LITHOLOGY OF BASIN-FILL DEPOSITS IN THE ALBUQUERQUE-BELEN BASIN, NEW MEXICO

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 89-4162

Prepared in cooperation with the
CITY OF ALBUQUERQUE PUBLIC WORKS DEPARTMENT

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By Charles A. Kaehler

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CONVERSION FACTORS

Measurements in this report are in inch-pound units. Use the following table to convert to metric units.

Multiply inch-pound units	By	To obtain metric units
foot	0.3048	meter
mile	1.609	kilometer
acre	0.004047	square kilometer

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

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ABSTRACT

Sedimentary deposits that fill the Albuquerque-Belen Basin in central New Mexico comprise an aquifer that supplies water to approximately one-third the population of the State. This study was undertaken to summarize the grain-size distribution of the deposits using drillers' and borehole-geophysical logs. Analyses of these logs indicate that fine-grained deposits generally underlie the west-central part of the basin. Coarse-grained deposits are concentrated primarily along the axis of the north-central part of the basin. Mixed lithologic textures are present in the rest of the basin and are especially pronounced in the east-central part. The thickest clayey-sand zone, generally greater than 200 feet, is in the west-central part of the basin.

Hydrogeologic sections indicate that considerable faulting of the basin-fill deposits has occurred. These faults, however, apparently have little effect on the movement of ground water through the basin-fill deposits.

INTRODUCTION

This study was undertaken to summarize the grain-size distribution of sedimentary deposits in the Albuquerque-Belen Basin in central New Mexico using drillers' and borehole-geophysical logs. The sediments that fill the Albuquerque-Belen Basin (fig. 1) comprise an aquifer that supplies water to approximately one-third the population of the State (Wilson, 1986). The basin ranges from 25 to 40 miles in width (east to west) and is approximately 100 miles in length (north to south). The east and west boundaries of the basin converge to the north and to the south. Structurally, the basin consists of tilted and downfaulted blocks bordered by bedrock uplifts.

Purpose and Scope

The purpose of this report is to present the areal and vertical grain-size distribution of sediments in the Albuquerque-Belen Basin. Lithologic categories were derived from drillers' logs of sediment samples from 128 wells or test holes. The areal distribution of sediments interpreted from drillers' logs are shown on a map of the basin. Lithologic interpretations from borehole-geophysical logs of 61 wells are presented in 10 sections.

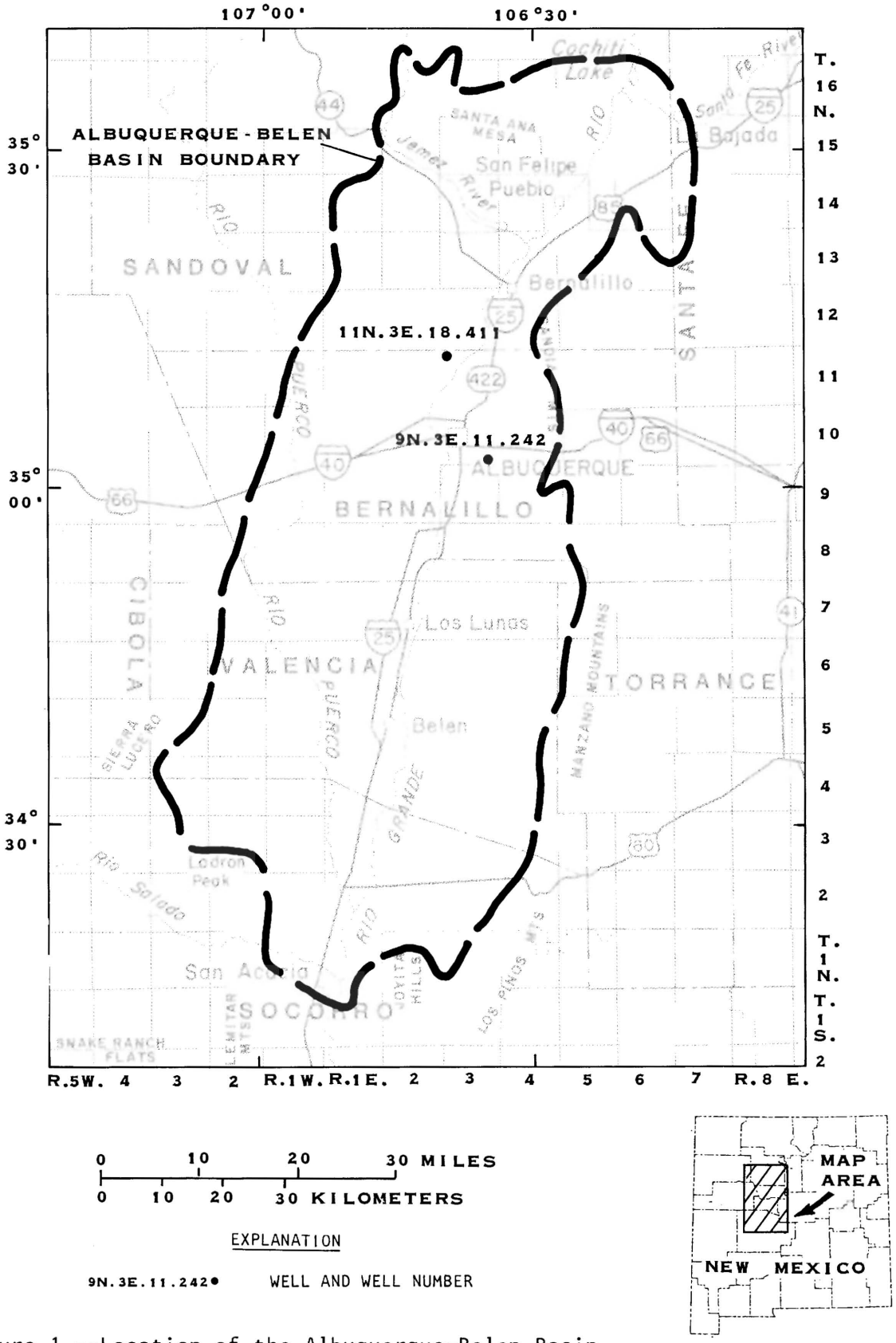


Figure 1.--Location of the Albuquerque-Belen Basin.

Well-Numbering System

The system of numbering wells in New Mexico is based on the common subdivision of public lands into sections. The well number, in addition to designating the well, locates its position to the nearest 10-acre tract in the land network. The well number is divided by periods into 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 (fig. 2). The fourth segment of the number, which consists of three digits, denotes the 160-, 40-, and 10-acre tracts in which the well is situated in the section. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is 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 9N.3E.11.242 is in the NE 1/4 of the SE 1/4 of the NE 1/4 of section 11, T. 9 N., R. 3 E.

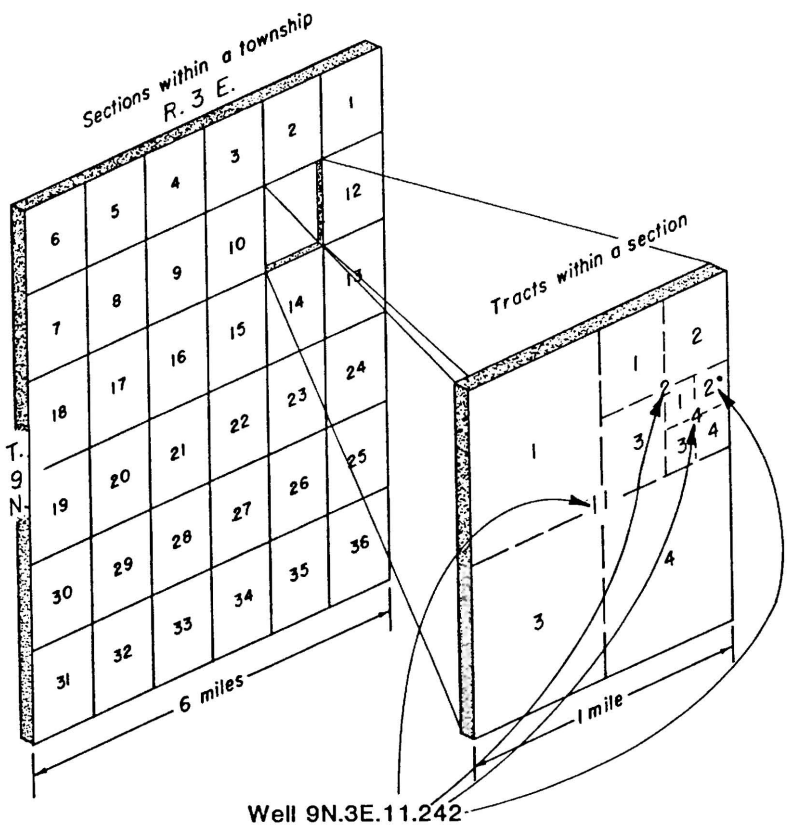


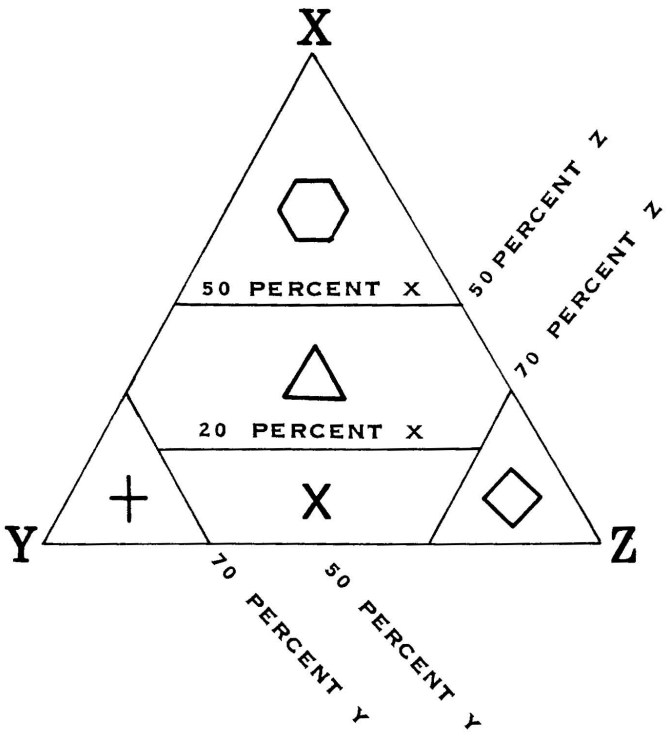
Figure 2.--System of numbering wells in New Mexico.

Analyses of Drillers' Logs

The method used to interpret drillers' logs is a modification of lithofacies analyses used in sedimentary studies. Descriptions of the saturated basin-fill sediments were classified and summarized using a lithologic-category triangle. In figure 3, the end member labeled X represents greater than 50 percent fine-grained materials such as clay, claystone, silt, siltstone, mudstone, shale, and caliche. The end member labeled Y contains greater than 70 percent sandstone, conglomerate, limestone, or volcanics. The end member labeled Z contains greater then 70 percent sand, gravel, cobbles, or boulders. The upper boundary of each zone analyzed was the water level in each well selected; the lower boundary was the total well depth or the basin-fill/bedrock contact, whichever was shallower. However, an arbitrary cutoff was used for the lower boundary in unusually deep wells. The saturated thickness of sediments penetrated by wells included in the analysis ranged from 79 to about 5,000 feet. The maximum depth of the drillers' logs was 1,500 feet.

Sediment types described in drillers' logs were systematically grouped into broad categories. For example, the clay category included tough clay, gumbo, and sticky shale. Compound descriptions were broken down into fractions for tabulation. Sand and clay, for example, were counted as 50 percent of each for the described interval. Sand, clay, and silt were counted as 33.3 percent of each for the described interval. Sandy clay was assumed to be 25 percent sand and 75 percent clay for the described interval. Similarly, clayey sand was assumed to be 25 percent clay and 75 percent sand.

Drillers' logs were divided into 100-foot sections. Depending on the percentage of various types of sedimentary materials described in each 100-foot section, the section was assigned to one of the lithologic groups making up the facies triangle shown in figure 3. After analysis of all 100-foot sections in a given well, the well was assigned an overall category on the basis of the major lithology in all 100-foot sections. Examples of a drillers' log and a log analysis are shown in tables 1 and 2.



EXPLANATION

END MEMBERS	GENERALIZED LITHOLOGIC TERMS USED ON DRILLERS' LOGS
X	Clay, claystone, silt, siltstone, shale, caliche
Y	Sandstone, conglomerate, limestone, volcanics
Z	Sand, gravel, cobbles, boulders
LITHOLOGIC-CATEGORY SYMBOL	PERCENTAGE OF LITHOLOGIC END MEMBER WITHIN EACH CATEGORY
⬡	Greater than 50 percent clay, silt, mudstone, shale, or caliche
△	Between 20 and 50 percent clay, mudstone, shale, or caliche; less than 70 percent sandstone, conglomerate, limestone, or volcanics; and less than 70 percent sand, gravel, cobbles, or boulders
+	Greater than 70 percent sandstone, conglomerate, limestone, or volcanics
X	Less than 20 percent clay, silt, mudstone, shale, or caliche; less than 70 percent sandstone, conglomerate, limestone, or volcanics; and less than 70 percent sand, gravel, cobbles, or boulders
◇	Greater than 70 percent sand, gravel, cobbles, or boulders

Figure 3.--Lithologic-category triangle.

Table 1.--Example drillers' log

[Well 9N.3E.11.242; water level is 262 feet below land surface]

Depth below land surface (feet)	Thickness (feet)	Description
0- 26	26	Sandy loam
26- 39	13	Gravel and sand layers
39- 60	21	Clay with few sand streaks
60- 80	20	Clay
80-101	21	Firm sandy clay
101-110	9	Sand and gravel
110-130	20	Clay and gravel layers
130-141	11	Gravel and clay layers
141-158	17	Gravel and sandstone layers
158-170	12	Gravel
170-210	40	Gravel and sandy clay layers
210-240	30	Gravel, firm and loose layers
240-245	5	Clay and gravel
245-252	7	Large and small gravel
252-260	8	Sandy clay
260-278	18	Firm sandy clay with small gravel
278-290	12	Sandy clay
290-297	7	Gravel
297-305	8	Sandy clay and gravel layers
305-312	7	Gravel
312-340	28	Gravel, coarse with sandy clay streaks
340-345	5	Gravel
345-353	8	Firm gravel with sand and clay mixed with it
353-365	12	Soft, firm layers of gravel with few clay streaks
365-380	15	Firm cemented gravel
380-415	35	Firm cemented gravel
415-420	5	Soft sandy clay
420-462	42	Small gravel in sandy clay

Table 2.--Example drillers' log analysis

[Well 9N.3E.11.242; water level is 262 feet below land surface; total depth is 462 feet below land surface. Well was assigned to a ◇ (greater than 70 percent sand, gravel, cobbles, or boulders) category for the total saturated thickness because of the 91.4 feet of sediments in that category]

Depth below land surface (feet)	Lithologic groups and tabulations (feet)	Percentage of sediments assigned to each lithologic triangle end member	Lithologic category (figure 3)
262-362	Sand: 3.4, 3, 1, 11.9, 2; Total = 21.3	X = 27.6;	◇
	Gravel: 2.4, 7, 4, 7, 14, 5, 4, 7.65; Total = 51.05	Y = 0;	
	Clay: 10.2, 9, 3, 2.1, 2, 1.35; Total = 27.65	Z = 72.4	
362-462	Sand: 1.25, 8.93; Total = 10.18	X = 31.0;	
	Gravel: 2.55, 6.3; Total = 8.85	Y = 50.0;	△
	Clay: 0.45, 3.75, 26.77; Total = 30.97	Z = 19.0	
	Conglomerate: 50 Total = 50.0		

Analyses of Borehole-Geophysical Logs

Types of borehole-geophysical logs analyzed included: electrical resistivity (available for almost all wells studied), conductivity, spontaneous potential, and natural gamma. On the basis of interpretation of these log types, sedimentary material penetrated by 61 wells was grouped into four broad categories: sand or gravel, clay or silt, clayey sand, and sandy clay.

The sand or gravel category describes coarse-grained clastic material of primarily sand size or larger having only moderate percentages of silt or clay. For interpretations using geophysical logs, this category may also include sandstone and conglomerate.

The clay or silt category describes fine-grained clastic sediments of primarily clay or silt size containing relatively small amounts of sand. Typical of Santa Fe Group sediments, the clay or silt category does not represent zones of pure clay or silt but a mixture of predominately clay and silt that contains some sand.

Mixtures of sand and clay were grouped into the last two categories. A clayey-sand category was interpreted to represent a predominance of coarse-grained clasts, but with a substantial amount of intermixed fine-grained material. A sandy-clay category includes silt and clay with a substantial amount of intermixed sand or gravel. An example of a geophysical log (gamma and resistivity) and interpreted lithologies is shown in figure 4. The analyses of logs from this well were accomplished using a complete suite of geophysical logs, a drillers' log, and a geologists' log of well cuttings. Not all these logs were available for all geophysical well logs analyzed and shown on plates 1-3.

LITHOLOGY OF BASIN-FILL DEPOSITS

The Santa Fe Group of Miocene to middle Pleistocene age comprises most of the basin-fill deposits in the Albuquerque-Belen Basin. Variations in lithology of the Santa Fe Group result from variations in structural configuration of the basin during Santa Fe Group deposition; from variations in depositional environments during basin development, including alluvial fans, playas, and pediment slopes; and from differences in source rocks for Santa Fe Group sediments.

The lower part of the Santa Fe Group was deposited in a closed basin prior to development of the Rio Grande drainage system. As a result, the lower part generally is finer grained than the upper part (Kelley, 1977).

The upper part of the Santa Fe Group was deposited, at times, by the through-flowing ancestral Rio Grande. Kelley (1977) discussed the stratigraphy of the basin in detail. Hawley and Galusha (1978) and Tedford (1982) provided updated stratigraphic summaries of the basin-fill material.

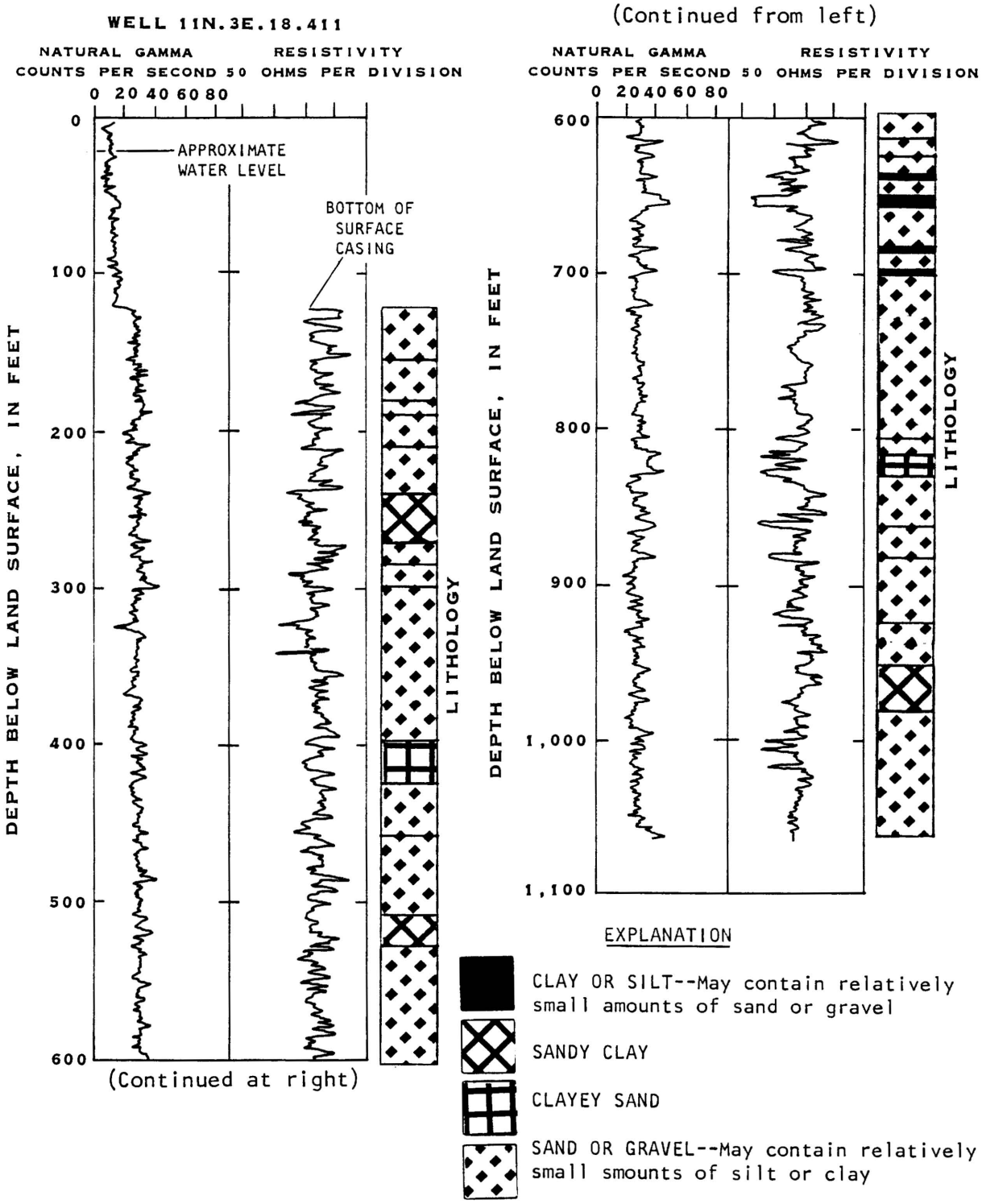


Figure 4.--Example of a geophysical log and interpreted lithologies.

Deposition of the Santa Fe Group ceased in the middle Pleistocene. Several episodes of erosion and backfilling by the ancestral Rio Grande followed Santa Fe Group deposition. The last of these episodes incised the erosional surface existing at that time and then deposited 80 to 120 feet of flood-plain alluvium (Bjorklund and Maxwell, 1961, p. 22), a process that created the present "inner valley" of the Rio Grande.

The flood-plain alluvium consists mainly of sand and is almost completely saturated. It is difficult to distinguish flood-plain alluvium from the underlying Santa Fe Group, though locally a gravel lens marks the base of the flood-plain alluvium. The Santa Fe Group and the flood-plain alluvium, which are hydraulically interconnected, are considered to be a single aquifer for the purpose of this report.

Other post-Santa Fe Group sediments include alluvium in arroyos, recent alluvial-fan deposits, and eolian sand. These unsaturated sediments, deposited on older erosional surfaces and in arroyos lying above the regional water table, are less than 80 feet thick (Lambert, 1968, p. 202).

The lithology of the basin-fill deposits, as described by drillers' logs, is shown areally in figure 5. The areal distribution of deposits shown in figure 5 was determined after summarizing the total thickness of deposits penetrated in each well into a single representation for the well using the deposit types shown in figure 3. Coarse-grained sediment is concentrated in the north-central part of the basin, along the geographic axis of the basin. The coarse texture in this area may result from the presence of a through-flowing stream during deposition of the upper Santa Fe Group. Fine-grained sediment is primarily concentrated in the west-central part of the basin. A mixture of lithologies is present in the east-central part of the basin, probably as a result of deposition on alluvial fans.

Variations in lithology with depth are shown in hydrogeologic sections (pls. 1-3) that summarize lithologic interpretations from geophysical logs. The location of these sections is shown in figure 6. Geophysical logs indicate that, as would be expected from the depositional environment of the Miocene to middle Pleistocene, the basin fill consists of sandy lenses alternating with clayey or silty lenses. The thickness of the clayey lenses in most of the basin is no more than 45 feet. Alternating sand and clayey lenses are prevalent on the east side of the basin, where deposition probably took place on alluvial fans. The thickest clayey-sand zone, greater than 200 feet thick, is in the west-central part of the basin.

The sections also indicate that considerable faulting of the basin-fill deposits has occurred. The location of the faults, their direction of dip, and the relative movement of deposits on either side of the faults are taken from Kelley (1977). The faults apparently have little effect on the movement of ground water through the basin-fill deposits.

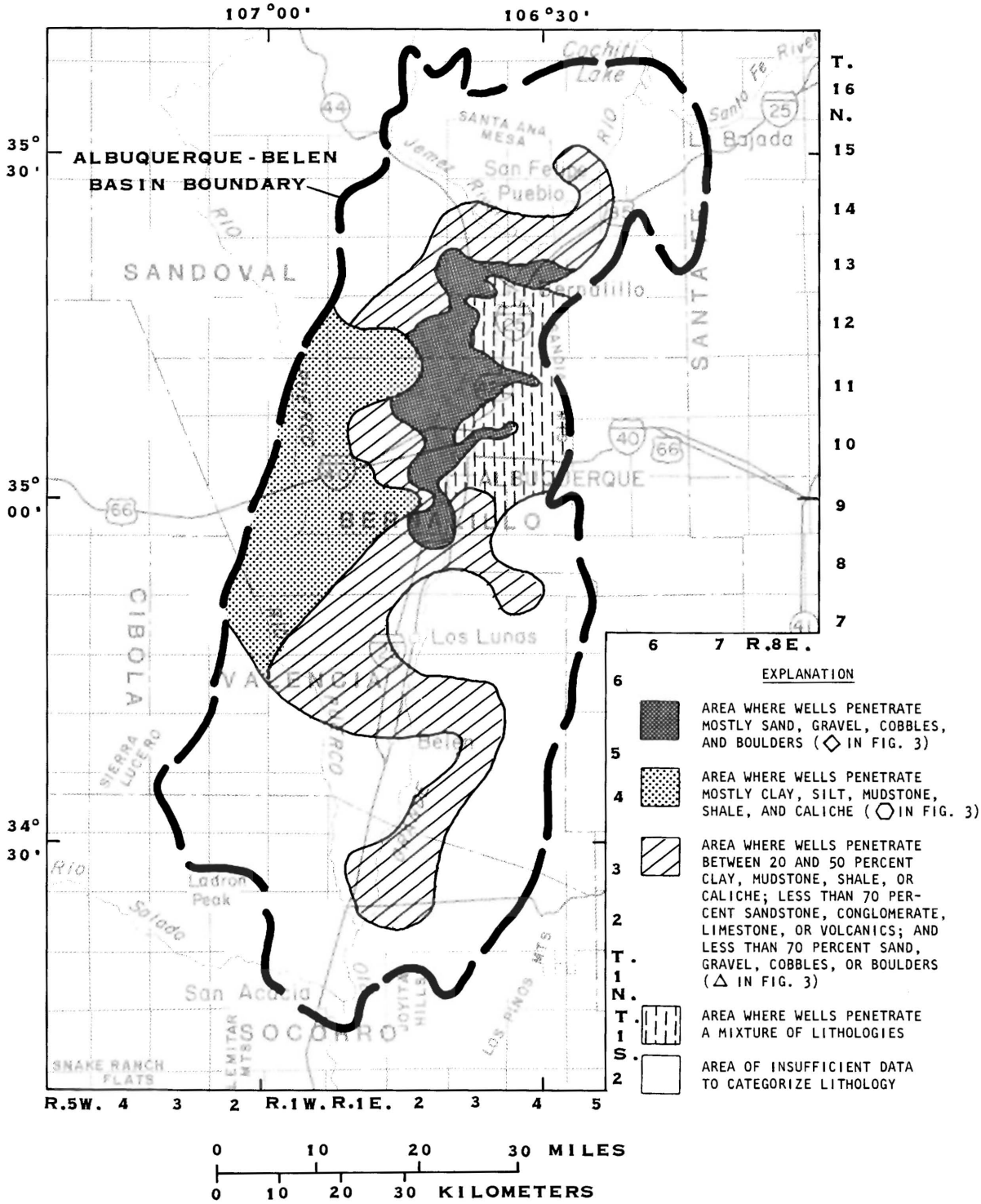


Figure 5.--Areal distribution of lithology of basin-fill deposits.

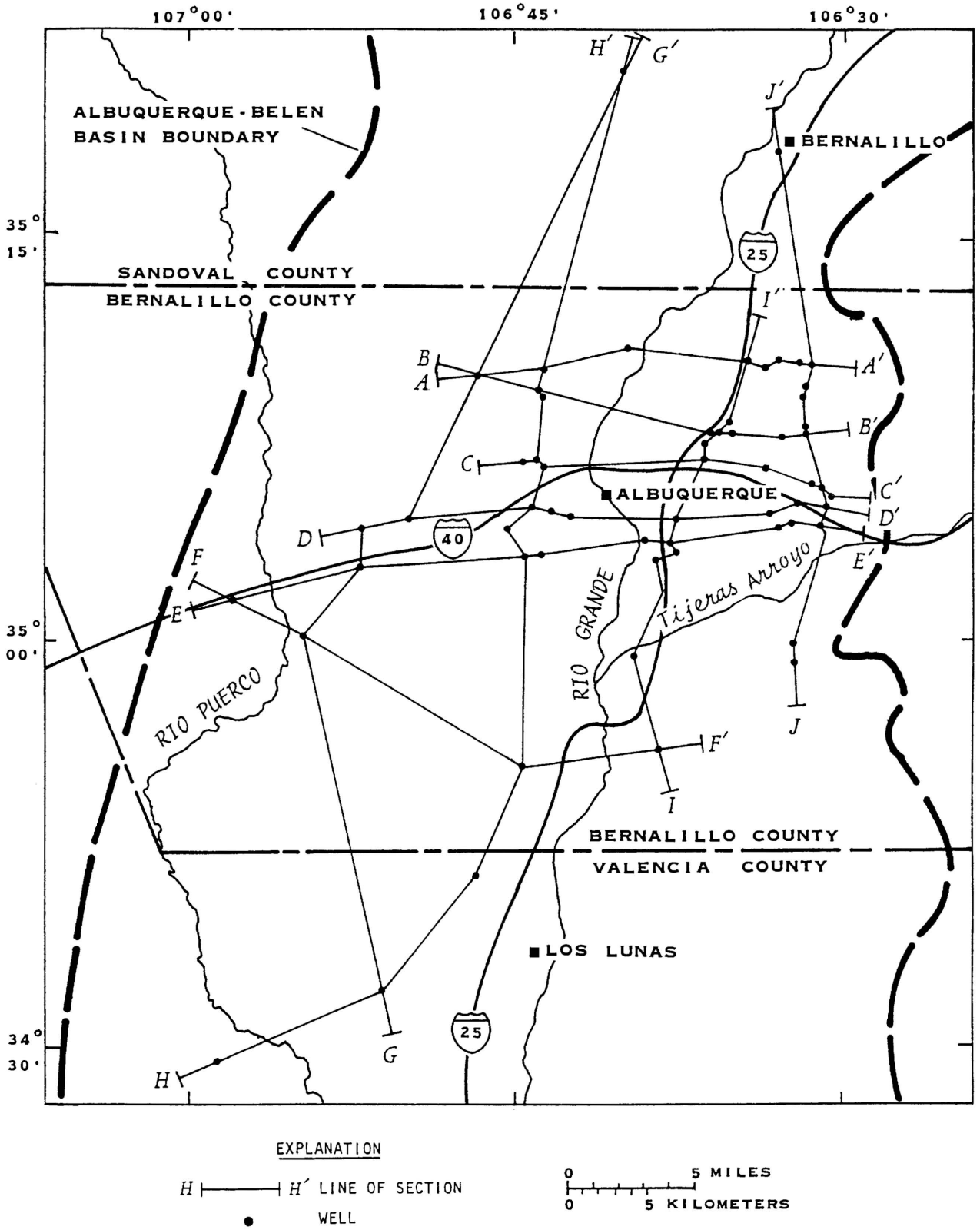


Figure 6.--Lines of section with geophysical well-log interpretations.

SUMMARY

Sediments that fill the Albuquerque-Belen Basin in central New Mexico comprise an aquifer that supplies water to approximately one-third the population of the State. This study was undertaken to summarize the grain-size distribution of sedimentary deposits in the basin using drillers' and borehole-geophysical logs.

The Santa Fe Group of Miocene to middle Pleistocene age comprises most of the basin-fill deposits in the Albuquerque-Belen Basin. Variations in the lithology of the Santa Fe Group result from variations in the structural configuration of the basin during deposition, variations in depositional environments, and areal differences in the source rocks from which the basin-fill deposits were derived.

Simplified representations of the lithology of the saturated sediments show this variability. Coarse-grained sediment is concentrated in the north-central part of the basin, along the geographic axis. The coarse texture in this area may result from the presence of a through-flowing stream during deposition of the upper Santa Fe Group. Fine-grained sediment is primarily concentrated in the west-central part of the basin. A mixture of lithologies is present in the east-central part of the basin, probably as a result of deposition on alluvial fans.

Hydrogeologic sections show that the upper part of the basin fill consists mostly of sandy lenses alternating with clayey or silty lenses. The thickness of the clayey lenses in most of the basin is no more than 45 feet. The thickest clayey-sand zone, often greater than 200 feet, is in the west-central part of the basin. These sections also indicate that considerable faulting of the basin-fill deposits has occurred, but the faults apparently have little effect on the movement of ground water through the basin-fill deposits.

In general, interpretations from the two sources of information, drillers' logs and geophysical logs, show the same areal distribution of deposits. Coarse-grained deposits in wells in the north-central part of the basin have substantially more clayey sand than in wells to the north. Fine-grained deposits west of Albuquerque show more clayey sand and sandy clay than are seen to the east. All east-west sections show deposits with more fine-grained sediments on the west side of the Rio Grande than on the east.

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