STRATIGRAPHY AND GROUND-WATER HYDROLOGY OF THE CAPITAN AQUIFER, SOUTHEASTERN NEW MEXICO AND WESTERN TEXAS

by

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Source and ownership of observation wells

The North Cedar Hills Unit 1, Humble State 1, Yates State 1, Hackberry Deep Unit 1, Middleton Federal B 1, South Wilson Deep Unit 1, North Custer Mountain Unit 1, Federal Davison 1, and Southwest Jal Unit 1 observation wells were obtained from cooperating oil companies at the time of abandonment and converted to observation wells. The U.S. Geological Survey owns and is responsible for the future use and disposal of these wells (fig. 5).

The city of Carlsbad Water Wells 10 and 13 are owned by the city of Carlsbad, whereas the city of Carlsbad Test Well 3 is apparently still owned by Mr. Forrest Miller of Carlsbad. The three wells were drilled, completed, and developed by the city of Carlsbad during various ground-water exploration programs and are on loan to the Geological Survey (fig. 5).

The Eugene Coates 3 well is a temporarily abandoned oil well that is completed in the Seven Rivers Formation. This well was loaned to the Geological Survey for a short period of time for use as an observation well during and after aquifer performance tests in a nearby water field.

Data recorded from a crest-stage gage located near Tansill Dam were collected and compared to the hydrographs from nearby wells completed in the Capitan aquifer. The Tansill Dam crest-stage gage was discontinued in early 1970.

Oil companies supplies core analyses from oil and gas test wells in response to requests made after searching the Permian Basin Well Data System scout records. Data extracted from these core analyses appear to provide a representative coverage of the hydraulic characteristics of the basin and shelf aquifers in Lea and Eddy Counties, New Mexico and Winkler and Ward Counties, Texas (table 6). Several aquifer performance tests of the Capitan and San Andres aquifers were conducted in cooperation with oil companies, and a limited amount of additional information was obtained from private sources (table 7). The aerial distribution of these data are shown by individual well in figure 21.

The values of hydraulic conductivity and porosity given in tables 6 and 7 are in good agreement with those reported by Hogan and Sipes (1966) and with the generalized information provided in studies or statistical summaries of individual fields published by the Texas Petroleum Research Committee, the Roswell and West Texas Geological Societies, and the Texas University Bureau of Economic Geology.

Sections of anhydrite, shale, gypsum, halite, and other "dense" or "tight" beds recovered from a cored interval are frequently discarded prior to determining the permeability and porosity. Also, cores are normally cut only in the most prospective part of the geologic section in exploratory wells and in the producing reservoir in development wells. Therefore, the values of permeability and porosity determined from cores and given in reports may be, and quite likely are, larger than values representative of the entire shelf and basin sections.

Comparison of the hydrographs for the Eugene Coates 3 well, completed in the Seven Rivers Formation, and the nearby Federal Davison 1 well, completed in the Capitan aquifer, confirms the measurable hydraulic communication between these formations in this area.

The long-term effect of withdrawal of oil, gas, and water from the Capitan aquifer and other associated reservoirs in measurable hydraulic communication on the potentiometric surface over a period of several decades can be seen by comparing the predevelopment potentiometric surface map to the postdevelopment map (figs. 22 and 23). The cause and effect relationships between the production of fluids and decline in head are substantiated by (1) the changes in head observed over a period of about six years in the wells in the Capitan aquifer observation-well network and (2) the relationships between volume of water produced and the decline in head over a period of about 45 years in the vicinity of the Hendrick field, Winkler County, Texas (figs. 24, 25, and 34).

Hendrick field

The discovery well in the Hendrick field, northeast of Wink in central Winkler County, one of the most prolific oil fields in western Texas, was completed in late 1926 (Carpenter and Hill, 1936, p. 123). Development of the field was rapid, and more than 600 wells had been drilled by early 1930 within an area encompassing approximately 10,000 acres. In May 1928, when the Hendrick field became the first field to be prorated in Texas, about 164 wells were producing more than 500,000 barrels (79,000 cubic metres) of oil and waste water per day. Sulfurous water ranging in amounts from 0.5 to 98 percent of the total fluid was produced in nearly half of these wells (Ackers, DeChicchis and Smith, 1930, p. 941). More than 130 million barrels (20,700,000 cubic metres) of oil had been produced by 1930, and water-oil ratios of as high as 16:1 were reported from estimated daily production records (Carpenter and Hill, 1936, p. 134). Data obtained from one of the largest operators in the Hendrick field indicate that waste water was being produced at sharply increasing rates and already constituted 95 percent of the total fluid produced in 1934. The ratio of water to oil gradually increased during the next ten years, until the percentage of waste water became a relatively constant 99 percent of all fluid produced from 1944 to 1960.

In 1957, only a very small fraction of the Hendrick field waste water was being recycled in waterflooding projects. Most of this waste water was placed in surface pits or in a communal disposal lake near Wink, Tex. (Garza and Wesselman, 1959, p. 45). As the number of waterflood projects increased in the sixties, more of this produced waste water was injected for secondary recovery purposes. Most of it continued to be disposed of in the usual manner, until laws were passed to preclude the disposal of brine effluent in earthen surface pits.

Extrapolation of the earliest available pressure data for the Hendrick field indicates an original bottom-hole pressure in excess of 1,350 psi (pounds per square inch), or about 3,120 feet of fresh-water head above mean sea level. An original "rock pressure" of 1,300 pounds for the Hendrick field was reported in Ackers, DeChicchis, and Smith (1930 p. 923). The hydraulic head in the Hendrick field had declined to less than 2,500 feet above mean sea level by 1969. The slow but consistent decline in reservoir pressure in conjunction with the high water-oil ratio in the fluid produced indicates the field is being produced under strong water-drive reservoir conditions (fig. 34).

Approximately 32,000 acre-feet (250,000,000 barrels; 39,700,000 cubic metres) of oil and an estimated 810,000 acre-feet (6,300,000,000 barrels; 1,000,000,000 cubic metres) of water have been produced from the Hendrick field through 1969. An average of over 28,000 acre-feet (218,000,000 barrels; 34,700,000 cubic metres) of water per year was produced from the Hendrick field during the 5-year period, 1965-69. About 200 million, or about 80 percent, of the 250 million barrels (39,700,000 cubic metres) of oil recovered through 1969 had been produced by the end of 1939. More than 58 percent of the total waste water produced from Permian Guadalupian formations as a waste by-product of the exploitation of oil and gas within the project area was produced from the Hendrick field. About 10 percent of the total oil produced from the same formations in this seven-county area has been produced from the Hendrick field.

The quality of water produced from the nearby water fields completed in the Capitan aquifer is identical to that from the Hendrick field. The reservoir pressures in the same water fields and the Hendrick field are similar and are apparently declining at similar rates (fig. 34). Thus, the hydraulic communication between the reservoir in the Hendrick field and the Capitan aquifer appears to be excellent. Therefore, most of the water produced from the Seven Rivers and Yates Formations in this field, can be considered as having been produced from the Capitan aquifer.