in the geophysical log of the oil test drilled a few miles east of Roy and in drillers' logs of deep tests elsewhere (Trauger et al., 1986, pp. 93–94, figs. 6a–b).

The Cheyenne Sandstone is a fine- to coarse-grained quartzose sand which is friable and white to light gray. The Cheyenne crops out in canyons in southwestern Baca County and underlies most of the county, thinning toward the east. The thickness of the Cheyenne varies substantially from location to location, averaging 50 ft (15 m) (McLaughlin, 1954).

The Cheyenne yields adequate quantities of water to wells for stock and domestic use throughout Baca County. Where the sandstone is poorly cemented and well sorted, yields to wells may be substantial. One well in the eastern part of Baca County had a reported yield of over 3,000 gpm. The water from the Cheyenne in that area is moderately hard, but suitable for most uses. The specific conductance of water samples from Cheyenne wells in Baca County ranges from 370 to 1,061 micromhos (McLaughlin, 1954).

Mesa Rica Sandstone

The Mesa Rica Sandstone is generally buff- to grayish-yellow with characteristic yellowish-orange mottling. It consists of a sequence of massive- to thinly-bedded, fine- to medium-grained strata averaging about 85 ft (26 m) thick. Beds of coarse to very coarse-grained sandstone and pebbly conglomerate occur locally at the base of the formation. The 20–30 ft (6–9 m) bed of clean, white, quartzitic sand mentioned as locally occurring at the base of the sequence in Harding County commonly is not well cemented, whereas the overlying strata are moderately to well cemented.

In Harding County the Mesa Rica Sandstone is topographically high and forms the caprock of many of the mesas and is non-water-bearing. However, where this sandstone is saturated, it can produce small quantities of potable water to stock and domestic wells. It and the overlying Dakota Sandstone together constitute an important aquifer in the area of Roy and Mosquero wherever the Ogallala is thin and non-water-bearing. Most yields are less than 5 gpm (F. Trauger, oral commun., 1987).

Dakota-Purgatoire aquifer

Owing to the interfingering of the Lower Cretaceous strata, the subsurface correlation of shallow sandstone strata is difficult in much of the conference area. In Baca County, Colorado, McLaughlin (1954) described the Purgatoire Formation (Pajarito Shale-Mesa Rica Sandstone in northeastern New Mexico) as a lateral equivalent of the Cheyenne Sandstone. The Purgatoire is locally overlain by the Dakota Sandstone. Therefore, where the intervening Kiowa (Parajito) Shale is absent, the Dakota-Mesa Rica-Purgatoire sandstones and shales form a single aquifer unit. According to Lappala (1973), this aquifer unit underlies more than 1,700 mi^2 of northeastern New Mexico, as well as part of adjoining Colorado and Oklahoma.

The Dakota Sandstone is well exposed in a large area along the Canadian River Valley and in western Mora County northeast of Las Vegas. The Dakota is also exposed in scattered localities in southwestern and northeastern Union County (Dane and Bachman, 1965).

In Baca County, Colorado, the Dakota is a series of sandstones and sandy shales, buff to tan or yellow in color. The sands are locally crossbedded, fine to coarse in texture and locally conglomeratic. The grains are predominately quartz, angular to well rounded. The thickness of the Dakota reaches 135 ft (41 m) in northwestern Baca County and thins to absent in the southeastern part of the county.

The Dakota Sandstone is the principal aquifer in Baca County. In areas where it is confined by overlying strata it yields moderate quantities of water to numerous wells. The Dakota is drained in areas where it has been dissected. The water quality from the Dakota in Baca County is variable, with the water having lower dissolved solids content coming from areas of shallower depth and greater proximity to outcrop areas. Specific conductance of water from the Dakota ranges from 148 micromhos to 5,640 micromhos (McLaughlin, 1954).

The Dakota Sandstone is utilized as an aquifer in eastern Colfax County, where it is estimated that fifty million acre-ft of recoverable water reserves are distributed across an area of three million acres (Griggs, 1948). The thickness of the Dakota averages 200 ft (61 m) in this area. The Dakota is confined above by the Graneros Shale in much of Colfax County. Specific capacities average 1 gpm/ft (Griggs, 1948).

The quality of water in the Dakota in eastern Colfax County is variable and apparently controlled to a large extent by the Sierra Grande arch. The water from the Dakota west of the Sierra Grande arch is markedly poorer in quality than the water from the Dakota in the area east of the arch. It is theorized that Quaternary age subsurface dikes have added bicarbonates, chlorides and sodium to the water in the Dakota in the Las Vegas basin on the western margin of the Sierra Grande arch (Griggs, 1948). The specific conductance of Dakota water in this area ranges from 40 to 910 micromhos.

In adjacent Union County, the Dakota-Mesa Rica-Purgatoire aquifer is productive over a wide area with some wells yielding large quantities of water (Cooper and Davis, 1967). Although many of these are non-flowing artesian wells, Lappala (1973) reported a flowing well in Cimarron County, Oklahoma to yield 400 gpm. The water-producing zones in the Dakota-Purgatoire aquifer are massive clean sandstones. However, lateral facies changes result in the sandstones being interbedded with clay and siltstone. Semi-confined conditions exist where these confining beds are areally extensive. The water quality is variable, with the specific conductance averaging about 500 micromhos.

A number of tests have been conducted in Union County on wells tapping the Dakota-Purgatoire aquifer. Transmissivity values of 34,400 and 36,600 gpd/ft were measured in a well located in the SW¼ sec. 5, T26N, R37E. The storativity value of 7×10^{-5} (dimensionless) is a characteristic of artesian conditions. Lappala (1973) conducted tests on nine different wells tapping this aquifer system in New Mexico and Colorado. A total of 14 values for transmissivity were determined, with the average being 27,700 gpd/ft. The values ranged from 3,700 to 66,600 gpd/ft.

Graneros Shale-Greenhorn Limestone-Carlile Shale sequence

The Graneros Shale-Greenhorn Limestone-Carlile Shale sequence crops out in many localities of western Union, eastern Colfax and northern Harding Counties, New Mexico, and in Baca County, Colorado. Its thickness is generally between 260 and 410 ft (79 and 125 m) in Baca, Union and Colfax Counties, but thins to as little as 60 ft (18 m) in central Harding County, and is absent south of Mosquero. The Greenhorn Limestone is from 5 to 45 ft (1.5 to 14 m) thick where present and is composed of thin beds of gray or brown to black dense limestone and interbedded gray to black calcareous shale. The Graneros Shale is from 20 to 215 ft (6 to 65 m) thick, and the Carlile Shale is from 30 to 215 ft (9 to 65 m) thick. The shales are mostly fissile and black to dark brownish. Locally they may contain somewhat sandy strata.

The sequence yields small quantities of water to wells in Baca County and to a few wells in Union, Harding and Colfax Counties, but nowhere is it considered a good aquifer. In general the wells are close to outcrops in areas of local recharge. The well yields are small, with the specific capacities being less than 0.5 gpm/ft (Griggs, 1948). Permeability of the whole sequence appears to become negligible at depths greater than 200 ft (61 m). The quality of water in the shale-limestone sequence is fair to poor. The water is hard, with specific conductance ranging from 448 to 5,900 micromhos.

AQUIFERS OF TERTIARY AGE

Ogallala Formation

The most important aquifer in northeastern New Mexico is the Ogallala Formation of Tertiary age. The Ogallala is a sequence of fine- to coarse-grained clastics which range in thickness from a featheredge to 300 ft (91 m). It is composed largely of sand, silt and clay with boulder, pebble and cobble strata near the base (Dinwiddie and Cooper, 1966). In many localities the Ogallala is covered by basaltic lava flows, alluvium and dune sands.

In Baca County, Colorado, the Ogallala supplies water of good quality to wells in areas where it is of sufficient thickness and saturated. In the productive areas, the quantity and quality of water from the Ogallala Formation depends greatly on the topography of the paleo-surface upon which the clastics were deposited. The paleotopography controlled the thickness, texture, sorting and water saturation of the resulting alluvial deposits. The yields of wells in Baca County range from small to moderate, generally always enough for domestic and stock purposes. The specific conductance of Ogallala water samples from this area ranges from 326 to 820 micromhos. A number of aquifer tests have been conducted on wells tapping the Ogallala aquifer in Baca County. Transmissivity test values determined by testing eight different wells ranged from 5,200 gpd/ft to 90,500 gpd/ft and averaged 28,200 gpd/ft. No values for storativity were determined.

In Union County the Ogallala is an important aquifer along the eastern boundary where it is thickest. It is utilized to a lesser extent in the western and central areas of the county where is thinner and underlies basalt (Cooper and Davis, 1967). The productivity of the Ogallala in Union County ranges from a few gallons per minute in wells in areas of thin saturations to 1,000 gallons per minute in areas where thick saturated sections occur. The thicker sections commonly occupy buried bedrock valleys along the eastern edge of the county. The quality of water from the Ogallala in Union County ranges from 398 to 800 micromhos. Lappala (1973) reported the results of one aquifer test that was conducted on a well completed in the Ogallala aquifer in Union County. The value of transmissivity was calculated to be 77,800 gpd/ft; no value for storativity was determined.

In much of Union County, New Mexico, and Baca County, Colorado, wells are commonly completed in more than one aquifer in order to maximize production. Commonly wells are drilled through the Ogallala aquifer and into the underlying Dakota-Purgatoire aquifer. The Ogallala was deposited on the outcrops of the Morrison-Exeter and the Dakota-Purgatoire aquifers. Therefore, along the subcrop of these aquifers, they are hydraulically connected to the Ogallala aquifer (Fig. 1).

The Ogallala is of importance as an aquifer in the southeastern part of Colfax County where it has up to 30 ft (9 m) of saturated thickness. The specific capacity of the Ogallala in this area ranges from 1 gpm/ft to 30 gpm/ft. The transmissibilities range from 3,000 gpd/ft (gallons per day per foot) to over 13,000 gpd/ft. The quality of water from the Ogallala in this area is good, with specific conductance ranging from 315 to 375 micromhos (Griggs, 1948).

The Ogallala Formation is an important aquifer in west-central Harding County in the vicinity of Mosquero and Roy where it furnishes water to the municipal well fields and to many rural domestic and stock wells. Trauger et al. (1986) speculate that the thickness of the Ogallala in this area ranges from 100 to 220 ft (30 to 60 m), and the saturated thickness may be as great as 50 ft (15 m) locally. It is 40 ft (12 m) in the Roy municipal well field. Productivity is best in areas where erosional channels exist in the pre-Ogallala surface. The old buried channels in the paleo-surface allow for greater saturated thickness but are of limited lateral extent so that wells drilled to one side or the other may find no water. The Ogallala in this area is characterized in the upper part of the section by the carbonate development commonly referred to as "caliche." Where this alteration is severe and vertically distributed throughout the sequence, the ability of the Ogallala to produce water to wells is greatly reduced.

Tests of the Ogallala in the Roy municipal well field have yielded transmissibilities averaging 11,500 gpd/ft, specific capacities averaging

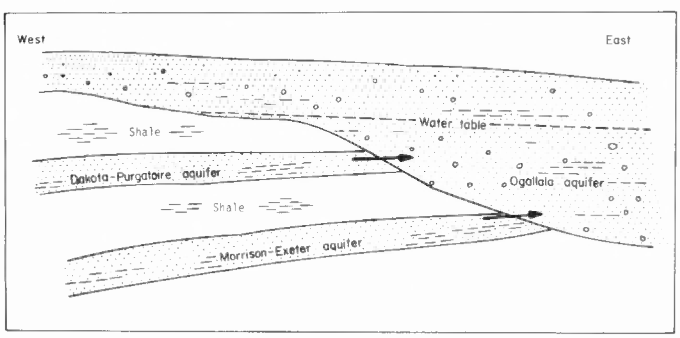

FIGURE 1. Diagrammatic cross section in Union County, New Mexico, showing stratigraphic relationship of the principal aquifer systems. Arrows show direction of leakage between aquifers. Modified after Lappala (1973, fig. 10).

9.3 gpm/ft and storage coefficients averaging about 0.1. The quality of Ogallala water from wells in this area ranges from 443 to 670 micromhos (Trauger et al., 1986).

AQUIFERS OF TERTIARY AND QUATERNARY AGE

Volcanic rocks

The rocks of Tertiary and Quaternary age in northeastern New Mexico and southeastern Colorado of potential use as aquifers consist of volcanic cinder deposits, basalt and rhyolite flows, and latitic tuffs which cap many mesas and fill numerous valleys in the area. These deposits vary greatly in thickness. The volcanic rocks generally are above the water table but may be prolific producers of good quality water where they are saturated.

In areas where the flows overlie impermeable sediments, springs are common. One such spring in the vicinity of Folsom, New Mexico, is reported to yield 50 gpm (Dinwiddie and Cooper, 1966). Where these volcanic rocks are thick and saturated, such as in the area of the Capulin basin, yields to wells may be over 1,000 gpm. The specific capacity of the volcanic aquifer in the Capulin area was reported to be 36 gpm/ft. The quality of the water from this aquifer ranges from 86 to 935 micromhos (Trauger and Kelly, 1975). These units are important only in the areas of eastern Colfax and western Union Counties.

AQUIFERS OF QUATERNARY AGE

Quaternary deposits supply water to wells in many parts of the conference area. The deposits may be younger-age stream-channel alluvial deposits and eolian silt and clay deposits or older-age subsidence-fill deposits, pediment-gravel deposits and terrace-gravel deposits.

Older alluvium

The older alluvium consists of pediment gravels which occur as veneers on pediment remnants, terrace gravels adjacent to major drainages and subsidence fills. The older alluvium is generally coarse in texture, but varies depending on the slope and proximity to sediment source areas. All deposits are laterally discontinuous. The thickness of these deposits depends on topographic location and may range from a few ft to as much as 50 ft (15 m) in some of the larger subsidence basins such as Black Lake, Kansas Valley Lake and Chicosa Lake in Harding County.

In most of the conference area the older alluvium is either not present or is above the water table. Wells completed in the older alluvium can be good water producers, with yields ranging from a few gallons per minute to as much as a hundred gallons per minute where the saturated thickness is as much as 30 ft (9 m). The quality of water from the older alluvium is variable, ranging from 781 to 3,840 micromhos and averaging about 900 micromhos. In general, the water from the alluvial deposits in the old lake basins is of the poorest quality.

Younger alluvium

The younger alluvial deposits in the conference area consist of clay, silt, sand and gravel deposited in present stream channels and floodplains, fill in the upland valleys and eolian sand deposits on the upland plains. These deposits are thin, averaging about 20 ft (6 m) in thickness. The composition and texture of the younger alluvium is variable, depending on the slope, topography and proximity to and composition of the source materials. The deposits tend to be fine-textured in flat areas and coarser-textured in stream valleys. As with the older alluvial deposits, the younger alluvium is laterally discontinuous.

The younger alluvium constitutes an aquifer only in a few areas in stream valleys where there is sufficient saturated thickness to sustain yield throughout the year. In the Capulin area the saturated thickness of the younger alluvium is as much as 100 ft (30 m), and yields to wells may reach 300 gpm (Dinwiddie and Cooper, 1966). The yields to wells completed in the younger alluvium in alluvial valleys are generally adequate for domestic and stock uses. In Harding County, irrigation wells in the vicinity of Rosebud may obtain some water from younger alluvium overlying the Exeter/Entrada Sandstone and Morrison Formation aquifer. The quality of water from the younger alluvium is fair to poor, the conductivity ranging from a low of 56 micromhos in Colfax County to 1,600 micromhos in Union County. For the most part it is satisfactory for domestic and stock use, the poorer quality water generally being found in the younger alluvium overlying deposits of shale, as in Union County.

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Steamboat Butte from the west, showing the striking angular unconformity between inclined strata of the Upper Triassic Travesser Formation and the overlying, horizontal strata of the Middle Jurassic Entrada Sandstone. Photograph by S. G. Lucas.