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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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POSSIBILITY OF DEVELOPING A SUPPLY OF GROUND WATER AT THE CAPULIN MOUNTAIN NATIONAL MONUMENT, UNION COUNTY, NEW MEXICO

W. D. E. Cardwell
Geologist

Prepared in cooperation with the
NATIONAL PARK SERVICE

September 1958

Open-file report
Subject to revision

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Possibility of Developing a Supply of Ground Water at the Capulin Mountain National Monument, Union County, New Mexico

By

W. D. E. Cardwell

Introduction

The Capulin Mountain National Monument is in the western part of Union County, N. Mex., about 30 miles east of Raton on U. S. Highway 64-87 and about 2 miles north of the village of Capulin on State Highway 325 (fig. 1). The monument comprises the cinder cone of the extinct volcano Capulin Mountain and the surrounding area on the flanks and at the base of the mountain.

The number of visitors to the monument has increased significantly in recent years, according to Mr. Merritt S. Johnston, Superintendent of the monument, and the increase is expected to continue. The necessity of providing an adequate supply of potable water for proposed camp sites, picnic grounds, and headquarters buildings has been anticipated by Mr. Johnston and other officials of the National Park Service. It is expected that about 40,000 gpd (gallons per day), or 30 gpm (gallons per minute), of ground water of suitable quality will be adequate to supply the requirements of the proposed facilities. The purpose of this report is to describe aquifers at the site that are capable of yielding 30 gpm of potable ground water at moderate cost.

Figure 1.--Map of northeastern New Mexico showing the location of Capulin Mountain National Monument.

Previous Investigations

The possibility of developing a supply of ground water on the monument has not been investigated previously. However, the geology and ground-water resources of contiguous eastern Colfax County was studied in detail by Griggs,[1] and the possibility of irrigation with ground water in the Capulin area was investigated by Herrick.[2]

1/ Griggs, R. L., 1948, Geology and ground-water resources of the eastern part of Colfax County, N. Mex.: New Mexico Bur. Mines Ground-Water Rept. 1.

2/ Herrick, E. H., 1951, Possibilities of irrigation in the Capulin area, Colfax and Union Counties, N. Mex.: U. S. Geol. Survey open-file report.

Present Investigation

The U. S. Geological Survey in cooperation with the National Park Service undertook to study the ground-water resources of Capulin Mountain National Monument in the spring of 1958. The writer spent two days in the field in June 1958 studying the geology, collecting samples of water for chemical analysis, and interviewing local residents and others familiar with the area. Available data, including well logs, chemical analyses, and geologic maps from published and unpublished reports, were used freely in the preparation of this report. The cooperation of Mr. Merritt S. Johnston, National Park Service, Mr. Charles Bourne, City Engineer of Raton, N. Mex., and Mr. W. D. Howard, drilling contractor, in supplying data on wells, geology, and other pertinent subjects is gratefully acknowledged.

Well-Numbering System

Wells are designated in this report both by name (Cornay and Morrow wells) and by the system of numbering water wells in New Mexico based on the common subdivisions in sectionized land. The well number designates the well and locates it to the nearest 10-acre tract. The number has four segments. The first segment denotes the township north or south of the New Mexico base line; the second denotes the range east or west of the New Mexico principal meridian; and the third denotes the section.

The fourth segment of the number, which consists of three digits, denotes the particular 10-acre tract in which the well is situated. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4 in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is generally a tract of 160 acres. Similarly, the quarter section is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 29.28.3.111 (Cornay well), Union County, is in the NW$\frac{1}{4}$NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 3, T. 29 N., R. 28 E.

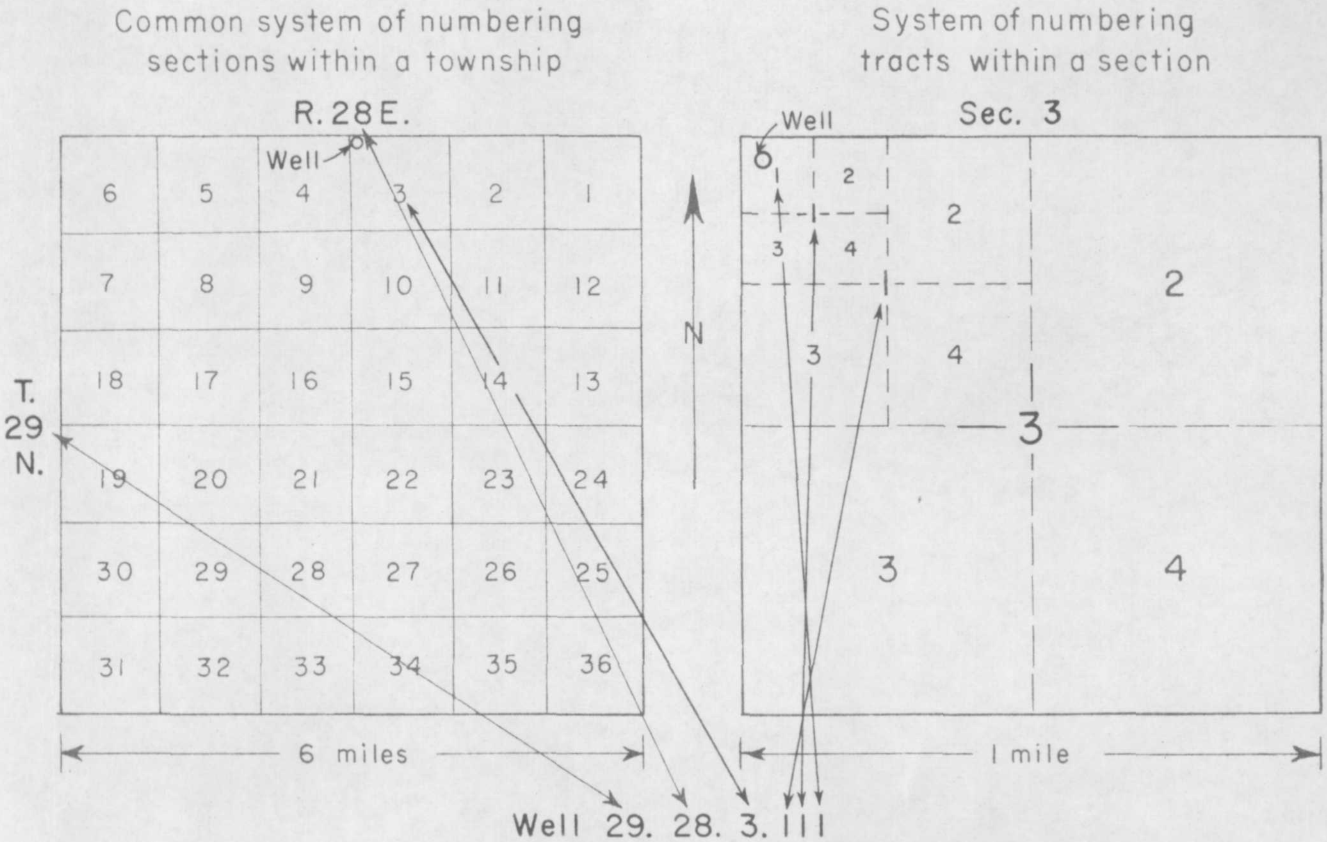

Figure 2.-- System of numbering wells in New Mexico

Topography and Drainage

Capulin Mountain is a symmetrical cinder cone, rising about 1,300 feet above a nearly level plain. The base of the cone is about $1\frac{1}{2}$ miles in diameter. The plain from which Capulin Mountain rises is relieved by many cinder cones, lava-capped mesas, basalt flows, and older volcanoes and is cut by tributaries of the Cimarron River to the north and of the Canadian River to the south.

The combination of the plain, the relief, and the drainage lends to the region an appearance of an enormous eastward-trending valley in which obscure streams have meandered between resistant, monadnock-like eminences. The drainage antedates at least the major part of the volcanic activity but has been modified by it.

Geologic Formations and their Water-Bearing Properties

The volcanic rocks forming Capulin Mountain are underlain by rocks ranging in age from Cretaceous to Recent. The oldest beds of Cretaceous rocks are among the best aquifers underlying the monument. They consist predominantly of two beds of sandstone separated by a bed of shale. The younger rocks of Cretaceous age for the most part were eroded away after their deposition and are represented only by a thin, relatively impervious bed of shale. The shale is overlain by a sequence of loosely consolidated beds of sand and gravel of Pliocene age which are good to excellent aquifers, where sufficiently thick and where saturated with water. The beds of sand and gravel are overlain by a complex of lava flows, both sheetlike and broken, and beds of cinders, ranging in age from late Pliocene to Recent. The lava flow-cinder complex probably is drained of ground water for the most part, except in places where water percolating downward through fissures may be trapped laterally by dikes and vertically by relatively impervious beds. Cinders, ash, and other volcanic ejecta overlying the lava flow-cinder complex form the slopes of Capulin Mountain. These deposits are Recent in age and are drained of ground water by reason of their great permeability and high angle of repose. A generalized stratigraphic section near the picnic grounds on the monument (fig. 3) is shown in table 1. The formations are described in descending order.

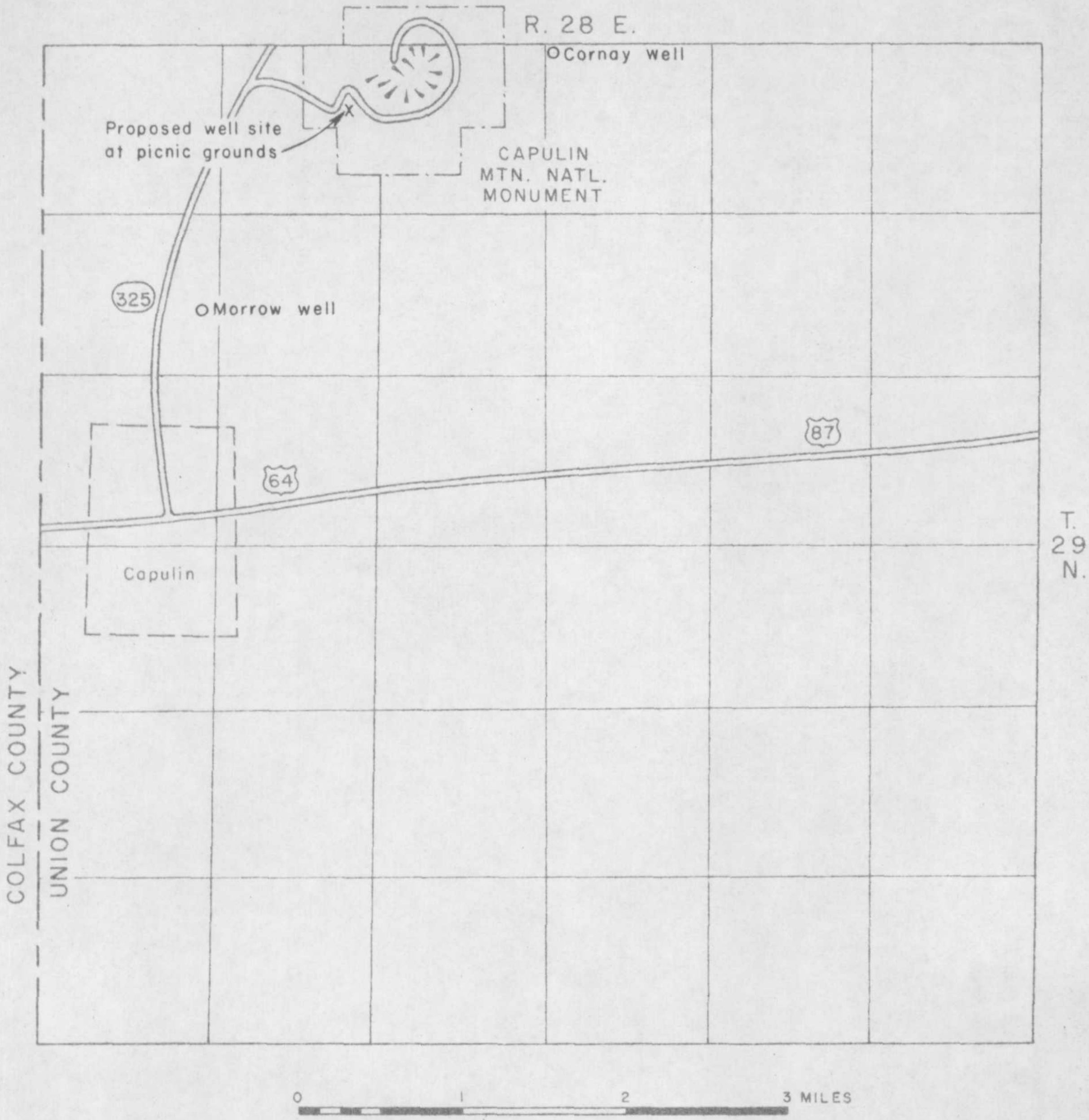

Figure 3.--Location of selected wells and proposed well site in the vicinity of Capulin Mountain National Monument, N. Mex.

Table 1.--Generalized stratigraphic section at the picnic grounds, Capulin Mountain National Monument

System	Series	Subdivision	Member	Thickness (feet)	Physical character	Water supply
Quaternary	Recent	Volcanic ejecta		0-50±	Stratified cinders, scoria, ash, bombs, and lapilli.	Lie above water table and, hence, yield no water to wells.
	Recent and Pleistocene	Lava flows; cinder beds		300-350±	Basalt flows, broken in places, and scattered beds of cinders ranging in thickness from 5 to 20 feet.	Drained of water except for perched zones where ground water may be trapped.
Tertiary	Pliocene	Lava flows, possibly a sill complex in part; cinder beds		100±	Basalt flows, hard; lowermost 15 feet possibly is a bed of cinders.	Drained of water for the most part; lowermost bed of cinders possibly saturated with water, in which event the bed might yield small to large quantities of water to wells.
		Ogallala formation		40-50±	Sand and gravel, silty; probably contains beds of clay, especially in the upper part.	Beds of sand and gravel yield approximately 30 gpm to Cornay well.
Cretaceous	Upper Cretaceous	Graneros(?) shale		5-10±	Dark-colored shale.	Relatively impervious. Yields no water to wells.
	Lower Cretaceous	Dakota sandstone		60-100±	Fine-grained thin-bedded to massive sandstone. Color ranges from white to brown.	Possibly could yield small to moderate quantities of water to wells.
		Purgatoire formation	Kiowa(?) shale	15-40±	Black to gray clayey shale.	Relatively impervious. Yields no water to wells.
			Cheyenne(?) sandstone	50-70±	Massive white to buff fine-grained sandstone.	Possibly could yield moderate to large quantities of water under artesian pressure to wells.

Cretaceous Rocks

The lowermost aquifer at the monument that can be developed with reasonable economy is the Cheyenne(?) sandstone member of the Purgatoire formation of Early Cretaceous age. The Cheyenne(?) does not crop out in the immediate vicinity of the monument; it probably overlies the Morrison formation of Jurassic age in the subsurface. Logs of oil tests indicate the presence of a rather typical section of the Purgatoire formation in the subsurface in sec. 35, T. 27 N., R. 24 E., and in sec. 5, T. 25 N., R. 24 E., Colfax County, N. Mex. (Griggs, 1948, p. 24).

Mr. W. D. Howard, water-well-drilling contractor of Raton, N. Mex., stated (personal communication) that he has drilled several water wells in the general area to the top of the Morrison formation. In them the Morrison is overlain by a bed of fine-grained well-sorted white sandstone (Cheyenne? sandstone member of the Purgatoire formation) ranging in thickness from about 50 to 70 feet and averaging about 60 feet. The sandstone is separated from another overlying sandstone (Dakota sandstone), ranging in thickness from 60 to 100 feet, by a bed of black shale (Kiowa? shale member of the Purgatoire formation), ranging in thickness from 15 to 40 feet.

The structure contours on top of the Dakota sandstone extrapolated from a map by Griggs (1948, pl. 2) indicate a northwestward dip of the Dakota of approximately 40 feet per mile in the western part of Union County. Presumably the dip of the Cheyenne(?) is similar. The land surface at the Cornay well is estimated to be approximately 200 feet lower than the picnic grounds on the monument. The log of the Cornay well (table 2) indicates the top of the Dakota sandstone to be at a depth of 359 feet below the land surface, or at an altitude of approximately 6,590 feet. The altitude of the top of the Dakota at the Cornay well, extrapolated from Griggs' map (1948, pl. 2), is 6,600 feet--a difference of only 10 feet. The top of the Cheyenne(?) should lie 75 to 140 feet below the top of the Dakota. A well fully penetrating the Cheyenne(?) at the picnic grounds therefore should range in depth from 700 to 800 feet. A properly constructed well in the Cheyenne(?) may yield as much as 100 gpm of water. The water may rise as much as 100 feet in the hole.

The Kiowa(?) shale member is relatively impervious and would not yield water to wells.

The Dakota sandstone should be penetrated completely at depths ranging from 650 to 700 feet below the land surface at the picnic grounds. Mr. Howard stated (personal communication) that in his experience the yields of wells penetrating the Dakota sandstone generally are smaller than those of wells tapping the Cheyenne(?), and that water in the Dakota generally does not rise in the hole.

The sequence of uppermost Cretaceous rocks is represented only by an erosional remnant of shale, presumably the Graneros shale, in the Cornay well (table 2). The section of shale penetrated by the Cornay well is only 4 feet thick. Possibly the shale is eroded away completely in parts of the area; in such places the Ogallala formation would overlie the Dakota sandstone directly.

Tertiary Rocks

The Ogallala formation in the project area consists of lensing beds of gravel, sand, silt, and clay that were deposited by braided streams flowing generally eastward from the Rocky Mountains. Silt is the predominant constituent of the formation. The streams that deposited the formation were choked with debris eroded from the rising Rocky Mountains. The channels of the streams were filled quickly with the more permeable alluvial materials, sand and gravel, while the less permeable materials, silt and clay, were being deposited on the flood plains of the streams. Leaving their choked channels, the streams meandered and braided when near grade, depositing new channel materials over older flood-plain deposits and new flood-plain materials over older channel deposits. In this manner a thick mantle of apparently heterogeneous alluvial materials was built up. Actually the sorting and continuity of beds in the Ogallala formation are more consistent than may appear from the results of random test drilling, but the permeability of the formation may change rapidly within relatively short horizontal and vertical distances as a result of the mode of deposition. Obviously, the thickest and most permeable beds of sand and gravel in the formation occupy the sites of former channels. Undoubtedly, such channel deposits or "pockets" of alluvium occupying depressions in the predepositional surface contain relatively thick, permeable materials capable of supporting wells of fairly large capacities--a few hundred gallons a minute--in the project area. To penetrate a channel deposit in the Ogallala with the drill would, however, be a matter of chance. A well tapping the formation in the area therefore might yield anything from zero to a few hundred gallons per minute, according to the saturation, thickness, and permeability of the formation at the well site. The Cornay well is reported to yield 30 gpm from the Ogallala, which at the well consists of a bed of sand and gravel 23 feet thick overlain by a bed of clay 21 feet thick (table 2). The Ogallala formation should be penetrated completely at the picnic grounds at approximately 600 feet below the land surface.

A bed of cinders approximately 15 feet thick immediately overlying the Ogallala formation, according to the log of the Cornay well (table 2), could be expected to yield comparatively large quantities of water to wells wherever it is saturated with water. The permeability of beds of cinders generally is great; however, the very magnitude of that permeability suggests the probability that the bed is drained of water except where water may be trapped by dikes or sills.

A thick section, about 85 feet, of hard lava flows or a lava flow-sill complex overlies the bed of cinders. The flows are relatively impervious for the most part, and accumulation of ground water in them is unlikely.

Quaternary Rocks

The basalt flow-cinder complex of Pliocene to Recent age overlies the Ogallala formation in the general area of Capulin Mountain. It crops out in places and is grouped with the Recent volcanic ejecta composing the slopes of Capulin Mountain. The group is called "volcanic rocks" on the geologic map (fig. 4). The thick section of the basalt flows and cinders, 300 to 400 feet, probably is drained of water for the most part except for perched zones where ground water may be trapped by dikes or sills.

The stratified volcanic ejecta composing the slopes of Capulin Mountain lie above the water table, and hence, could yield no water to wells. The great permeability of the beds, however, facilitates recharge from precipitation.

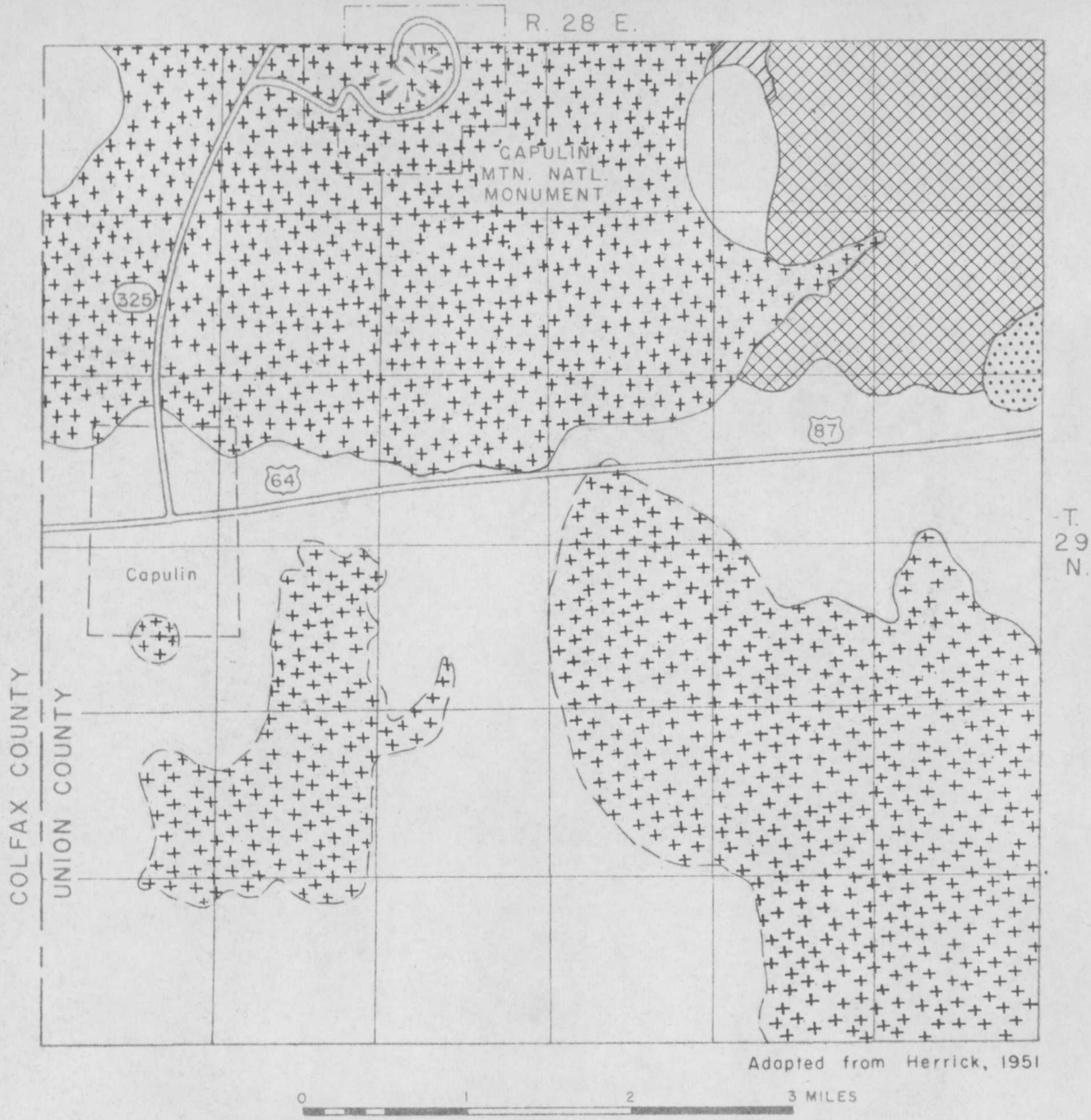

Figure 4.--Generalized areal geology in the vicinity of Capulin Mountain National Monument, N. Mex.

EXPLANATION

QUATERNARY and TERTIARY:
- Alluvium
- Volcanic rocks
- Ogallala formation

CRETACEOUS:
- Upper Cretaceous: Undifferentiated rocks
- Lower Cretaceous: Dakota sandstone and Purgatoire formation

Quality of Water

The analyses in table 3 show that in chemical quality the water from wells 29.28.31.111 (Cornay) and 29.28.7.421 (Morrow) meets the standards of the U. S. Public Health Service for drinking water, except for iron content which is reported to be low. Although the water is hard, the hardness is of the carbonate ("temporary") type. The water should be good to excellect for drinking and irrigation and good for other ordinary household uses.

The concentration of fluoride, 0.6 and 0.8 ppm (parts per million), is in the range considered beneficial in reducing the incidence of tooth decay in children. Fluoride in drinking water in concentrations greater than about 1.5 ppm is likely to result in permanent mottling of the enamel of teeth of children if the water is used during the formation of the teeth.[1/]

1/ Dean, H. T., Jay, Philip, Arnold, F. A., Jr., and Elvove, Elias, 1941, Domestic water and dental caries: Public Health Repts., v. 56.

The quality of water from the two wells is similar, the only great difference being that water from the Morrow well has a significantly greater concentration of nitrate, 9.7 ppm, than the Cornay well, 0.2 ppm. Possibly this difference results from contamination of water in the Morrow well from surface sources through old and possibly leaky casing.

The similarity of the analyses is interesting in that they indicate the possibility that the two wells tap the same water-bearing formation. Even though the analyses are typical of those of water from the Ogallala formation, to designate the aquifer definitely as being Ogallala strictly on the basis of chemical analyses is questionable. Griggs (1948, p. 53) stated that water from the Dakota sandstone in the eastern two tiers of townships in Colfax County is of much better chemical quality than that farther west in the county. An examination of chemical analyses in Griggs' report (1948) shows that many samples of water from the Dakota sandstone in eastern Colfax County are similar in chemical quality to those from the Cornay and Morrow wells.

Conclusions

A properly constructed well at the picnic grounds of Capulin Mountain National Monument probably would be capable of yielding 30 gpm or more of potable water.

The base of the Cheyenne(?) sandstone member of the Purgatoire formation should be reached at a depth ranging from 700 to 800 feet. The Cheyenne(?) potentially is the best aquifer in the area. The water should be of good chemical quality and under enough artesian pressure to rise in a well perhaps as much as 100 feet. The comparatively great depth of the aquifer, however, would add to costs of well installation. If shallower aquifers prove to be capable of yielding water of suitable quality in sufficient amounts, the Cheyenne(?) could be eliminated from further consideration.

The base of the Dakota sandstone should be reached at a depth ranging from 650 to 700 feet. It is unlikely that water in the Dakota is under enough artesian pressure to rise very far in a well. Even though water in the Dakota probably is of good quality, the formation can be eliminated from further consideration if an ample supply of water proves to be available from shallower aquifers.

The base of the Ogallala formation should be reached at depths ranging from 500 to 600 feet. The Ogallala might yield even greater quantities of water to wells than the Cheyenne(?) sandstone member. The water is not likely to be under much artesian pressure. It should be of good chemical quality. The formation may contain the shallowest aquifers in the area capable of yielding moderate to large quantities of water to wells perennially.

The possibility of obtaining water from saturated cinders or fissured lava flows above the Ogallala formation should not be overlooked. It is possible that water of suitable quality and sufficient quantity may be available locally at comparatively shallow depths, where water is trapped by impermeable rocks and the reservoir so formed is capable of being recharged at substantial rates. The location of such bodies of perched ground water could not be predicted in advance of drilling, however.

Table 2.--Driller's log of well 29.28.3.111 (Cornay well)[1]

Drilled by W. D. Howard, completed 3/12/58

	Thickness (feet)	Depth (feet)
Volcanic ejecta		
Soil	4	4
Lava flow, broken; contains boulders	12	16
Cinders, black	25	41
Lava flow	4	45
Cinders, black to brown	16	61
Lava flow	11	72
Cinders, red (caving)	7	79
Lava flow (crevice at 89 feet, loss of drilling fluid)	10	89
Lava flow, very hard (crevice at 98 feet, loss of drilling fluid)	9	98
Lava flows (crevices at 109, 113, 119, 125, 131 and 135 feet)	61	159
Lava flow, broken	3	162
Cinders, gravel size (water bearing)	6	168
Cinders; contains layers of yellow clay	17	185
Lava flows (crevice at 196 feet)	22	207
Lava flow, very hard ($1\frac{1}{2}$ to 2 hours per foot)	38	245
Lava flow, very hard, light gray to white. (Seepage of water at 246 feet)	5	250
Lava flow, very hard (ranging from 2 hours 35 minutes to 4 hours per foot)	35	285
Lava flow, medium hard	6	291
Cinders, brown	13	304
Ogallala formation		
Clay, brown; contains gravel	21	325
Sand	9	334
Gravel, coarse	2	336
Sand and gravel	12	348
Graneros(?) shale		
Shale	4	352
Dakota sandstone		
Sandstone	7	359

1/ Formational names added by W. D. E. Cardwell.

Table 3.--Chemical analyses of water from selected wells in the vicinity of Capulin Mountain National Monument, N. Mex.

Analyses by Geological Survey, United States Department of the Interior

(parts per million)

36631

Laboratory number	38843	38842				
Date of collection	6/18/58	6/18/58				
Silica (SiO_2)	25	33				
Iron (Fe), dissolved 1/	-	-				
Iron (Fe), total	-	-				
Manganese (Mn), dissolved 1/	-	-				
Manganese (Mn), total	-	-				
Calcium (Ca)	33	32				
Magnesium (Mg)	18	18				
Sodium (Na)	29	36				
Potassium (K)	7.0	5.1				
Bicarbonate (HCO_3)	225	217				
Carbonate (CO_3)	0	0				
Sulfate (SO_4)	29	35				
Chloride (Cl)	10	13				
Fluoride (F)	.8	.6				
Nitrate (NO_3)	.2	9.7				
Dissolved solids						
Sum	263	289				
Residue on evaporation at 180°C	272	272				
Hardness as $CaCO_3$	156	154				
Non-carbonate	0	0				
Specific conductance (micromhos at 25°C)	430	453				
pH	7.1	8.2				
Color	-	-				

1/In solution at time of analysis.

Lab. No. 38843 - Stock well; 29.28.31.111 (Cornay); depth, 359 ft.; Diam., 10 in. to 336 ft., 6½ in. to 359 ft.; cased to 351 ft.; date drilled, 3/12/58; Point of collection, discharge pipe; WBF, Ogallala(?) formation; WL, 324 ft. below land surface; yield, 35 gpm bailed; temp., 59° F.

Lab. No. 38842 - Stock well; 29.28.7.421 (Morrow); depth, 130 ft.?; Diam., 6 in(?); date drilled, prior to 1920; point of collection, discharge pipe; WBF, Ogallala(?) formation; WL, 107 below land surface, rept.; yield, 1 gpm, estimated; temp., 80° F.; Remarks, water probably heated in discharge pipe -- well pumping very small amount of water at time of collection.