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CENOZOIC BASIN-FILL STRATIGRAPHY AND DEPOSITIONAL HISTORY OF THE ALBUQUERQUE BASIN, CENTRAL NEW MEXICO

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Abstract—The Albuquerque basin is composed of a northern, eastward-tilted half-graben and a southern, westward-tilted half-graben. A southward extension of the Tijeras fault appears to mark the boundary between the half-grabens. Latest Oligocene to middle Pleistocene Santa Fe Group deposits are the major syn-rift unit of the basin. Thickness of the Santa Fe Group ranges from 1000 to 2000 m along basin margins to as much as 4407 m in the central basin. Underlying the Santa Fe Group are two units that generally correlate with the Galisteo-Baca formations and the Datil Group. They range in age from Eocene to late Oligocene and indicate the presence of at least two basins that pre-date the Albuquerque basin. Thicknesses of these units are up to 3000 m.

Cenozoic deposition in the Albuquerque basin area began in the Eocene when Galisteo-Baca sediments were deposited into the Galisteo-El Rito and Carthage-La Joya basins. These basins continued to receive sediments (the unit of Isleta #2) during the Oligocene. Early Santa Fe Group sedimentation (30–15 my) occurred in two internally-drained basins that correspond to the half-grabens. After 10 my, Santa Fe sediments had filled to the point where a single, internally-drained Albuquerque basin was formed. At about 5 my, the basin drainage shifted to through-flowing with the development of the ancestral Rio Grande. The first major episode of Rio Grande entrenchment at about 0.5 my ended Santa Fe Group deposition.

INTRODUCTION

The Albuquerque basin, covering an area of about 7400 km^2 (Fig. 1), is one of the largest basins of the Rio Grande rift. It is the most studied of all the Rio Grande rift basins and contains the greatest concentration of oil test wells in the entire rift (Table 1). Sparked by its potential for ground-water development, hazardous waste containment sites and for petroleum exploration, the basin is an area of economic interest. This paper focuses on the basin-fill stratigraphy and depositional history of the Albuquerque basin.

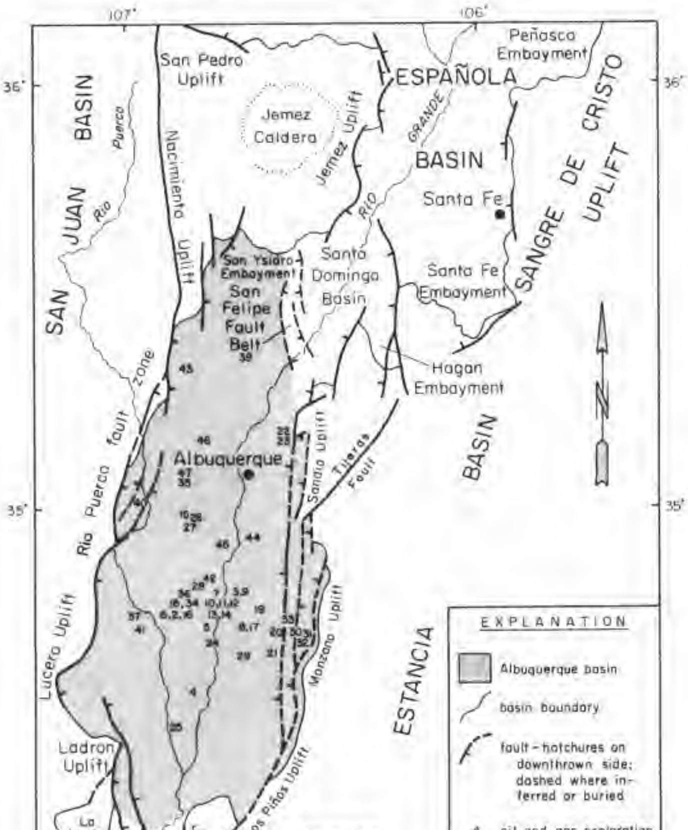

FIGURE 1. Tectonic map of Albuquerque basin as defined in this paper. Numbers refer to locations of oil test wells listed on Table 1. Well 38 is not plotted because location is unknown. Modified from Anonymous (1961) and Woodward et al. (1978).

The basin is roughly 112 km long and varies in width from about 20 km in the north to about 60 km in the central basin area. The eastern margin is well defined by the Sandia-Manzano-Los Pinos mountain chain; however, the western margin is less well-defined by physiographic features. Elevations of the margin uplifts are as much as 3050 m in the east and up to 2134 m in the west. Within the Albuquerque basin, elevations range from about 1310 m along the Rio Grande to around 1830 m along the eastern piedmont slope. The Rio Grande and Rio Puerco are the major drainages in the basin. A long, southward-narrowing tableland, the Llano de Albuquerque, lies between these two valleys.

GEOLOGIC SETTING OF THE ALBUQUERQUE BASIN

Seismic reflection work by the Shell Oil Company has shown that the Albuquerque basin is generally composed of a northern, eastward-tilted half-graben and a southern, westward-tilted half-graben. A southward extension of the Tijeras fault appears to be the transition zone between these half-grabens just south of Albuquerque (Fig. 1). Faults that greatly displace the basin fill do not occur near the topographically high margins, but rather occur further basinward. According to one interpretation of the Shell seismic sections, many of these faults appear to have listric geometries. The structural relief of the basin is well over 10000 m (Lozinsky, 1988).

In this paper, the Albuquerque basin extends structurally from the San Felipe fault belt in the north to the La Joyita uplift in the south (Fig. 1). Along the eastern margin, the eastward-tilted Sandia-Manzano-Los Pinos uplift consists primarily of Precambrian plutonic and metamorphic rocks which are unconformably overlain by upper Paleozoic limestones and sandstones. The Lucero uplift and the topographically-subdued Rio Puerco fault zone define the western margin of the basin. This region west of the Albuquerque basin is part of the Colorado Plateau. Upper Paleozoic limestone, shale and sandstone capped by late Cenozoic basalt flows crop out in the Lucero uplift. The fault zone that separates the Lucero uplift from the basin is extremely complex and shows Laramide-age reverse and possibly strike-slip motion with late Cenozoic normal faulting (Callender and Zilinski, 1976; Hammond, 1987). The Rio Puerco fault zone consists of a series of northeast-

TABLE 1. List of oil test wells drilled in the Albuquerque basin; * denotes wells studied in detail by Lozinsky (1988). Modified from Black (1982).

Well Number	Name	Location	Completion Date	Total Depth ft	m
1.	Tejon Oil and Dev. No. 1	7-14N-8E	7-7-14	1,850	564
2.	Cal-New Mexico Gochares No. 1	8-6N-1E	9-20-26	2,900	884
3.	Stone No. 1	25-7N-3E	6-15-26	1,405	428
4.	Belen Oil Sefople No. 1	23-4N-1E	7-10-27	3,545	1,080
5.	Gilmore and Sheldon Tome Grant #1	30-6N-2E	12-2-26	1,180	360
6.	Hub Oil-HNTH #1	13-6N-1W	12-31-28	3,425	1,044
7.	Stone Norland No. 1	32-7N-2E	11-6-27	2,144	654
8.	Gilmore and Sheldon Tome #1	30-6N-3E	4-9-28	1,100	335
9.	Stone #2	25-7N-2E	11-12-28	1,976	602
10.	Harlan et al. Harlan #1	5-6N-2E	8-1-30	4,223	1,287
11.	Harlan et al. Harlan #2	5-6N-2E	11-21-30	4,023	1,226
12.	Harlan et al. Harlan #3	9-6N-2E	4-5-31	6,474	1,973
13.	Harlan et al. Harlan #4	9-6N-2E	6-28-31	3,820	1,164
14.	Harlan et al. Harlan #5	9-6N-2E	8-25-31	4,007	1,221
15.	Norins Pajarito Grant #1	22-9N-1E	6-24-33	5,104	1,556
16.	West, Natural Resources Corp. #1	8-6N-1E	9-3-32	1,725	526
17.	Mills Tome #1	29-6N-3E	8-2-33	507	154
18.	Big Three Dalies Townsite #2	5-6N-1E	11-17-37	6,143	1,065
19.	Mills Tome #2	9-6N-3E	11-18-37	446	136
20.	Ringle Dev. Co. Fee #1	36-6N-3E	11-12-35	1,115	340
21.	Ringle Dev. Co. Fugua No. 1	11-5N-4E	1-1-35	100	30
22.	Norins N. Alb. Acres No. 1	19-11N-4E	7-1-35	573	175
23.	Norins N. Alb. Acres No. 2	19-11N-4E	7-8-40	5,024	1,531
24.	Ringle Dev. Co. Ringle No. 1	6-5N-2E	11-16-35	750	229
25.	Central N. Mex. Brown-Livingston	16-3N-1E	11-28-39	2,840	866
26.	Norins Pajarito Grant #2	22-9N-1E	8-9-53	385	117
27.	Norins Pajarito Grant #3	27-9N-1E	4-7-61	2,780	847
*28.	Leiner San Clemente No. 1	23-7N-1E	8-5-59	5,606	1,709
*29.	Graber Fugua No. 1	19-5N-3E	4-7-46	6,300	1,920
30.	Ringle Ringle #1	34-6N-4E	6-29-47	825	251
31.	Ringle Tome #2	34-6N-4E	3-1-47	890	271
32.	Ringle Tome #3	34-6N-4E	10-7-47	597	182
33.	Castleberry Tome No. 1	20-6N-4E	10-19-47	500	152
34.	Bailes & Von Oldhan Dales No. 1	5-6N-1E	9-21-49	6,096	1,858
*35.	Carpenter Atrisco No. 1	28-10N-1E	9-29-48	6,652	2,028
*36.	Long Dalies No. 1	32-7N-1E	5-14-52	6,091	1,856
*37.	Humble Oil SFP #1	18-6N-1W	11-18-53	17,691	5,060
38.	Carey 1-A	?	1-8-56	?	?
*39.	Shell SFP No. 1	18-13N-3E	8-28-72	11,045	3,366
40.	Shell Laguna-Wilson Foust #1	8-9N-1W	12-25-72	11,115	3,389
*41.	Shell SFP #2	29-6N-1W	9-24-74	14,305	4,360
*42.	Shell Isleta Central #1	7-7N-2E	7-18-75	16,346	4,982
*43.	Shell SFP #3	28-13N-1E	6-26-76	10,276	3,132
*44.	TransOcean Isleta No. 1	8-8N-3E	11-19-78	10,378	3,163
*45.	Shell Isleta No. 2	16-8N-2E	5-15-80	21,266	6,482
*46.	Shell West Mesa Federal No. 1	24-11N-1E	10-27-85	19,375	5,906
47.	Utex No. 1 Westland-Dev. 1J1F	1-10N-1E	7-16-86	16,665	5,080

trending en echelon faults (Slack and Campbell, 1976). Rocks exposed directly west of the fault zone include Cretaceous sandstone and shale with minor Jurassic units. South of the Lucero uplift, the Ladron Mountains are a structurally complex horst that consists mainly of Precambrian plutonic and metamorphic rocks with minor upper Paleozoic units.

The Nacimiento uplift and the Jemez Mountains border the basin to the northwest and north, respectively. Precambrian plutonic and metamorphic rocks overlain by Paleozoic and Mesozoic units crop out in the Nacimiento uplift (Woodward, 1987). The Jemez Mountains are comprised of late Miocene to Pleistocene mafic to silicic volcanic rocks and are part of a large caldera complex (Smith et al., 1970; Gardner et al., 1986).

PREVIOUS WORK IN THE ALBUQUERQUE BASIN

Most geologic studies in the Albuquerque basin have focused on exposed portions of the basin fill. Bryan and McCann (1937, 1938) conducted some of the earliest studies, and their work is still used today by many workers to describe generally the basin fill. Two of Bryan's students, Denny (1940) and Wright (1946), extended the mapping of deposits and major structural units into the southern and west-central parts of the Albuquerque basin.

Since the work of Bryan and his students, other researchers have completed several local detailed studies of the basin fill. They include: (1) Bailey et al. (1969), Smith et al. (1970) and Gardner et al. (1986) in the region adjacent to the Jemez Mountains; (2) Spiegel (1961), Galusha (1966), Lambert (1968), Manley (1978), Gawne (1981) and Tedford (1982) in the northern basin area; and (3) Machette (1978a, b) in the southern basin area. Kelley (1977) published the only geologic map covering the entire basin. Lozinsky (1988) recently completed a detailed study of the basin-fill deposits utilizing both surface and subsurface information.

Volcanism within the basin and along its margin was investigated by Kelley and Kudo (1978), Baldridge et al. (1982) and Baldridge et al. (1987). Bachman and Mehnert (1978) reported age dates on several of the volcanic features within the basin and discussed the geomorphic history of the rift. The margin area along the Rio Puerco fault zone was studied by Slack and Campbell (1976), and along the Lucero uplift by Callender and Zilinski (1976) and Hammond (1987). The Rio Grande rift guidebook (Hawley, 1978) and the 33rd New Mexico Geological Society field conference guidebook (Grambling and Wells, 1982) contain many articles, maps and road logs that are pertinent to the Albuquerque basin area.

BASIN-FILL STRATIGRAPHY

The uppermost Oligocene to middle Pleistocene Santa Fe Group is the main synorogenic unit in the Albuquerque basin. Thickness of the Santa Fe Group ranges from 1000 to 2000 m along the margin areas to as much as 4407 m in the deeper portions of the basin. The 4407-m-thick section penetrated in the Shell Isleta #2 oil test well (Table 1) is the thickest documented section of the Santa Fe Group in the entire Rio Grande rift (Lozinsky, 1988).

Eocene to late Oligocene sedimentary deposits underlie the Santa Fe Group and indicate the existence of at least two depositional basins that pre-date the Albuquerque basin. These early basins probably include the Galisteo-El Rito basin of Gorham and Ingersoll (1979) and the Carthage-La Joya basin of Chapin and Cather (1981). Two units comprise the pre-Santa Fe Tertiary deposits. The lower unit contains deposits that were derived mainly from non-volcanic source areas during the Eocene. The lower unit is correlative with the Galisteo and Baca formations that are exposed to the northeast and southwest of the Albuquerque basin, respectively. The upper unit, informally called the unit of Isleta #2 (Lozinsky, 1988), was derived from both a silicic to mafic volcanic and a sedimentary source area from late Eocene to late Oligocene. This unit is correlative with the Datil Group and the sequence of Oligocene volcanic units that overlies the Datil Group (Osburn and Chapin, 1983) and the Espinaso Formation (Kautz et al., 1981). These units are also exposed to the northeast and southwest of the Albuquerque basin, respectively.

Thickness of the pre-Santa Fe Tertiary deposits ranges from about 1500 m in the south half-graben to more than 3000 m in the north half-graben. These deposits are restricted to the western and central portions of the basin and are not recognized along the eastern margin. Here, oil test wells show that the Santa Fe Group rests directly on Mesozoic strata (Lozinsky, 1988). Underlying the pre-Santa Fe Tertiary deposits are Mesozoic, Paleozoic and Precambrian strata.

DEPOSITIONAL HISTORY

During the Eocene, two depositional centers, the Galisteo-El Rito basin in the north and the Carthage-La Joya basin in the south, were present in the region which is now the Albuquerque basin. A drainage divide that separated the two basins may have existed along a southwestern extension of the Tijeras fault. These basins formed as a result of Laramide-age wrench faulting along the eastern margin of the Colorado Plateau (Chapin and Cather, 1981). Primarily sedimentary and Precambrian detritus was being deposited into the basins during this time. Source areas for these deposits included the Nacimiento, Lucero and Sandia uplifts for the Galisteo-El Rito basin and the Lucero, Sierra and Sandia uplifts for the Carthage-La Joya basin. Thicknesses of the Galisteo-Baca deposits are less than 500 m (Lozinsky, 1988).

These basins continued to receive sediments, the unit of Isleta #2, into late Oligocene. During this time, great volumes of ash-flow tuff, rhyolite and basaltic andesite were erupting from calderas southwest of the Albuquerque basin in the Mogollon-Datil field. Source rocks for the unit of Isleta #2 included sedimentary and intermediate-to-silicic volcanic rocks. The Sierra and Lucero uplifts were probably the major source areas. An ash-flow tuff, dated at 36.3 ± 1.8 my by Shell Oil was penetrated in the Isleta #2 well. This indicates that at least one ash-flow was deposited as far north as the Isleta #2 well. The unit of Isleta #2 reached thicknesses of over 2000 m.

During early Santa Fe deposition (30–15 my), the Albuquerque basin probably consisted of two depositional sub-basins that corresponded to the northern and southern half-grabens. These sub-basins had internal drainage and sedimentation rates ranged from 24 to 75 m/my. Sedimentary and silicic-to-intermediate volcanic terranes were the major source areas. By 10 my, the Precambrian core of the eastern uplifts became exposed, and plutonic and metamorphic rocks began to be deposited into the two sub-basins.

Increased tectonism from 10–5 my resulted in higher sedimentation rates that ranged from 204 m/my to as much as 600 m/my. The bulk of the Santa Fe Group was deposited at this time, probably to thicknesses of up to 4000 m. Due to the higher sedimentation rates after 10 my, the two sub-basins filled to the point where the drainage divide was buried, forming a single Albuquerque basin. Drainage in the basin was still internal, and basin fill was derived from the surrounding uplifts. However, two major fluvial systems, one flowing from the northwest and the other from the northeast, were also transporting detritus from more distant source areas to be deposited in the Albuquerque basin. These fluvial systems probably terminated in the southern part of the basin. Volcanism was also occurring within the basin and along its margins.

The basin drainage pattern shifted from internal to through-flowing with the development of the ancestral Rio Grande at about 5 my. Two major ancestral tributaries, the Rio San Jose from the west and the Rio Puerco from the northwest, joined the ancestral Rio Grande to form a large plain of fluvial aggradation in the central Albuquerque basin. Sedimentation rates decreased to about 22 to 33 m/my during this time. The total accumulated thickness of the upper Santa Fe Group which represents this time interval is about 100–150 m. Sediments were still being derived from the surrounding uplifts and from more distant source areas outside the basin.

About 0.5 my, widespread basin aggradation ceased, and Santa Fe Group deposition ended during the first major incision episode of Rio Grande valley entrenchment. The initial incision is a critical event in the late Cenozoic history of the Albuquerque basin because the basin had been undergoing net aggradation during Santa Fe Group deposition. Since Santa Fe Group time, the basin has been undergoing net degradation as several more cycles of river incision produced the present-day inner valley of the Rio Grande.

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REFERENCES

Anonymous, 1961, Structural problems of the Rio Grande trough in Albuquerque country: New Mexico Geological Society, Guidebook 12, p. 144–147.

Bachman, G. O. and Mehnert, H. H., 1978, New K–Ar dates and the late Pliocene to Holocene geomorphic history of the central Rio Grande region, New Mexico: Geological Society of America Bulletin, v. 89, p. 283–292.

Bailey, R. A., Smith, R. L. and Ross, C. S., 1969, Stratigraphic nomenclature of volcanic rocks in the Jemez Mountains, New Mexico: U.S. Geological Survey, Bulletin 1274-P, p. 1–19.

Baldridge, W. S., Perry, F. V. and Glazney, E. S., 1982, Petrology and geochemistry of the Cat Hills volcanic field, central Rio Grande rift, New Mexico: Geological Society of America Bulletin, v. 93, p. 635–643.

Baldridge, W. S., Perry, F. K. and Shafiqullah, M., 1987, Late Cenozoic volcanism of the southeastern Colorado Plateau: I. Volcanic geology of the Lucero area, New Mexico: Geological Society of America Bulletin, v. 99, p. 463–470.

Black, B. A., 1982, Oil and gas exploration in the Albuquerque basin: New Mexico Geological Society, Guidebook 33, p. 313–324.

Bryan, K. and McCann, F. T., 1937, The Ceja del Rio Puerco: a border feature of the Basin and Range province in New Mexico, part I: Journal of Geology, v. 45, p. 801–828.

Bryan, K. and McCann, F. T., 1938, The Ceja del Rio Puerco: a border feature of the Basin and Range province in New Mexico, part II: Journal of Geology, v. 46, p. 1–16.

Callender, J. C. and Zilinski, R. E., 1976, Kinematics of Tertiary and Quaternary deformation along the eastern edge of the Lucero uplift, central New Mexico: New Mexico Geological Society, Special Publication 6, p. 53–61.

Chapin, C. E. and Cather, S. M., 1981, Eocene tectonics and sedimentation in the Colorado Plateau-Rocky Mountain area: Arizona Geological Society Digest, v. 14, p. 173–198.

Denny, C. S., 1940, Tertiary geology of the San Acacia area, New Mexico: Journal of Geology, v. 48, p. 73–106.

Galusha, T., 1966, The Zia Sand Formation, new early to medial Miocene beds in New Mexico: American Museum Novitates 2271, 12 p.

Gardner, J. N., Goff, F., Garcia, S. and Hagan, R. C., 1986, Stratigraphic relations and lithologic variations in the Jemez volcanic field, New Mexico: Journal of Geophysical Research, v. 91, p. 1763–1778.

Gawne, C. A., 1981, Sedimentology and stratigraphy of the Miocene Zia Sand of New Mexico: Geological Society of America Bulletin, v. 92, p. 999–1007.

Gorham, T. M. and Ingersoll, R. V., 1979, Evolution of the Eocene Galisteo basin, north-central New Mexico: New Mexico Geological Society, Guidebook 30, p. 219–224.

Grambling, J. A., and Wells, S. G., eds., 1982, Albuquerque Country II [New Mexico Geological Society Guidebook 33]: Albuquerque, New Mexico Geological Society, 370 p.

Hammond, C. M., 1987, Geology of the Navajo Gap area between the Ladron Mountains and Mesa Sarca, Socorro County, New Mexico: a structural analysis [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 212 p.

Hawley, J. W., compiler, 1978, Guidebook to the Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources, Circular 163, 241 p.

Kautz, P. F., Ingersoll, R. V., Baldridge, W. S., Damon, P. E. and Shafiqullah, M., 1981, Geology of the Espinaso Formation (Oligocene), north-central New Mexico: summary: Geological Society of America Bulletin, v. 92, p. 980–983.

Kelley, V. C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 33, 59 p.

Kelley, V. C. and Kudo, A. M., 1978, Volcanoes and related basalts of the Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 156, 30 p.

Lambert, P. W., 1968, Quaternary stratigraphy of the Albuquerque area, New Mexico [Ph.D. dissertation]: Albuquerque, University of New Mexico, 257 p.

Lozinsky, R. P., 1988, Stratigraphy, sedimentology, and sand petrology of the Santa Fe Group and pre-Santa Fe Tertiary deposits in the Albuquerque basin, central New Mexico [Ph.D. dissertation]: Socorro, New Mexico Institute of Mining and Technology, 298 p.

Machette, M. N., 1978a, Geologic map of the San Acacia quadrangle, Socorro County, New Mexico: U.S. Geological Survey, Geologic Quadrangle Map GQ-1415, scale 1:24,000.

Machette, M. N., 1978b, Preliminary geologic map of the Socorro 1° × 2° quadrangle, central New Mexico: U.S. Geological Survey, Open-file Report 78-607, scale 1:250,000.

Manley, K., 1978, Geologic map of Bernalillo NW quadrangle, Sandoval County, New Mexico: U.S. Geological Survey, Geologic Quadrangle Map GQ-1446, scale 1:24,000.

Osburn, G. R. and Chapin, C. E., 1983, Nomenclature for Cenozoic rocks of northeast Mogollon-Datil volcanic field, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Stratigraphic Chart 1.

Slack, P. B. and Campbell, J. A., 1976, Structural geology of the Rio Puerco fault zone and its relationship to central New Mexico tectonics: New Mexico Geological Society, Special Publication 6, p. 46–52.

Smith, R. L., Bailey, R. A. and Ross, C. S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey, Miscellaneous Investigations series, Map I-571, scale 1:250,000.

Spiegel, Z., 1961, Late Cenozoic sediments of the lower Jemez River region: New Mexico Geological Society, Guidebook 12, p. 132–138.

Tedford, R. H., 1982, Neogene stratigraphy of the northwestern Albuquerque basin: New Mexico Geological Society, Guidebook 33, p. 273–278.

Woodward, L. A., 1987, Geology and mineral resources of Sierra Nacimiento and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 42, 84 p.

Woodward, L. A., Callender, J. F., Seager, W. R., Gries, J. C., Shaffer, W. L. and Zilinski, R. E., 1978, Tectonic map of the Rio Grande rift region in New Mexico, Chihuahua, and Texas: New Mexico Bureau of Mines and Mineral Resources, Circular 163, sheet 2.

Wright, H. E., 1946, Tertiary and Quaternary geology of the lower Puerco area, New Mexico: Geological Society of America Bulletin, v. 57, p. 383–456.