



## *Earthquakes in Albuquerque country*

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*This is one of many related papers that were included in the 1982 NMGS Fall Field Conference Guidebook.*

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# EARTHQUAKES OF ALBUQUERQUE COUNTRY

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## INTRODUCTION

New Mexico experienced more than a thousand earthquakes during the period 1849-1975 (Northrop, 1976). Of these, about one-half can be regarded as definitely recorded and the remainder as less definitely or vaguely recorded. The first earthquakes reported in New Mexico occurred at Socorro in 1849. Instrumental studies did not begin until 1959-60 (Sanford and Holmes, 1961a, b) and fairly complete instrumental records are available only after 1962. Thus, we have non-instrumental data from 1849 to the present (a century and a third) compared to instrumental data from 1962 to the present.

Seismograph stations were installed at Denver, Colorado and at Tucson, Arizona about 1909. The first permanent seismograph station in New Mexico was installed in 1960 near the campus of New Mexico Institute of Mining and Technology (Sanford and Holmes, 1961b). In 1961-62, the U.S. Coast and Geodetic Survey established its seismological laboratory (now the U.S. Geological Survey, Albuquerque Seismological Laboratory) southeast of Albuquerque and began operating this and other stations at Las Cruces, New Mexico, and at Tucson and Payson, Arizona. The Los Alamos Scientific Laboratory installed a network of stations in the vicinity of Albuquerque in 1976 (Sanford and others, 1981, p. 9).

Most of New Mexico's earthquakes recorded prior to 1962 were located in the Rio Grande rift zone along the Rio Grande Valley, with a notable concentration from Albuquerque to Socorro. Many of these occurred in swarms: Socorro (1849-50), Sabinal and Jarales (1893), Socorro (1904 and 1906), and Belen (1935). Since 1962, many earthquakes have been instrumentally located throughout New Mexico beyond the rift zone.

This paper reviews the earthquake history of the Albuquerque-Belen area. The area covers one degree of latitude from 34.5° to 35.5° N and one degree of longitude from 106° to 107° W. The map (fig. 1) measures about 91 km east-west and 111 km north-south. Total area is about

10,100 km<sup>2</sup>. I am indebted to Professor Allan R. Sanford of the New Mexico Institute of Mining and Technology for a critical reading of the manuscript.

## Sources of Data

A summary volume, entitled *Earthquake History of the United States*, was published by the U.S. Coast and Geodetic Survey (USCGS) in 1928. Revised editions were published at occasional intervals in 1938, 1947, 1958, 1965, and 1973. This series is here cited as EHUS plus the year of publication (rather than by author). Generally, only earthquakes of Modified Mercalli intensity V and over are included in such summaries. More detailed information is given in the *annual* series, *United States Earthquakes, 1928—*. This series is here cited as USE plus the year covered (not the publication year). Additional information is given in the quarterly series, *Abstracts of earthquake reports for the Pacific Coast and the Western Mountain region*, prepared by the Seismological Field Survey, and is here cited as MSA plus the serial number.

Frequent reference is made to accounts published in local newspapers, chiefly Albuquerque papers such as the *Albuquerque Evening Herald*, *Albuquerque Journal*, *Albuquerque Morning Democrat*, *Albuquerque Tribune*, *New Mexico State Tribune*, and others such as the *San Francisco Examiner*.

## Intensity Scales

The intensity of an earthquake is a local measure of the effects on people, objects such as books, crockery, pictures, and furniture, and structures such as buildings. It is expressed on the Modified Mercalli intensity scale of 1931, with its 12 units ranging from I to XII. Prior to 1931, the scale generally used in the United States was the Rossi-Forel scale, with only 10 units ranging from I to X. An abridged version of the Modified Mercalli intensity scale of 1931, including Rossi-Forel equivalents, is given in Table 1.

Table 1. Comparison of Modified Mercalli and Rossi-Forel scales of earthquake intensity.

	Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale)
II.	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale)
III.	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing truck. Duration estimated. (III Rossi-Forel Scale)
IV.	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, and doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale)
V.	Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale)
VI.	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale)
VII.	Everybody runs outdoors. Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars. (VIII — Rossi-Forel Scale)
VIII.	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel Scale)
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX + Rossi-Forel Scale)
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale)
XI.	Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII.	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

EARTHQUAKES ORIGINATING WITHIN THE ALBUQUERQUE-BELEN AREA

Earthquake epicenters have been located from careful review of eyewitness and secondhand reports. Locations are approximate because, prior to 1962, shocks could only be placed at the nearest population center. Earthquakes whose epicenters are within the Albuquerque-Belen map area are listed in Table 2. Figure 1 shows epicenters of 36 quakes whose intensities are V or greater.

The following text presents information from press accounts, paraphrased in most cases, discussing the earthquakes. Occasional quotations are made. Note that all times given are Mountain Standard Time (MST).

Table 2. Earthquakes reported felt with epicenters in the Albuquerque-Belen area (latitude 34.5°-35.5°N, longitude 106°-107°W).

Year	Date Month Day	Origin Time MST	Approximate Location	Modified Mercalli Intensity	
1893	Apr. 6	20:00	Belen	IV	
		03:00	Belen & Los Lunas	VI	
		20:20	Belen	VI	
		04:00	Belen & Los Lunas	VI+	
	Jul. 12	06:40-06:45	Albuquerque	V to VI (*)	
	Sep. 7		Los Lunas & Sabinal	VII (*)	
	1895	Oct. 4	19:44	Sabinal & Jarales	V
			22:25	Sabinal & Jarales	V
5		03:15	Sabinal & Jarales	V	
		07:44	Sabinal & Jarales	V	
7		Note—An earthquake reported for Oct. 7 appears to be an error for Oct. 5. (*)			
1899	Feb. 9		Belen (several shocks)	III	
1906	Nov. 15	02:10	Peralta	IV	
1918	May 28	04:30	Cerrillos	VII to VIII (*)	
1928	Mar. 15	06:30	Belen	III	
		10:40	Belen	IV	
1930	Mar. 23	12:00	Albuquerque	IV	
		Dec. 3	14:36	Albuquerque	V to VI (*)
1931	Jan. 4	15:30	Albuquerque	III	
		27	21:00	Albuquerque	III
1935	Feb. 3	16:45	Albuquerque	V (*)	
		4	21:48	Albuquerque	VI+ (*)
1935	Dec. 12	23:30	Belen	IV	
		13	Belen (several shocks)	III	
		14	23:45(?)	Belen	IV
		15	02:00(?)	Belen	IV
			03:00(?)	Belen	IV
			11:00-12:00	Belen	III to IV
		16	06:45	Belen	IV
			11:00	Belen	V
			15:00	Belen	III
			21:30	Belen	II to III
		17	07:30	Belen	IV
			08:00	Belen	III
			22:33.3	Belen	V to VI (*)
				(during p.m. of 17th and early a.m. of 18th, 7 minor shocks)	II to III
		18	18:57.1	Belen	V to VI (*)
			19	01:00	Belen
		13:30		Belen	V
		18:30(?)		Belen	IV
		(during p.m. of 19th and a.m. of 20th, a total of 16 shocks)	II to III		
20	01:00	Belen	VI		
	03:30	Belen	VII		
	22:20	Belen	V		
	21	01:30	Belen	III	
04:30		Belen	III		
05:00		Belen	III		
18:56		Belen (most severe yet)	VII		
22		Belen	VI		
	19:40	Belen	VI		
	17:15	Belen	V		
	23:00	Belen	III		

Table 2 (continued).

Year	Date Month Day	Origin Time MST	Approximate Location	Modified Mercalli Intensity		
		23	05:00	Belen (followed by several lighter shocks)	V	
		24	04:45(?)	Belen	IV	
			11:50	Belen	V	
			12:15	Belen	V	
		27	08:00	Belen	III	
		28	12:05	Belen	VII	
			15:15	Belen (most severe yet)	VII+	
		29		Belen (several shocks during a.m.)	III	
		30	22:10	Belen (strongest shock of entire swarm)	VII+	
		1936	Jan. 2	10:30	Belen	III
				09:30	Belen (last of swarm)	IV
Sep. 9	05:55		Albuquerque	IV		
1938	Mar. 15	05:57	Albuquerque	IV+		
		16	16:54	Albuquerque	III	
		17:00	Albuquerque	III		
		17:05	Albuquerque	III		
		23:00	Los Lunas	III		
1947	Nov. 6	09:50	San Antonio & Zamora	VI (*)		
		2	10:00(?)	Albuquerque	IV	
1954	Nov. 3	13:39	Albuquerque	V (*)		
		25	20:30	Placitas	V (*)	
1956	Apr. 27	07:10	Albuquerque	II to III		
1970	Nov. 28	00:40:11.8	Albuquerque	VI (**)		
1971	Jan. 4	00:39:07.0	Albuquerque	VI (**)		
		06:15	Albuquerque	III		

\*Listed by Sanford and others (1981, table 1, p. 8).  
 \*\*Listed by Sanford and others (1981, table 3, p. 10).

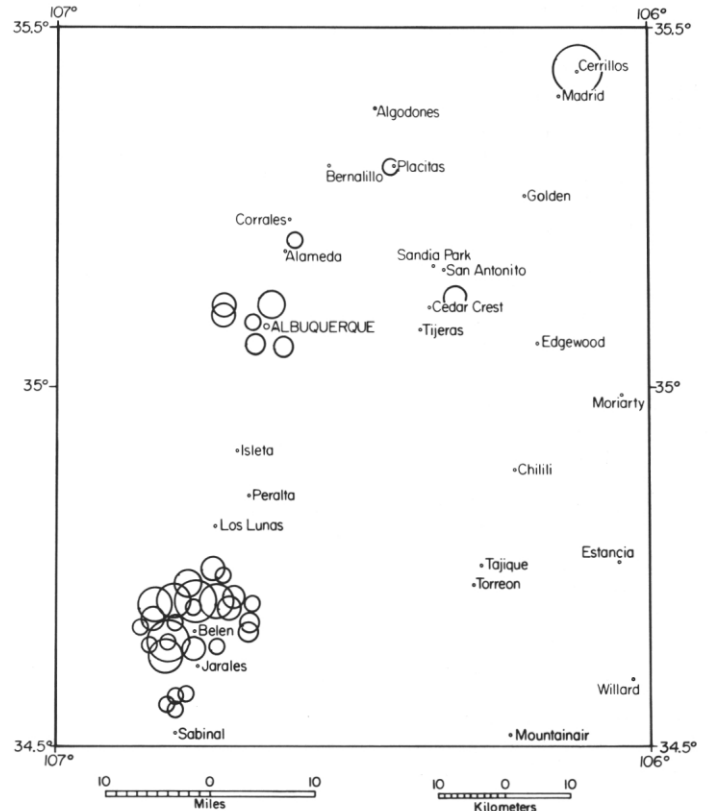


Figure 1. Locations of 36 earthquakes originating within the Albuquerque-Belen area, 1893-1971, with maximum Modified Mercalli intensities of V or greater. Diameters of circles are proportional to intensities V, V to VI, VI, VI+, VII, VII+, and VII to VIII.

### Pre-1900 Earthquakes

**1893, April 6, 20:00, Belen. Modified Mercalli intensity IV.**

**1893, April 7, 03:00, Belen and Los Lunas. Intensity VI.**

**1893, April 7, 20:20, Belen. Intensity VI.**

**1893, April 8, 04:00, Belen and Los Lunas. Intensity VI + .**

The primary source for these four earthquakes is Holden's (1898, p. 218) catalogue, which contains the following two paragraphs.

1893. April 6-8; Albuquerque, N. Mex. The inhabitants of the river towns south of the city are much alarmed. During the past forty-eight hours the earth has frequently shaken. The depot at Las [sic] Lunas shook to such an extent early this morning that the agent fled in terror (VII) [Rossi-Forel intensity]. The Indians living in the valley are also much excited. No earth tremors have been felt here (*i.e.*, at Albuquerque).

1893. April 8; Albuquerque, N. Mex. Las [sic] Lunas, Belin [sic], and several other towns along the Rio Grande River are all in excitement over what appears to be a series of infantile earthquakes. Four shocks have been distinctly felt since Thursday. There was one this morning, attended by ominous rumbling underground and of three seconds' duration, during which time eight or ten vibrations were felt. Glass was broken, dishes rattled, and a few frame houses in the towns swayed as if shaken by a terrible windstorm (VI?, VII?).

The *Albuquerque Morning Democrat* (Sunday, April 9, 1893) provides the following story, headlined "Earthquake Shocks."

A resident of Belen, who is here on business, received a letter from his wife yesterday morning in which she gives a graphic description of earthquake shocks distinctly felt in that town Thursday night and Friday morning. The first shock occurred at 8 o'clock Friday evening, and at 3 o'clock in the morning there were three more violent vibrations. The bed shook and cracked, and the lady says that bottles on her bureau almost fell off. Several people got up and dressed and prepared for the worst.

At Los Lunas shocks were also distinctly felt, and many persons were awakened and alarmed. The frame depot is said to have swayed, and glasses and other articles were broken in the commotion.

An Albuquerque lady informed the reporter that she was awakened by an earthquake at 4 o'clock yesterday morning. She had experienced such shocks before and could not be mistaken in the peculiar sensation it imparts.

Under a headline "The Earthquake at Belen," a dispatch from Belen dated April 8 appeared in the *Albuquerque Morning Democrat* on Tuesday, April 11, 1893.

Within the last thirty-six hours this place has been visited by a series of twelve earthquake shocks, three of which were of considerable force. The heaviest shock came at 8:20 p.m. yesterday, and was of sufficient force to throw goods from the shelves in the stores. Nearly all the houses in and around Belen are more or less damaged, several having been thrown entirely down, but no loss of life has yet been reported. Nearly everybody in Belen slept outside of their houses last night, being afraid another and more severe shock might come. The wave seemed to come from a southeasterly direction and was confined to a narrow strip of country, as points further south than Sabinal were not disturbed.

For the earthquakes which occurred during April 6-8, four are included in Table 2. Note that one is assigned an intensity of IV, two are of VI, and the last is of VI + .

**1893, July 12, 06:40-06:45, Albuquerque. Intensity V to VI.**

Holden's (1898, p. 221) entry is as follows.

Three shocks of earthquake that shook, from west to east, every house in the city and vicinity and every movable article were distinctly felt here this morning between 6 and 7 o'clock. The chandeliers in the Commercial Club, a stone structure, rocked for at least ten minutes, and the early risers at the club became very much agitated (VI?). A number of clocks throughout the city stopped (VI?). The wave came from the west.

Additional information from the *Albuquerque Morning Democrat*, Thursday, July 13, 1893, headlined "An Earthquake Disturbance," is as follows.

Several distinct shocks of earthquake occurred in this city at about a quarter to 7 o'clock yesterday morning and were perceptibly noticed by a large number of citizens, while other people who were up and about were not aware of the disturbance. The testimony of some of the most observant is to the effect that there were three shocks followed by a continuous vibration for several seconds. The Democrat's informants do not agree as to the course of

the disturbance, some saying it was from north to south, while others are positive the direction was from east to west.

H. E. Hogue, the foreman of the Democrat, says he was awake at the time and it appeared to him as if the Democrat building, where he rooms, received three powerful shocks from north to south. The mirror in his dressing case swung to and fro visibly. The shocks were followed by a continuous vibration.

Marshal Dodd was at breakfast and the swaying motions were plainly manifested to himself and wife.

W. T. McCreight was in his room at the time and is positive the course of the motion was from east to west.

Numerous citizens testify as to lamps and other pendant articles swaying to and fro and that various articles were thrown from shelves, etc.

Dean Bliss, who attends the university, was in his stable and felt the shock perceptibly. He says the east side of the stable raised and thinks the wave came from the east.

Prof. Ramsay says that the shocks were felt distinctly at his residence and that Custodian Custers found that the university clock stopped at twenty minutes to 7.

Several listings indicate that during July-August-early September (to September 7) central New Mexico was subject to "violent earthquakes" almost daily. A story in the *Albuquerque Tribune* (December 19, 1935) noted Police Judge Ramon Baca's impressions.

Living four or five miles south of Belen at that time, [he] remembers that he and his family slept in the open for two weeks. The tremors came in July, and for two weeks the farmers would not sleep inside. "I remember we had a bucket of water on the table when the first one come [sic]," Judge Baca said. "The shock pitched the table over, and half the water spilled from the bucket before the table got back on its legs. . . . We were cutting my father's wheat and I was using the sickle. As we entered the wheat field another tremor struck. The wheat field rose and fell and it looked like the ocean with waves rolling back and forth."

**1893, September 7, Los Lunas and Sabinal. Intensity VII.**

Holden's (1898, p. 224) catalogue notes the following observations.

Five commotions Thursday, September 7, threw down [at Los Lunas] a score of old adobe buildings already shaky from previous earthquakes (VII). No lives were lost, but a peculiar feature is that there were numerous cases of nervous sickness, even convulsions, among the inhabitants as soon as the rumbling commenced. The center of the disturbance is Sabinal, where a spring has appeared in a place which always had been dry and barren.

**1895, October 4-5, Sabinal and Jarales.**

There were two earthquakes on October 4 and two on October 5, each of intensity V. Most listings report erroneously a single earthquake on October 7. Holden's (1898, p. 243) entry is not dated but follows an entry dated 1895, October 7 for an earthquake in California. Holden repeats a dispatch from Albuquerque to the *San Francisco Examiner* (October 8, 1895) as follows.

The people of Sabinal and Jarales [sic], two small settlements south of this city [Albuquerque], are greatly excited over three distinct earthquake shocks, and many have moved from their homes into the mountains. The waves were from the southeast to the northwest and were so strong that houses rocked to and fro and household goods tumbled from the shelves (VII?). The shocks were felt here [in Albuquerque] last night, but only slightly.

The *Albuquerque Morning Democrat* (Tuesday, October 8, 1895) contained the following headlines and comments.

Sabinal Shaken Up/Four Distinct Quakes of the Earth There Friday Night: Special to the Democrat, Sabinal, N.M., October 7. Four earthquake shocks occurred here Friday night, the first at 7:44 o'clock in the evening and the last at 7:44 o'clock in the morning, just twelve hours apart to the minute. The second and third occurred at 10:25 o'clock in the evening and at 3:15 o'clock in the morning respectively.

Apparently no earthquake occurred on October 6 or 7.

**1899, February 9, Belen. Several shocks with intensity about III.**

According to the Monthly Weather Review (February 1899, p. 63), "several shocks are reported from Belen, N. Mex."

Post-1900 Earthquakes

1906, November 15, 02:10, Peralta. Intensity IV.

This shock, reported by Reid (1911, p. 12), may have been a fore-shock of the Socorro shock (intensity VIII or VIII + ) which occurred three hours later at 05:15.

1918, May 28, 04:30, Cerrillos. Intensity VII to VIII.

This was one of New Mexico's strongest earthquakes but the total affected area was surprisingly small-only about 31,000 km'. An exhaustive study by Olsen (1979) included an isoseismal map, reproduced here as Figure 2. An interesting summary of noninstrumental reports from the U.S. Weather Bureau's Monthly Weather Review is given by Olsen (1979, Table 1). Many plastered ceilings and chimneys fell. People on the street were thrown off their feet; a "heavy break in surface of earth at edge of town" was noted. Rossi-Forel intensity X was assigned. Because Olsen's paper was published so recently, further discussion will not be attempted here, except to note that Northrop (1976, Tables 2, 3, and 4) had assigned a Modified Mercalli intensity

of VIII + and had estimated the affected area at 32,375 km' and a local magnitude of 5.5. Olsen (1979, p. 71, 73) suggests an intensity of VII or possibly low VIII and a magnitude of 4.5 to 5.0.

1928, March 15, 06:30, Belen. Intensity III.

1928, March 15, 10:40, Belen. Intensity IV, "with abrupt onset and rocking motion."

1930, March 23, 12:00, Albuquerque. Intensity IV.

"A very brief shock shook homes and rattled dishes."

1930, December 3, 14:36, Albuquerque. Intensity V to VI.

Two distinct shocks with vertical movement were generally felt, resulting in cracked plaster and dishes. The exact location of the epicenter is in doubt; it has been given variously as latitude 35.00°N, longitude 106.00°W; 35.00°, 106.40°; and 35.00°, 106.50°. These are probably all too far southeast of Albuquerque. Additional information from the *New Mexico State Tribune* (December 3 and 4) follows.

The earthquake was felt in every part of the city and in outlying areas "at exactly 2:37 p.m." Dishes were shaken from shelves; floors trembled. The *Tribune* office was flooded with phone calls from every part of town. A definite "explosion" was reported by many. At the power plant of the gas

and electric company, needles on power plant instruments were disarranged. By old-timers this shock was reported to be the first in the history of the city to cause general excitement. "For a while Albuquerque was prepared to move out." It was reported from Magdalena to Domingo (175 km) in a straight line and there were no reports from points on either side of this line. A bottle of ginger ale was shaken from the shelf in the Champion grocery, hitting A. Matteucci on the head.

At the University of New Mexico, the head of the English department, Professor George St. Clair, was reading poetry to his class on the second floor of Hodgin Hall. Having lived in the Philippines, he had experienced quakes before and stopped in the middle of a stanza to inform his class: "This is an earthquake!" He then proceeded to rush down the stairs, beating the entire class to the ground. My wife, Ivah, and I were living in an apartment at the northeast corner of Ash and Grand at the west edge of the UNM campus. She was thrown off a dressing-table bench to the floor.

1930, December 4, 15:30, Albuquerque. Intensity III.

This was probably an aftershock of the one of the preceding day.

1931, January 27, 21:00, Albuquerque. Intensity III.

"Recognized by several," USE (1931) does not give the time. News accounts place it around 9:00 p.m.

1931, February 3, 16:45, Albuquerque. Intensity V.

The *Albuquerque Journal* (Wednesday, February 4) had headlines

"Slight Tremor of Earth Here; Little Damage/Is Third Quake in Two Months; Topples a Chimney and Is Felt in Several Parts of the City."

It was severe enough to tumble down a chimney at 523 West Fruit Avenue. The jolt was also felt on the third floor of the courthouse, in other downtown buildings, and in a number of homes.

1931, February 4, 21:48, Albuquerque. Intensity VI + .

Location of the epicenter has been given variously as 35°, 106°; 35.1°, 106.8°; and 35.00°, 106.45°. Intensity has been assigned as VI and again as VI to VII; VI + appears more realistic. A resume in USE (1931) gives the following summary.

Evidently strongly localized. Hundreds left houses, many in pajamas, and many reported they were thrown from bed. Panic threatened in theaters as audiences rose to their feet and some started for exits. Ten-foot crack appeared in a bakery and bricks toppled from bake ovens. Goods were thrown from shelves of several stores. A hot-water tank fell from a wall and a pharmacy mirror was cracked. Some plaster was cracked and water spilled from indoor containers. Large rocks rolled into streets from sand hills about the city. It was evidently felt at Martineztown also. Recorded at Tucson.

The following details are a summary of stories in the *Albuquerque Journal* and the *New Mexico State Tribune*.

The 10-foot crack in the wall of a bakery was at the Sanitary Bakery, 911 South 3d Street. Calls flooded the telephone exchange. Many people reported rattling of dishes. A woman fainted at the Pastime Theater, 217 West Central. The pharmacy mirror cracked at the Albuquerque Pharmacy, corner of Fourth and Central. A chimney cracked at 923 West Gold, and part of it fell. An adobe house near Barelás Bridge was badly cracked. Across the river south of town, two adobe houses were so badly damaged that the district attorney's office reported they were unsafe. The water tank was shaken from the wall at 724 South Second. The office clock at the U.S. Veterans' Bureau stopped at 9:50 p.m.

Pandemonium broke loose at the zoo. Animals awakened from their sleep tore up and down their cages. A mad bedlam of noise issued from all parts of the park. The roars of the African lions were heard for a mile . . . Bruce Hebenstreit . . . was shaken out of bed.

1935, December 12 through January 4, 1936: the Belen swarm.

News accounts suggest that the Belen swarm consisted of at least 81 shocks on 24 different days at or near Belen (Northrop, 1961). Table 2 includes 41 shocks on 19 different days. Modified Mercalli intensities are assigned as follows:

Intensity	Number of shocks	Intensity	Number of shocks
VII +	2	IV	9
VII	3		1
VI	3	III	10
V-VI	2		3
V	8		

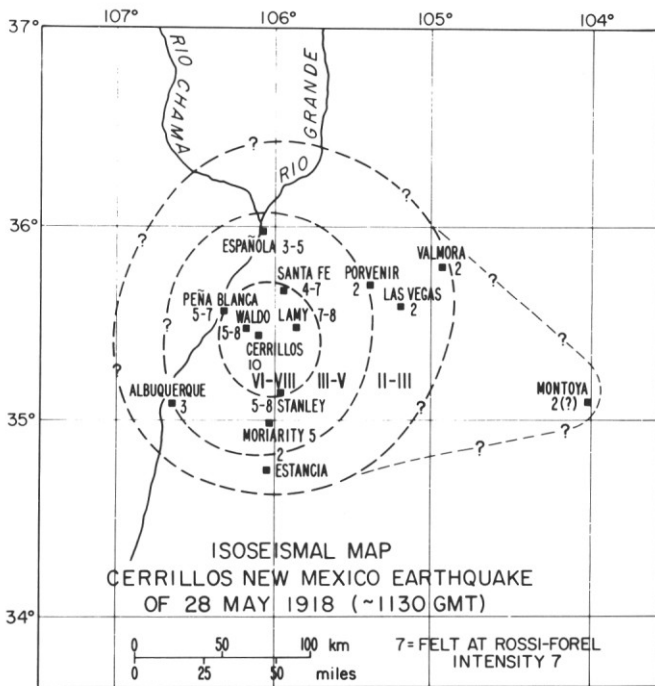


Figure 2. Isoseismal map of the May 28, 1918 earthquake at Cerrillos with Rossi-Forel intensities; 11:30 GMT = 04:30 MST. Reproduced from Olsen (1979, p. 70).

USE (1935) gives brief notes under dates of December 12, 14, 17, 18, 19, 21, and 30, with instrumental locations for two earthquakes at 34.7°N, 106.8°W. Sanford, Olsen, and Jaksha (1981) give 34.8°N, 106.8°W for one shock and 34.8°N, 106.85°W for the other. These coordinates place epicenters west of Los Lunas, a little too far north in my opinion.

Eighteen shocks of this swarm with intensity V or greater are clustered around Belen in Figure 1. Information from 22 clippings of Albuquerque morning and evening papers is summarized below.

1935, December 12, 23:30, intensity IV. This was the initial shock of the swarm.

1935, December 13. Several shocks, every few hours.

1935, December 14. Shortly before midnight. Local residents thought it was severe, but probably only IV.

1935, December 15. At least two shocks in the early morning, and one "distinct shock" during church. Several of these early shocks were felt at Magdalena, 74 km (46 mi) to the southwest.

1935, December 16, 06:45, IV.

1935, December 16, 11:00, V. Plaster fell; small cracks in buildings; dishes thrown from shelves. One school closed. Felt at Magdalena.

1935, December 16, 15:00, III.

1935, December 16, 21:30, two light shocks, II to III.

1935, December 17, 07:30, strong shock of about IV. Canned goods thrown from shelf in Safeway store.

1935, December 17, 08:00, two light shocks, III. It was announced that the grade school would reopen December 18.

1935, December 17, 22:33.3, intensity V to VI. USE (1935) noted that this shock was felt by many; some were alarmed. Moderately loud subterranean sounds (like bumping and wind) were heard. Buildings creaked, and loose objects rattled as if a truck had hit building. Some plaster fell down, and small objects were shaken from shelves. The quake was felt weakly at Los Lunas, Magdalena, and Socorro. Newspapers reported that the high school and two grade schools were closed. Two tremors reported in Albuquerque.

During the evening of the 17th and early morning of the 18th, there were at least 7 minor shocks.

1935, December 18, 18:57.1, intensity V to VI. Intermittent shocks all day. This one was felt by several residents in the eastern part of Albuquerque. It was followed by several lighter shocks.

1935, December 19, 01:00, intensity V. At Belen, more falling plaster and cracked walls were noted. A crack an inch wide was found in a brick wall at the Buckland drug store. Several stores reported that canned goods were shaken from shelves. Several lighter shocks followed.

1935, December 19, 13:30, intensity V. The quake was felt in Albuquerque, in northern part of town and at city hall.

1935, December 19, 18:30(?), IV. A fairly strong shock was felt at dinner time. Several lighter shocks followed. During the night of the 19th and early morning of the 20th, a total of 16 shocks were reported.

1935, December 20, 01:00, intensity VI.

1935, December 20, 03:30, intensity VII. Three strong shocks occurred at about 03:30. These shook a big #3800 engine on the Santa Fe tracks; several switch engines rocked hard enough to alarm engineers and firemen. Belen citizens were becoming nervous and apprehensive. Several lighter tremors followed.

1935, December 20, 22:20, intensity V. A severe shock occurred.

1935, December 21, at least three weak earthquakes occurred at 01:30, 04:30, and 05:00, each of intensity III.

1935, December 21, 18:56, intensity VII. This was the most severe shock of this swarm up to this time. Various times were reported from 18:53 to 18:56. At Belen several clocks stopped. Drug store reported bottles were jarred off shelves. Quake was felt in Albu-

querque along East Central Avenue and northern part of town.

Several shocks were reported in Belen between 18:56 and 19:40.

One has been entered in Table 2 as of intensity VI.

1935, December 21, 19:40, intensity VI. Several of these shocks were felt at Socorro, where windows and dishes rattled. USE (1935) noted that "these were the strongest shocks in the series of earthquakes beginning December 12. . . . All substantially built buildings withstood the tremors, although old adobe structures on the outskirts of the city began to show signs of weakening."

1935, December 22, 17:15, V.

1935, December 22, 23:00, III.

1935, December 23, 05:00, V. Four or five lighter shocks followed.

The press reported that not a day has passed without some tremors since December 12.

1935, December 24, 04:45(?), intensity IV. A light shock between 04:30 and 05:00.

1935, December 24, 11:50, V. "Fairly severe."

1935, December 24, 12:15, V. "Fairly severe."

Curiously, there were no earthquakes on Christmas Day or the following day.

1935, December 27, 08:00, III.

1935, December 28, 12:05, VII. As severe as any of the series. It shook open the doors of several buildings.

1935, December 28, 15:15, intensity VII+ . The most severe shock yet; rattled dishes and opened doors. It was felt in Albuquerque at 509 North 14th Street and 1122 South Edith. Goods were rattled in several stores in Albuquerque.

1935, December 29, several shocks of intensity III in the morning.

1935, December 30, 22:10, intensity VII + . This appears to have been the strongest earthquake of the entire swarm. It was certainly the strongest of the swarm felt in Albuquerque where it was reported from Five Points to a place 4 miles north on North Fourth Street, in University Heights and Monte Vista, and in the Huning Addition along the Rio Grande. A davenport shook violently; a piano rocked against the wall. Houses trembled, timbers creaked, and Christmas trees were upset. At least 40 phone calls were received at the *Albuquerque Journal* office.

1936, January 2, 10:30, Belen, intensity III.

1936, January 4, 09:30, Belen, intensity IV-the last of the swarm.

This earthquake was light at Belen, but felt in Albuquerque; several reports came from the western part of Albuquerque.

**1936, September 9, 05:55, Albuquerque. Intensity IV.**

**1936, September 9, 05:57, Albuquerque. Intensity IV+ .**

A distinct shock awakened several sleepers; variously reported between 05:55 and 06:00. One person reported a slight shock first, followed by a stronger one which "felt as though the house had been struck with a sledge hammer." Windows rattled, beds shook, and dishes rattled. Many persons thought it was either an explosion or the passing of a heavy truck. One person reported an east-west trend, but another thought it was a southeast-northwest trend. Most reports came from the southeastern residential section, but one was from Los Griegos.

**1936, September 11, 16:54, 17:00, 17:05, Albuquerque.**

Three shocks of intensity III, with rattling of windows at 714 Southern.

**1938, March 22, 23:00, Los Lunas. Intensity III.**

"Slight shock."

**1938, April 15, 14:00, Albuquerque. Intensity III.**

"Slight shock."

**1938, April 16, 01:15, Albuquerque. Intensity III.**

"Slight shock."

**1947, November 6, 09:50, San Antonito and Zamora, in the Sandia Mountains east of Albuquerque. Intensity VI.**

This was an interesting earthquake because it was the first to be reported from the Sandia Mountains and because there has been some

confusion in location of the epicenter. EHUS (1965) erred in giving coordinates as 34°, 107'; this is the approximate location of San Antonio, a town south of Socorro. Sturgul and Irwin (1971, event 58) further compounded the error by giving location as "Northeastern Bernalillo County, N M (Sandia Mt. Region, Texas) 34°N, 1021/2°W," which would be in Texas. EHUS (1973) gives 35.0°, 106.4°; this was accepted by Sanford and others (1981). A better location of the epicenter may be northeast of Tijeras, at 35.12°, 106.33°.

Details are given in USE (1947), MSA-56 (1947), and Kelley and Northrop (1975).

**1954, November 2, 10:00(?), Bernalillo. Intensity IV.**

Epicenter was between Bernalillo and Albuquerque and possibly to west of the Rio Grande. Extreme length of the affected area was about 32 km north-south; width was more difficult to ascertain but probably only a few kilometers east-west. Intensity at Bernalillo was about IV; in Albuquerque, about III; and in Sandoval (Corrales), about II.

**1954, November 3, 13:39, Albuquerque and Bernalillo. Intensity V.**

EHUS (1973) gives location of epicenter as 35.1°, 106.7°. It may have been a little farther north, near Alameda. This was more severe than the shock of the preceding day. Intensities of V were assigned to downtown Albuquerque but only IV at the University of New Mexico campus; it was felt strongly on the third floor of the Geology Building but not in the basement or on the first floor. Two people felt it on the second floor of the Geology Building. Several persons on the first and second floors of Hodgin Hall felt it. Intensity was III at Valley High School and other places north of Albuquerque. At Bernalillo, intensity V was reported, and also at Sandoval (Corrales); the press noted that furniture shook in the 2-story courthouse and filing cabinets "danced."

**1956, April 25, 20:30, Placitas. Intensity V.**

Sanford, Olsen, and Jaksha (1981) give location of epicenter as 35.10°, 106.30°, but coordinates may have been 35.31°, 106.43°. Reports from several families indicate intensity V. Intensity IV was reported in Tijeras Canyon and in Tres Pistolas Canyon, which branches off north from Tijeras Canyon. Details may be found in MSA-90 (1956); this is repeated by Kelley and Northrop (1975, p. 131).

**1957, July 27, 07:10, Albuquerque. Intensity II to III.**

One observer reported that a tight-fitting door vibrated for about 10 seconds.

**1970, November 28, 00:40:11.8, Albuquerque. Intensity VI.**

Slightly different coordinates have been given by various references, ranging from 35.0°, 106.7° to 35.10°, 106.61° and 35.16°, 106.75°. Sanford (1976, p. 8) assigns an intensity of only V, but others have given this shock an intensity of VI. The following summary is from

USE (1970).

Depth of 9 km. Felt over about 3,100 km<sup>2</sup> (1,200 mi<sup>2</sup>), principally in the Albuquerque region. Thousands were awakened at Albuquerque. Plaster cracked, windows broke, and many small items were broken. Roof of a barn collapsed. An air-conditioner on a roof shook loose and fell through a skylight. Other observers reported cracks in garage floor, exterior plaster cracks, and cracks in block fence walls. Many burglar alarms were activated. Animals were disturbed at the city zoo. Detailed reports of a questionnaire survey are given in MSA-148 (1970).

**1971, January 4, 00:39:07.0, Albuquerque. Intensity VI.**

Again, as in the preceding earthquake, there is some variation in the reported location of the epicenter. The following summary is from MSA-149 (1971).

Felt over about 1,600 km<sup>2</sup> (600 mi<sup>2</sup>) of the Albuquerque region. Maximum intensity VI at Albuquerque, where minor damage, principally in the west and northwest sections of the city, was reported, consisting chiefly of cracked walls and plaster, broken windows, and damage to fallen objects. Damage at the University of Albuquerque was estimated at \$30,000 to \$40,000, much of it due to breakage and spillage of chemicals. Hardest hit at the University of Albuquerque were the chemistry laboratories in St. Francis Hall. "Chemicals, valued at about \$10,000, flowed from shattered

containers, dissolving floor tile and molding. Steel shelves were bent and twisted. . . . Assumption Hall, which houses the university library, also reported extensive damage. Bookracks were bent and twisted, dumping thousands of books to the floor." Another observer reported that most of the books "were thrown from west-east." At the Biology department, "only shelves running in a north-south direction fell over or had items fall off; shelves running east-west were not damaged."

The principal damage at West Mesa High School was fracturing on the ends of six or seven "double-T" roof members, most of them in the gymnasium. At The Prism, a shop in Old Town, the floor was covered with broken glass; this shop had reported no damage in the preceding shock of November 28, 1970. A Persian gazelle at the zoo died, apparently after running into a wall. At the Bernalillo County jail, walls were cracked, plaster fell, and a prisoner was shaken out of his top bunk.

There was an aftershock, intensity III, at 06:15.

The epicenters of both the 1970 and 1971 earthquakes can probably be pinpointed in an area southwest of the University of Albuquerque, northwest of Old Town, west of the Rio Grande, west of Coors Road, and north of West Mesa High School and the Coronado Freeway (Interstate 40). It is here suggested that these two Albuquerque earthquakes are related to the fissures along which eruptions of the Albuquerque volcanoes occurred.

## EARTHQUAKES WITH EPICENTERS BEYOND THE AREA

A dozen earthquakes reported felt within the Albuquerque-Belen area but which originated somewhere beyond the area are shown in Table 3. In Table 3 and under the Modified Mercalli Intensity heading, two columns are given, one for intensity at the epicenter and the other for intensity in the Albuquerque-Belen area. Only highlights of these earthquakes are given below.

**1887, May 3, Bavispe, Sonora, Mexico. Intensity VIII to IX.**

A summary of this earthquake, whose epicenter was about 31°N, 109°W, is given in EHUS (1973). It was felt from Toluca, near Mexico City, to Albuquerque and Santa Fe, New Mexico, on the north; and from Yuma, Arizona, on the west, to a point 96 km (60 mi) east of El Paso, Texas, on the east. "Millions of cubic feet of rock were thrown from the mountains. Cliffs of solid crystalline rock were shattered. One narrow canyon contained an immense amount of material from adjacent cliffs."

**1906, July 12; July 16; November 15, Socorro, New Mexico.**

This year a remarkable swarm of earthquakes commenced July 2 and continued until at least January 16, 1907. Three shocks are listed in Table 3. The swarm was described by Reid (1911) in some detail, including an isoseismal map of the shock of November 15, reproduced here as Figure 3. Sanford and others (1972, p. 2) gave each of the three shocks an intensity of VIII but also gave a radius of perceptibility of 330 km for July 16, compared to a radius of only 270 km for each of the other two shocks. Sanford, Olsen, and Jaksha (1979, Table 1) lowered the intensity of the July 12 shock to VII-VIII and estimated the area of perceptibility as 125,000 km<sup>2</sup>; they gave July 16 an intensity of VIII and an area of 175,000 km<sup>2</sup>. They gave November 15 an intensity of VIII and increased the area to 245,000 km<sup>2</sup>. Reid (1911, p. 12) had definitely stated that November 15 was the severest shock of the entire swarm; its intensity was probably near VIII +.

In recent years, A. R. Sanford and several others have published much information on the 1906 swarm (Sanford, 1963; Sanford and others, 1972; Ashcroft, 1974; Hoffman, 1975; von Hake, 1975; and Northrop, 1976). For the July 12 and 16 shocks, Ashcroft (1974, p. 329) noted that the "actual property loss was estimated at less than \$3,000; no one was seriously injured, and no one was killed. Perhaps fifty people sought refuge in other towns."



Table 3. Earthquakes reported felt in the Albuquerque-Belen area (latitude 34.5°-35.5°N, longitude 106°-107°W) with epicenters beyond the area.

Year	Date Month	Day	Origin Time MST	Approximate Location	Modified Mercalli Intensity At Epicenter	Intensity Within Area
1887	May	3	14:13	Bavispe, Sonora, Mexico	VIII-IX	II-III
1906	Jul.	12	05:15	Socorro, New Mexico	VII-VIII	V-VI (*)
		16	12:00	Socorro, New Mexico	VIII	VI-VII (*)
		15	05:15	Socorro, New Mexico	VIII+	VI-VII (*)
1931	Aug.	16	04:40:21	Valentine, Texas	VIII+	III
1935	Feb.	20	18:25	Bernardo, New Mexico	VI	V-VI (*)
			20:05	Bernardo, New Mexico	V	IV-V (*)
		22	08:49:30	La Joya, New Mexico	V	III-IV (*)
1960	Jul.	23	07:15:26	La Joya, New Mexico	VI	IV-V (*)
		24	03:37	Bernardo, New Mexico	V	IV-V (*)
		4	03:48:05.3	Southwest of Belen, New Mexico	III	II-III
1980	Mar.	21	17:49:12.5	Estancia Valley, New Mexico	IV	III-IV

USE (1931) gives a detailed summary (p. 10-11) and a double-page isoseismal map (p. 12-13); this map was reproduced by Northrop and Sanford (1972, fig. 8) and also by Northrop (1976, fig. 6, p. 81).

-Listea by sanrora ano others (1961, table 1, p. 6).

**1931, August 16, Valentine, Texas. Intensity VIII + .**

USE (1931) gives a detailed summary (p. 10-11) and a double-page isoseismal map (p. 12-13); this map was reproduced by Northrop and Sanford (1972, fig. 8) and also by Northrop (1976, fig. 6, p. 81). Sanford and Topozada (1974) note that the epicenter plotted by Byerly was 110 km north of the USCGS epicenter and they plotted a new isoseismal map (their fig. 4, p. 8).

**1935, February 20, 18:25 and 20:05, Bernardo, New Mexico.**

Two shocks at Bernardo, the first of intensity VI and the second of V. Bernardo is about 9 km south of the southern boundary of the Albuquerque-Belen map area. USE (1935) states: "Coping cracked on building; walls and plaster cracked, adobe and concrete buildings partially damaged. Accompanied by thunderous roar."

**1960, July 22, 08:49:30, La Joya, New Mexico. Intensity V.**

La Joya is about 8 km south of Bernardo.

**1960, July 23, 07:15:26, La Joya. Intensity VI.**

**1960, July 24, 03:37, Bernardo. Intensity V.**

**1975, March 4, 03:48:05.3, southwest of Belen. Intensity III.**

The epicenter of this shock was just west of the west boundary of the map area. Coordinates were given as 34.55°, 107.05° (USE, 1975) or 34.55°, 107.12° (Sanford and others, 1981). It was felt at Belen.

**1980, March 21, 17:49:12.5, Estancia Valley, just east of the east boundary of the map area. Intensity IV.**

Coordinates were given as 34.59°, 105.91°. Intensity IV was felt at Estancia, Mountainair, and Willard; intensity III was felt at Cedarvale and Torreon.

**OTHER ASPECTS**

**Magnitude**

The magnitude of an earthquake, often called the Richter magnitude, is a measure of the energy released at the focus of an earthquake. It is determined by amplitudes produced on a seismogram. Few measured magnitudes are available for any New Mexico quakes prior to 1962, but it is possible to estimate magnitude on the basis of observed intensity and the radius or area of perceptibility. Thus, Sanford (1976, Tables 1 and 2) estimated a magnitude of 5.5 for Cerrillos 1918, and magnitudes ranging from 3.5 to 4.5 for Albuquerque shocks of 1893, 1930, 1931, 1936, 1947, 1954, and 1956; see also Newton and others (1976, Table 2, p. 23). Sanford and others (1979, Table 1) estimated magnitudes of 4.1 to 5.2 for Cerrillos 1918 and 4.4 to 6.5 for Socorro 1906.

**Depth of Focus**

Only a few determinations of focal depth have been made for New Mexico shocks, starting in 1960. Many have originated at shallow depths, ranging from 5 to 10 km (3 to 6 miles).

**Property Damage**

New Mexico's most disastrous earthquake was the one at Dulce near the Colorado line west of Chama in 1966, which resulted in at least \$200,000 damage, mostly to the U.S. Bureau of Indian Affairs plant, especially dormitories, and to the Dulce elementary-high school complex (USE, 1966; MSA-129, 1966).

The second most costly shock was at Albuquerque in 1971; this did about \$40,000 damage at the University of Albuquerque, West Mesa High School, and several gift shops and liquor stores in the Old Town area.

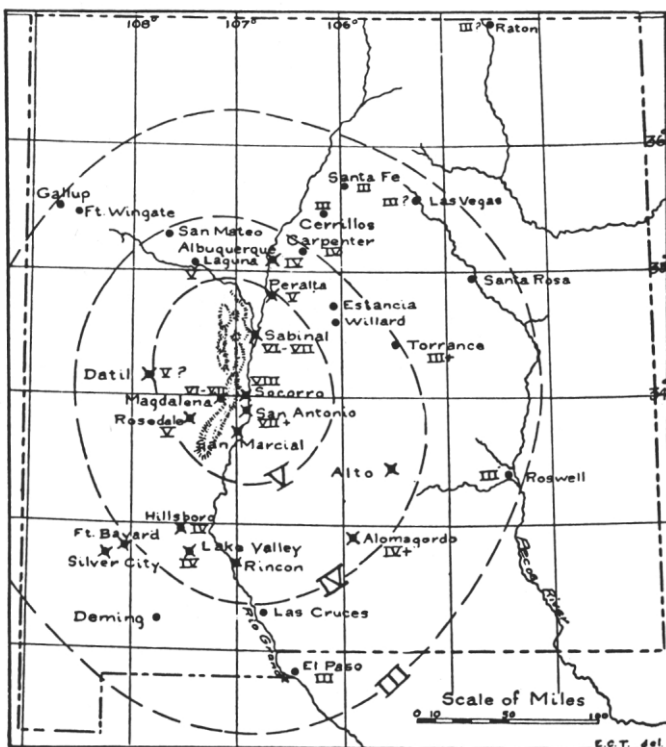


Figure 3. Isoseismal map of the November 15, 1906 earthquake at Socorro with Rossi-Forel intensities. The towns marked with a cross also reported either the shock of July 12 or that of July 16, 1906. Reproduced from Reid (1911, p. 13).

There do not appear to be any estimates of damage from the Cerrillos shock of 1918 or from the Belen swarm of 1935. Ashcroft's (1974) estimate of less than \$3,000 damage at Socorro in 1906 was noted above. It is rather remarkable that no loss of life or serious injury from earthquake has been recorded in New Mexico.

### The Future

Earthquakes of intensity VI to VIII may be expected along the Rio Grande rift, particularly in the segment from Albuquerque to Socorro. Discussions of seismic risk are given in Sanford (1976), Sanford and others (1972), and Northrop (1976).

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Albuquerque, 1883 (Albuquerque Museum Photoarchives).