Geology and Ground-Water Resources of Eddy County, New Mexico

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AL RESOURCES

INCOME, 1947
$ 6,000,000
1,377,838
371,616
124,282
113,059
350,192
1,600,000
831,000
$10,768,887

Geology

STRATIGRAPHY

The following discussion of the geology of Eddy County is based on the reports listed in the list of references and on information obtained in the field during the present investigation. The areas of outcrop of the different geologic units are shown on plate 1.

The rocks exposed in Eddy County are all of sedimentary origin, with the exception of a small igneous dike about 10 miles south of the Carlsbad Caverns, and are of Permian, Triassic, Tertiary, and Quaternary age. The correlation chart, figure 3, from King (1948, p. 101), shows the general relationship of the formations in the county.

PERMIAN SYSTEM

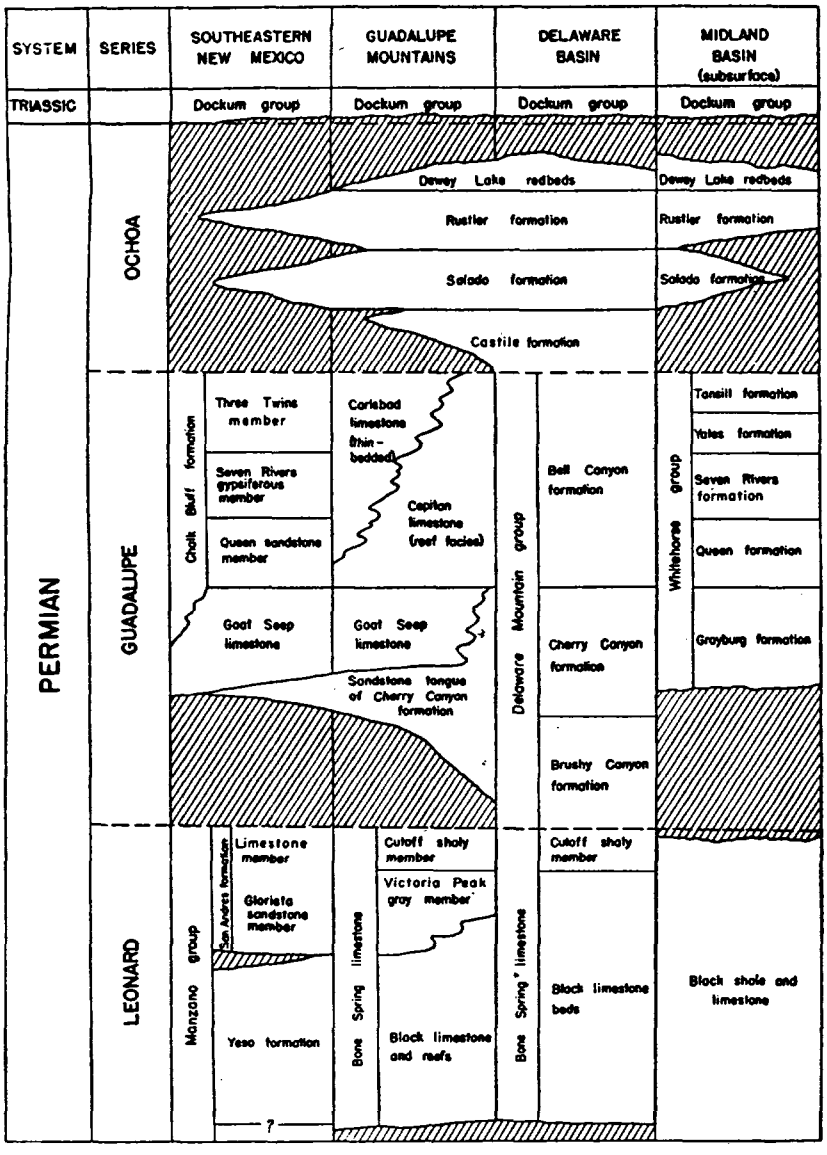
Leonard series

San Andres formation.—The oldest formation exposed in Eddy County is the San Andres, which is also the oldest formation known to provide water to wells in the county. The San Andres crops out in a small area in the northwest part of the county and over a large adjoining area west and northwest of the county. The San Andres formation in Eddy County consists of a basal sandstone member, the Glorieta sandstone member, 12 to 90 feet thick, and an overlying limestone member, about 1,000 feet thick (Theis, Sayre, and others, 1942, p. 29).

The Glorieta sandstone member is not exposed in Eddy County but to the northwest in the Sacramento Mountains it crops out as a medium- to coarse-grained sandstone cemented with lime or iron. No wells are known to obtain water from the Glorieta sandstone member in Eddy County.

The limestone member of the San Andres formation in Eddy County is composed of limestone, dolomitic limestone, and dolomite and ranges in color from gray to light tan. The upper part of the limestone member is generally lighter-colored, thinner-bedded, and more dolomitic than the lower part. Solution cavities in the limestone range from a fraction of an inch to several feet in diameter. Although its outcrop area in Eddy County is small, this limestone exists beneath the surface under a large area and is an important artesian aquifer in the Roswell artesian basin in northern Eddy County.

The Bone Spring limestone, the reef equivalent of the San Andres and Yeso formations (King, 1948, p. 101), is not exposed in Eddy County. Well drillers have reported a black shaly limestone in some of the deep wells in the Guadalupe Mountains in southern Eddy County which may be the Cutoff shaly member at the top of the Bone Spring limestone. In each case water was reported just above the black shaly limestone.



CORRELATION OF GEOLOGIC FORMATIONS OF THE PERMIAN AND TRIASSIC SYSTEMS IN AND NEAR EDDY COUNTY, N. MEX. (*Modified from chart by P. B. King, U. S. Geol. Survey Prof. Paper 215, fig. 12.*)

Fig. 3

Guadalupe series

The Guadalupe and its equivalent, tl mentary rocks that h changes in character noted by Girty (190 first interpreted by deposition.

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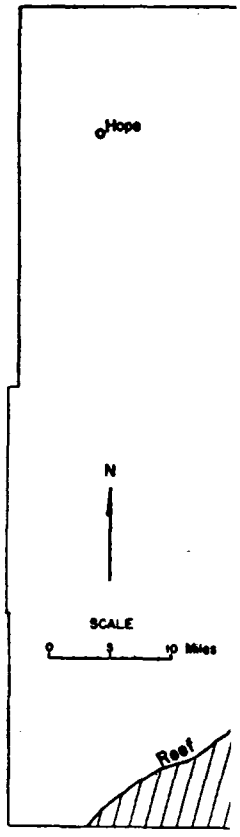
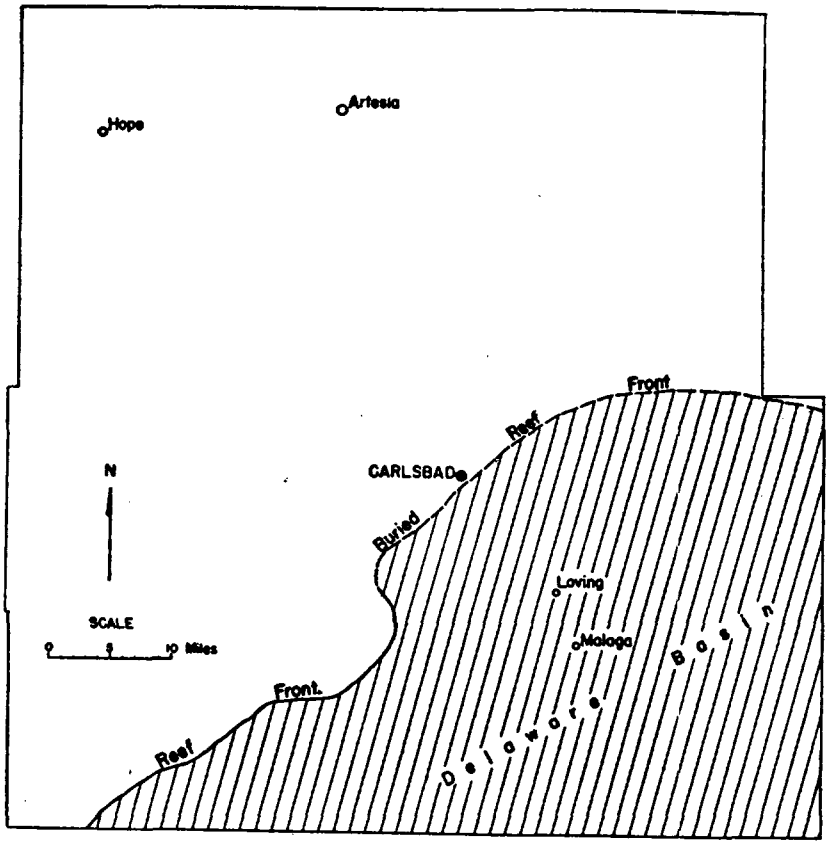


REEF FRONT A N. MEX. (*After Wa vol. 21, no. 7, 1937.*)

Guadalupe series

The Guadalupe series, which overlies the San Andres formation and its equivalent, the Bone Spring limestone, is a thick series of sedimentary rocks that has a wide lateral range in composition. The lateral changes in character of these rocks in the Guadalupe Mountains area, noted by Girty (1909, p. 138) and Richardson (1910, pp. 325-337), were first interpreted by Lloyd (1929, pp. 645-648) as being due to reef deposition.

In Eddy County the reef follows approximately the southeast escarpment of the Guadalupe Mountains from the south county line to the vicinity of Carlsbad. (See fig. 4). Northeast of Carlsbad the reef is overlain by younger sedimentary rocks. The buried reef trends north-



REEF FRONT AND EXTENT OF DELAWARE BASIN IN EDDY COUNTY, N. MEX. *(After Walter B. Long, Am. Assoc. Petroleum Geologists Bull., vol. 21, no. 7, 1937.)*

Fig. 4

east and intersects the east county line at about T. 20 S. The area southeast of the reef is called the Delaware Basin and the area northwest of the reef is called the back-reef or shelf area. The sedimentary rocks of Guadalupe age are thus divided into three facies: (1) a basinal facies of sandstone and some thin-bedded limestone interfingering to the northwest with the limestone of the reef zone; (2) a reef facies of massive to medium-bedded limestone grading to the northwest into medium- to thin-bedded limestone and dolomite; (3) a shelf or back-reef facies of medium- to thin-bedded dolomite and limestone grading to the northwest into redbeds and gypsum.

Delaware Mountain group.—The basinal sedimentary rocks of the Guadalupe series are called the Delaware Mountain group, which includes, from oldest to youngest, the Brushy Canyon formation, the Cherry Canyon formation, and the Bell Canyon formation.

The Brushy Canyon formation is about 1,000 feet thick and consists chiefly of sandstone having some limestone lenses and, locally, conglomerate at the base (King, 1948, pp. 28, 29). The Brushy Canyon is not exposed in Eddy County, and no wells in the county are known to obtain water from this formation.

The Cherry Canyon formation, about 1,000 feet thick, consists chiefly of thin-bedded fine-grained sandstone and some persistent limestone beds. The upper three-fourths of the Cherry Canyon interfingers to the northwest with the Goat Seep limestone, but the lower one-fourth of the Cherry Canyon persists as a sandstone tongue northwestward into the Guadalupe Mountains. (King, 1948, p. 32). This sandstone tongue of the Cherry Canyon crops out locally in canyons in Eddy County south of the Seven Rivers embayment, and it may yield water to some wells and springs in that area.

The Bell Canyon formation, 670 to 1,040 feet thick, consists chiefly of sandstone and some thin limestone beds (King, 1948, p. 53). The Lamar limestone member, which lies near the top of the formation, crops out at the base of the reef escarpment just north of the south county line of Eddy County. The Bell Canyon formation interfingers to the northwest with the massive reef limestone of the Capitan limestone. Large springs near the base of the reef escarpment probably are supplied by ground water moving through the upper beds of the Bell Canyon formation.

Goat Seep limestone.—Lang (1937, p. 858) gave the name *Dog Canyon limestone* to an assemblage of rocks more than 1,000 feet thick lying beneath the Queen sandstone and above the San Andres formation. The rocks are predominantly buff to gray massive limestone. Because of possible confusion of the name *Dog Canyon* with the term *Dog Creek shale,* used in Oklahoma for beds of about the same age, King (1948, pp. 38, 39) proposed that the name *Goat Seep limestone* be substituted for the name *Dog Canyon limestone.* The Goat Seep is the approximate equivalent of the Grayburg formation of the White-

horse group and interfingers to the southeast with the Cherry Canyon formation.

The Goat Seep limestone crops out in Eddy County along the west escarpment of the Guadalupe Mountains and in canyons in the Guadalupe Mountains from Last Chance Canyon southward to and beyond the county line. It may crop out also in places in the Seven Rivers embayment. It furnishes water to stock and domestic wells in and near its outcrop area in the mountains and probably furnishes water to most of the deeper wells in the Seven Rivers embayment. In the southern part of the Roswell artesian basin in northern Eddy County the lower part of the Chalk Bluff formation, which is the equivalent of the Goat Seep limestone and the Grayburg formation of the Whitehorse group (see fig. 3), is an important source of ground water for irrigation.

Capitan limestone.—The Capitan limestone crops out along the front of the reef escarpment and in the canyon walls in Guadalupe Ridge in the southern part of the county. It interfingers to the southeast with the Bell Canyon formation and to the northwest with the Carlsbad limestone. The Capitan is a massive gray to buff limestone 1,000 to 2,000 feet thick containing solution cavities ranging in size from slight enlargements of joints and bedding planes to the huge caverns of the Carlsbad Caverns National Park.

The Capitan limestone yields water to several deep wells at White City and probably yields water to a few stock wells near the reef escarpment northeast of White City. Several small springs issue from the Capitan in canyons in Guadalupe Ridge, and it is probable that water discharging from several large springs southeast of the reef front comes indirectly from the Capitan limestone.

Carlsbad limestone.—The Carlsbad limestone interfingers with and in part overlaps the Capitan limestone. It crops out over a large area high in the Guadalupe Mountains in the southwest part of the county as the cap rock overlying the Capitan limestone and over most of the area between the Seven Rivers embayment and the reef escarpment. (See pl. 1.) The Carlsbad limestone lies progressively lower to the northeast and plunges beneath the surface a short distance north of Carlsbad. The Azotea tongue of the Carlsbad limestone, named by Lang (1937, p. 868), extends northwest into the back-reef area and forms the cap rock on Azotea Mesa and the Seven Rivers Hills.

The Carlsbad limestone is a medium- to thin-bedded gray to buff limestone and dolomite but has some interbedded buff to pink siltstone. Its maximum thickness is about 1,000 feet. The formation thins to the northwest as it grades into redbeds and evaporites of the Chalk Bluff formation. It also thins to the southeast as it interfingers with and overlaps the Capitan limestone.

In the southern part of the mountains the Carlsbad limestone lies well above the water table, but to the northeast, as it descends in altitude, it becomes an important source of water, supplying some of the

Carlsbad municipal wells, irrigation wells in La Huerta, and many stock and domestic wells in the Carlsbad area.

Chalk Bluff formation.—In the northern Guadalupe Mountains and northwest of Carlsbad the Carlsbad limestone grades into and interfingers with back-reef sedimentary rocks, which include evaporites, dolomites, redbeds, and sandstones. These back-reef equivalents of the Carlsbad limestone, together with the underlying clastic equivalents of the Goat Seep limestone, compose the Chalk Bluff formation. The subsurface equivalent of the Chalk Bluff formation is called the Whitehorse group. That part of the Chalk Bluff formation above the equivalent of the Goat Seep limestone has been divided into three members: the Queen sandstone member at the base, the Seven Rivers gypsiferous member, and the Three Twins member. The Whitehorse group is divided into five formations: the Grayburg formation at the base, the Queen formation, the Seven Rivers formation, the Yates formation, and the Tansill formation. The Grayburg formation is the approximate equivalent of the Goat Seep limestone; the Queen formation is the equivalent of the Queen sandstone member of the Chalk Bluff formation; the Seven Rivers formation is the equivalent of the Seven Rivers gypsiferous member of the Chalk Bluff formation; and the Yates and Tansill formations are the equivalents of the Three Twins member of the Chalk Bluff. (See fig. 3.)

The Queen sandstone member of the Chalk Bluff formation, first described by Crandall (1929), is exposed on the tableland in the vicinity of the old Queen Post Office, on the northwest slope of the Hess Hills, and over a large area in the Seven Rivers embayment. The sandstone member ranges from 60 to 100 feet in thickness and consists of white, buff to brown, and red fine-grained sandstone and some interbedded limestone (Lang, 1937, p. 859). Peterson and Skinner (1947, pp. 23-27) consider the Queen sandstone member a sandstone facies interfingering laterally with the dolomites of the Grayburg formation.

On the tableland in the vicinity of the old Queen Post Office, the Queen sandstone member is above the water level in all wells investigated, but northeast of the Huapache monocline, in the Seven Rivers embayment, it probably furnishes water to most of the shallower stock and domestic wells.

The Seven Rivers gypsiferous member of the Chalk Bluff formation consists chiefly of anhydrite, gypsum, redbeds, and some interbedded limestone and dolomite. It is exposed along the east boundary of the Seven Rivers embayment in the western escarpments of the Hess Hills, Azotea Mesa, and the Seven Rivers Hills. It also crops out in the McMillan escarpment southeast of Lake McMillan. In the Seven Rivers Hills the Seven Rivers gypsiferous member has a maximum thickness of about 200 feet. It thins to the southeast as it is replaced by the Carlsbad limestone. In the Seven Rivers Hills and in Azotea Mesa, the Seven Rivers gypsiferous member is capped by the Azotea tongue of the Carls-

bad limestone. It thins to the southeast as the limestone becomes thicker (Lang, 1937, p. 860). The Seven Rivers embayment was formed primarily by erosion of the weakly resistant Seven Rivers gypsiferous member.

The Seven Rivers gypsiferous member is not an important source of ground water in the Guadalupe Mountains. Over most of its extent in the mountains it probably lies above the water table and thus does not yield water to wells. Water leaks from Lake McMillan into the Seven Rivers gypsiferous member, and the water is discharged to the Pecos River at Major Johnson Springs. The Seven Rivers member of the Chalk Bluff formation and its subsurface equivalent, the Seven Rivers formation of the Whitehorse group, may yield water to some wells in the vicinity of Major Johnson Springs and along a narrow belt just east of the Pecos River from Lake McMillan north to and beyond the county line.

The top member of the Chalk Bluff formation, the Three Twins member, overlies the Azotea tongue of the Carlsbad limestone and the Seven Rivers gypsiferous member. The Three Twins member consists of evaporites, redbeds, and dolomitic limestone, and it grades southeastward into the Carlsbad limestone (Lang, 1937, p. 860). It is exposed over a small area in the northern part of Azotea Mesa and over a large area east of Lake McMillan.

The Three Twins member probably yields perched ground water to some of the wells and springs in its outcrop area northwest of Carlsbad. East of the Pecos River the Three Twins member and its subsurface equivalents, the Yates and Tansill formations of the Whitehorse group, probably yield water to most of the wells in a belt 5 to 10 miles wide from Lake Avalon north to and beyond the county line.

Ochoa series

Castile formation.—Overlying the sedimentary rocks of the Delaware Mountain group in the Delaware Basin is the Castile formation, consisting of 1,300 to 2,000 feet of anhydrite, gypsum, and small amounts of halite, dolomite, and sandstone. As originally deposited, most of the gypsum probably was anhydrite, but it has since been altered by ground water. The Castile formation thins northwest to a feather edge along the base of the reef escarpment and thickens to the southeast toward the lower part of the basin. It crops out in a broad belt south and southeast of Black River and is buried elsewhere in the Delaware Basin, but it does not extend northwest of the buried limestone reef of the Capitan. The extent of the Delaware Basin in Eddy County is shown in figure 4.

In the outcrop area the Castile formation yields water to many stock and domestic wells. The water from many of these wells is high in sulfate and is undesirable for human consumption. Several springs near the base of the reef escarpment issue from the Castile formation through the alluvium. The larger springs yield water of fair to good quality.

Salado formation.—The Salado formation, consisting of halite and small amounts of anhydrite, polyhalite and other potassium salts, and red sandy shale, overlies the Castile formation in the area east of the Pecos River. West of the river most of it has been removed by solution. The Salado formation does not crop out in Eddy County, but it occurs at depth in most of the county east of the Pecos. Potash ore is mined in this formation.

No wells in the county take water from this formation. In the potash mines area the Salado contains no pore spaces capable of transmitting any great quantity of water. No water enters the potash mines from this formation, although the overlying Rustler formation contains water. The brine contaminating the Pecos River water at Malaga Bend is derived from solution at the top of the Salado formation (Robinson and Lang, 1938, pp. 77-100).

Rustler formation.—The Rustler formation unconformably overlies the Salado formation in most of the area east of the Pecos River, and the Castile formation and the Whitehorse group or its equivalents west of the Pecos. In the potash-mines area the bedding of the Rustler is generally parallel to the truncated upper surface of the Salado formation. The Rustler formation ranges in thickness from about 200 feet in northern Eddy County to about 500 feet southeast of Carlsbad. It consists of anhydrite, gypsum, interbedded red and green sandy clay, and some beds of dolomite.

The Rustler in the area of the potash mines can be divided into two units: a lower clastic unit 165 to 235 feet thick and an upper anhydrite unit about 225 feet thick (Theis, Sayre, and others, 1942, pp. 62, 63). The clastic unit is mainly red and gray shale but includes some interbedded anhydrite. The upper anhydrite unit contains irregular beds of dolomite and has a 20- to 30-foot persistent basal dolomite.

The following generalized section of the Rustler formation in the potash-mines area has been given by Lang (Robinson and Lang, 1938, pp. 83, 84). Lang divides this section into two parts: The upper part,

GENERALIZED SECTION OF THE RUSTLER FORMATION IN THE PECOS VALLEY, NEW MEXICO

MATERIAL	THICKNESS *Ft.*	DEPTH *Ft.*
Gypsum	30	30
Dolomitic gypsum	30	60
Gypsum	100	160
Redbeds	30	190
Gypsum	20	210
Dolomitic limestone	35	245
Redbeds	30	275
Gray sand	70	345
Redbeds	20	365
Gypsum	130	495
Redbeds	5	500

generally about 200 feet thick, includes all beds lying above the 35-foot dolomitic limestone unit, and the lower part, about 300 feet thick, includes the 35-foot dolomitic limestone unit and all beds below it down to the Salado formation.

In the northern part of the county the Rustler crops out east of the Pecos River in the eastern part of a belt of gypsum and redbeds. In this area the Rustler overlies the Chalk Bluff formation and is not easily distinguished from it. South of Carlsbad the west boundary of the main outcrop area of the Rustler approximately follows the Pecos River, but it extends a few miles west of the river near the south county line. The east boundary of the outcrop area of the Rustler is largely concealed by the mantle of the so-called Mescalero sands which cover both the Rustler and the overlying Triassic redbeds. The Rustler also crops out west of the Pecos in the Frontier Hills.

In its outcrop areas the Rustler yields water to many stock wells and some domestic wells. It also furnishes some of the water used by the International Minerals and Chemical Co., and the Potash Co. of America for refining potash. In the Carlsbad area it yields some water for small-scale irrigation. The water from the Rustler generally is not desirable for domestic use because of its high chloride and sulfate content. In certain areas wells penetrating the lower part of the Rustler yield a concentrated brine derived from the underlying Salado formation which cannot be used even for livestock. This brine aquifer at the base of the Rustler discharges salt water into the Pecos River in the vicinity of Malaga Bend (Robinson and Lang, 1938, pp. 77-100).

Triassic system

Dockum group

Overlying the Rustler formation in Eddy County are redbeds and sandstones of the Dockum group. The lower part of these beds has been considered Permian and correlated with the Dewey Lake redbeds by some geologists (DeFord, Willis, and Riggs, 1940). The total thickness of the Dockum group east of Artesia is about 1,000 feet. The formations of the Dockum group exposed in Eddy County are the Pierce Canyon redbeds, the Santa Rosa sandstone, and redbeds that possibly represent the Chinle formation.

The Pierce Canyon redbeds overlie the Rustler formation. They are about 350 feet thick and consist of red sandy shale and fine-grained sandstones marked with greenish-gray reduction spots. The formation thins to the north and is absent north of the latitude of Artesia. The Pierce Canyon redbeds crop out in the upper part of Nash Draw, in Clayton Basin, in some of the canyons on the east side of the Pecos River south of Malaga, and in other isolated areas east of the Pecos.

The Santa Rosa sandstone overlies the Pierce Canyon redbeds south of the latitude of Artesia and the Rustler formation north of Artesia. The Santa Rosa is 200 to 300 feet thick and consists of gray