

LANCASTER EARTHQUAKES

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When a magnitude 4.1 earthquake rumbled through Lancaster County on Easter Sunday night, 22 April, 1984, some people were frightened, most were curious and many were surprised. "We don't have earthquakes here," seemed to be a common reaction. The fact is, however, that Lancaster is the most seismically active county in Pennsylvania and is one of the more active areas in the eastern United States. Since the middle of the eighteenth century, some two dozen earthquakes have had epicenters in Lancaster or Lebanon Counties. This record of seismicity is summarized in the accompanying table.

Before describing these earthquakes, we shall explain a few technical terms used in seismology. Earthquakes occur when there is a sudden release of strain energy at a fault plane, which is a fracture in the earth's rocky crust. When this happens, stress is relieved and the strain energy is converted into fault slip, heat and seismic waves. These waves radiate away from a point called the hypocenter of the quake, usually located miles below the surface of the earth. The point on the surface directly above the hypocenter is called the epicenter.

Seismic waves are detected and measured by seismographs. The magnitude of an earthquake is determined from seismographic records. Ideally, magnitude is related to energy and forms a consistent basis for com-

LIST OF LANCASTER EARTHQUAKES

YEAR	DATE	LOCAL TIME	MAGNITUDE*	MAX. INTENSITY
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DEFINITE EARTHQUAKES

1752	17 Dec.	c. 6:00 p.m.	3.6	IV
1798	11 Jan.	c. 2:00 a.m.		IV
1800	20 Nov.	c. 5:00 a.m.	4.1	V
1801	27 Jan.	3:40 p.m.		IV
1818	19 Mar.	c. 4:00 a.m.		III
1820	21 Aug.	9:40 a.m.	3.4	V
1822	4 May	3:10 p.m.		IV
1829	9 Sep.	9:45 p.m.		III
1834	2 May	11:30 p.m.	4.0	V
1885	15 Jan.			III
1885	8 Mar.	8:00 p.m.		V
1889	8 Mar.	6:40 p.m.	4.3	VI
1964	12 May	2:45 a.m.	3.2	VI(?)
1972	7 Dec.	10:00 p.m.		V
1978	16 Jul.	2:40 a.m.	3.0	V
1978	6 Oct.	3:25 p.m.	3.1	V
1984	18 Apr.	11:55 p.m.	2.9	V
1984	22 Apr.	7:43 p.m.	4.1	VI
1986	2 May	10:53 a.m.	2.5	IV

Probable Earthquakes

1738 or 1739				
1793	Sep.			
1886	28 Sep.	11:00 p.m.		IV
1984	19 Sep.	3:20 p.m.		III

Questionable Events, probably not earthquakes

1886	27 Sep.		p.m.	
1893	26 Apr.		5:00 a.m.	
1905	25 Nov.		p.m.	
1939	1 Apr.	c. 10:00	p.m.	
1940	28 May			

*Magnitudes for events before 1964 are estimated from intensities and felt area.

paring the size of one earthquake to another. As originally defined by Charles F. Richter, each unit of magnitude represented a ten-fold increase in the maximum amplitude of ground motion. The greatest earthquakes are seldom greater than 5, although the 1811 New Madrid, Missouri earthquake is estimated to have had a magnitude near 8 and the 1886 Charleston, South Carolina earthquake is believed to have been almost magnitude 7.

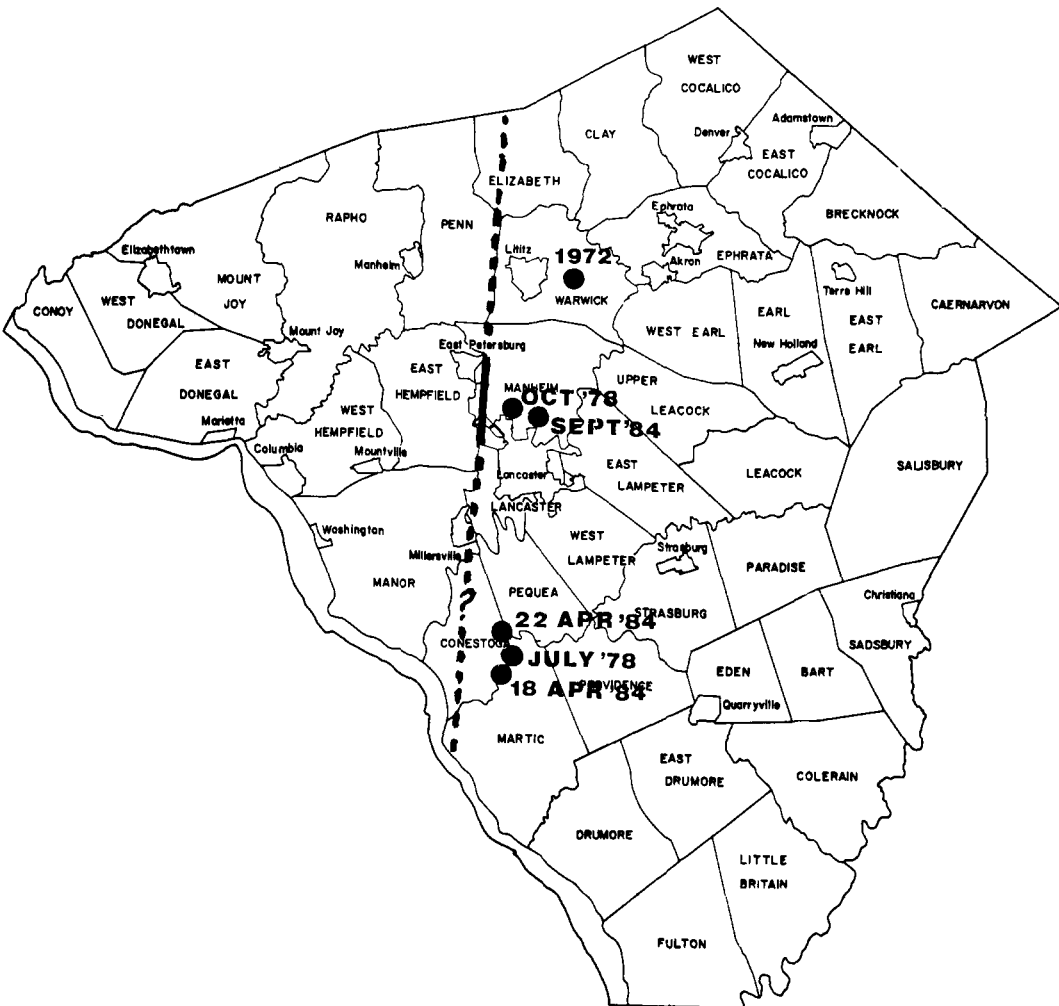
Another way to compare earthquakes is on the basis of seismic intensity. The most commonly used intensity scale in the United States is called the Modified Mercalli Scale. Intensity is based on how people feel the quake, as well as on damage and other physical effects. Modified Mercalli intensity often is expressed by a Roman numeral, partly to avoid confusion with magnitude. The scale ranges from "felt by almost no one" (I) to "total destruction" (XII). The most common intensities in the historical record of Lancaster earthquakes are II, IV, V and VI. At intensity II, most people feel the quake as a mild vibration and suspended objects may swing slightly. Intensity IV is similar to the vibrations of a very heavy truck passing nearby; windows and dishes in cabinets rattle. At intensity V, doors spring open, unstable objects are overturned, furniture is moved, and liquids spill from well-filled containers. Intensity VI is the threshold of damage: cracked masonry, fallen plaster and broken windows. Intensity generally decreases with distance from the epicenter, but local conditions of geology and topography also affect seismic intensity.

Instrumentally determined magnitudes are available only for the most recent earthquakes. For older events, magnitudes have been estimated from intensities and from the size of the area over which the quake was felt.

The Lancaster Seismic Zone

Earthquakes in Lancaster and southern Lebanon Counties define a zone of seismic activity approximately 50 km. (30 mi.) long in a north-south direction.¹ This zone may coincide with one or more faults that were formed some 200 million years ago when North America was just beginning to separate from Europe and Africa. Small intrusions (dikes) of igneous rock also parallel this trend. It seems that these faults are favorably oriented with respect to the present-day state of stress in the earth's crust, so that they have become planes of renewed slip and strain-energy release.

The release of this energy has not been constant with time. Lancaster's earthquake history can be divided into three, or perhaps four, distinct periods of activity separated by long periods of inactivity. There is some evidence to suggest that each period of activity begins in the northern part of the zone and works its way southward, culminating in a relatively large event.



The Period To 1834

An earthquake may have occurred in the Lancaster Seismic Zone in 1738 or 1739², but the earliest well-established event was on 17 December, 1752. *The Annapolis Gazette* reported this occurrence:

December 26. We have advice from Lancaster, that on Sunday, the 17th instant, a shock of an earthquake was felt there, between six and seven at night.¹

Forty-one years elapse before the next report of an earthquake, which

is a rather vague reference to a "shock felt" at Harrisburg sometime during September, 1793.⁴ A more definite event is recorded by *The Carlisle Gazette* as having occurred on 11 January, 1798.

The Lancaster German paper mentions, that on Thursday the 11th inst. between the hours of two and three in the morning, there was felt in that town and its neighborhood a severe shock of an earthquake, which continued for several minutes. The shock was accompanied, it is said, with a blaze not unlike the burning of a chimney.⁵

We may suppose that the "blaze" refers to the roaring, rumbling sound which has been a characteristic of Lancaster earthquakes.

One of the strongest shocks in the Lancaster Seismic Zone occurred about 5:00 a.m., 20 November, 1800. This earthquake was felt over a large area, including Harrisburg, Carlisle, Reading, Philadelphia, Wilmington and Baltimore. The maximum intensity was at least V, and the magnitude is estimated at 4.1. Several aftershocks, some quite strong, were felt during the following week.⁶ About two months later, an earthquake almost as severe was felt in Lancaster about 3:40 p.m., on 27 January, 1801.⁷

The next Lancaster earthquake was on 19 March, 1818. Around 4:00 a.m. a tremor of 10 to 12 seconds duration was felt, followed by others around 9:00 a.m.⁸ On 21 August, 1820, at 9:40 a.m., Lancaster experienced an earthquake with maximum intensity of V and estimated magnitude 3.4. Aftershocks were felt on 25 and 27 August.⁹ Seismic activity continued with the earthquake of 2 May, 1822. This tremor was felt in the city at 3:10 p.m. and had a maximum intensity of IV. *The New York Post* reported that this event "caused considerable sensation and alarm among the inhabitants."¹⁰

This early nineteenth century active period was brought to a close by events in 1829 and 1834. A rather mild quake was felt on 9 September, 1829 at 9:45 p.m.¹¹ A much more severe shock occurred on 5 February, 1834 about 11:30 p.m. In Columbia, crockery was shaken very considerably on shelves and a low, rumbling noise was heard "which many, at the moment, thought was occasioned by the passing of a stage along the street."¹² The magnitude of this quake was about 4.0.

The Period 1885 to 1893

After the 1834 earthquake, 50 quiet years ensued. Then a new series of events began on 15 January, 1885 when a weak tremor was felt at Shaefertown in Lebanon County.¹³ This was followed by a larger quake felt in the city of Lancaster about 8:00 p.m. on Sunday, 8 March, 1885. *The Lancaster Intelligencer* reported that the earthquake struck "while the people of Lancaster were at their devotions" and that the sound was like that of the "fall of masses of snow from the roof."¹⁴ The newspaper includes speculations on the cause of the quake, centering on the theory that a "great cave" underlies the city and that a fall of rock from the ceiling of this cave was

responsible.

Two events, one of them highly questionable, were reported in September, 1886. It must be remembered that the largest earthquake ever to occur on the East Coast had devastated Charleston, South Carolina on 31 August of that year. The Lancaster newspapers were full of earthquake stories that September and Lancastrians were very earthquake-conscious. In that light we may view the report coming from "Squire Brush of Washington Boro" that on the evening of 27 September his house "began swaying to and fro." The squire continued, "I was alarmed and, with my family, hastened outside. The house was still rocking, and I knew we were experiencing a shock of earthquake." *The Lancaster Intelligencer* ran this story under the heading "Was it an Earthquake?"¹⁵ It seems that no one else felt it.

Less easy to dismiss is the report the next day that about 11:00 p.m. on 28 September, "two shocks of earthquake were felt in Elizabethtown."¹⁶ These shocks caused doors and windows to rattle and were accompanied by a "dull sound."

The largest event of the late nineteenth century occurred at 6:40 p.m. on Friday, 8 March 1889. This earthquake was felt over a very large area, including parts of New York City. Intensity V effects were experienced in Lancaster, York, Middletown, Harrisburg, and Towson, Maryland. Catalogs of earthquakes often give the location of this earthquake as York, possibly because of newspaper reports that "houses tumbled" in York.¹⁷ Taken literally, this would indicate an intensity as high as VIII, but that is hardly credible. Actually, the intensity seems to have been no higher in York than in Lancaster. *The Philadelphia Evening Bulletin* reported that farmers coming from the northern part of Lancaster County described an aftershock the next day.¹⁸ This might indicate an epicenter in northern Lancaster County; however, analysis of the felt area and intensities suggests an epicenter in the southern part of the county.¹⁹

In its account of the 1889 earthquake, *The Lancaster Intelligencer* paid considerable attention to the efforts of "professor J. B. Kerschner" [sic] to determine the exact time when tremors were first felt in the city. This was certainly Jefferson Engels Kershner, founder of the astronomical observatory at Franklin and Marshall College and a man keenly interested in the measurement of time.²⁰ By averaging the observations of several persons, "corrected to observatory time," he found the time the earthquake was felt to have been exactly 40.210 minutes past 6:00 p.m.²¹ The newspaper assured its readers that this was of great scientific importance, though it is hard to see why inasmuch as no science of seismology existed in that era.

The last nineteenth century event occurred on 26 April, 1893. *The Lancaster Intelligencer* makes no mention of this event, but *The Philadelphia Evening Bulletin* reported a "slight shock" accompanied by an explosive

sound, followed by a low rumble in Lancaster early that morning. *The Lancaster Journal* said that some reports of tremors may have been due to blasting at a railroad construction site.²²

The Twentieth Century

The next 70 years seem to have been free of earthquakes, except for three possible, but doubtful, events that appear in some listings. A catalog of earthquakes published in 1968 lists an earthquake felt at Harrisburg on the afternoon of 25 November, 1905.²³ No other information has been found to confirm this occurrence as being an earthquake. The U.S. Coast and Geodetic Survey report of United States earthquakes for 1939 includes a "weak shock felt at Lancaster, Pa." between 9:30 and 10:30 p.m. on Saturday, 1 April.²⁴ None of the Lancaster newspapers contain any confirmation of this event. However, the main story in *The Lancaster Sunday News* of 2 April concerns a major fire at a truck terminal, during which several gasoline tanks exploded.²⁵ Could this be the source of the "weak shock?" Another enigmatic event appears in the Coast and Geodetic Survey listing for 1940, which indicates that on 28 May a light shock was felt at Harrisburg and recorded on "nearby seismographs, according to Bulletin of Northeastern Seismological Association."²⁶ No further information has been found about his occurrence.

The most recent period of definite seismic activity began on 12 May, 1964 with a sizable shock centered near Cornwall, Lebanon County. The magnitude of this event, the first earthquake in the Lancaster area to be analyzed using seismic instruments, was 3.2. The maximum intensity was VI.²⁷

The Cornwall earthquake was followed more than eight years later by an event on 7 December, 1972, felt about 10:00 p.m. in the northern part of Lancaster County. An amusing passage occurs in *The Reading Eagle-Times* account of the 1972 quake.

Mr. [James] Humphreville [a Lancaster consulting geologist] said the earthquake theory was verified by Lamont Doherty at the Geological Observatory, Palisades, N.Y., who said that he was sending a team into Lancaster County for a 24 to 48-hour study of the quake area.²⁸

The editors seem to have been unaware that Lamont-Doherty is the name of the geological observatory of Columbia University, not the name of an individual there.

The next two events came in 1978. The first, about 2:40 a.m. on Sunday, 16 July, had a magnitude of 3.0. It was felt most strongly in the vicinity of Rawlinsville and Marticville in southern Lancaster County.²⁹ The second 1978 event was on Friday, 6 October. This time the intensity was greatest north of the city of Lancaster, in the vicinity of Neffsville and Blossom Hill.

The magnitude of this earthquake was 3.1; the maximum intensity was V, bordering on VI.³⁰

On Wednesday, 18 April, 1984, about 11:05 p.m., a magnitude 2.9 earthquake occurred with an epicenter in the Rawlinsville-Marticville area. This was followed four days later by the Easter earthquake, an event similar to those of 1800, 1834 and 1889. Many small aftershocks were felt or recorded in the months following, and more detailed information has been obtained about this earthquake than about any other in Lancaster's history.³¹

Most recently, two small shocks have been felt in the Lancaster Seismic Zone. A slight tremor which was felt about 3:40 p.m. on 18 September, 1984 could be regarded as an aftershock of the April earthquake, but its epicenter appears to have been north of Lancaster city; it was felt most strongly in Eden and Manheim Townships.³² Finally (as of this writing), a magnitude 2.5 event occurred at 10:53 a.m., Friday, 2 May, 1986. The maximum intensity of IV was felt in the vicinity of Marticville and Conestoga.

Conclusion

Far from being aseismic, Lancaster has an active history of earthquakes, and is the Pennsylvania county which has experienced the greatest earthquake energy release. Fortunately, the largest events have been no more severe than magnitude about 4 and intensity VI. No serious property damage or injury has resulted. If the pattern of the past continues, then Lancaster may be entering one of the long quiet periods and be free of earthquakes for some time to come. But we must remember that there are few endeavors as risky as forecasting earthquakes.

Notes

Newspaper references to particular earthquakes are not exhaustive.

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3. *The Annapolis Gazette*, 15 Feb. 1753.

4. *The Harrisburg Morgenrothe* (German), 17 Nov. 1800.

5. *The Carlisle Gazette*, 24 Jan. 1789.

6. *The Lancaster Journal*, 22 Nov. 1800.

7. *The Carlisle Gazette*, 4 Feb. 1801.

8. *The Lancaster Journal*, 20 Mar. 1818.

9. *The New York Commercial Advertiser*, 29 Aug. 1820; *The Lancaster Journal*, 1 Sep. 1820.

10. *The New York Post*, 7 May 1822; *The Lancaster Journal*, 10 May 1822.

11. *The Lancaster Journal*, 18 Sep. 1829.

12. *The New York Post*, 13 Feb. 1834; *The Lancaster Journal*, 10 Feb. 1834.

13. *The Lancaster Intelligencer*, 16 Jan. 1885.
14. *The Lancaster Intelligencer*, 9 Mar. 1885; *The Philadelphia Evening Bulletin*, 9 Mar. 1885.
15. *The Lancaster Intelligencer*, 28 Sep. 1886.
16. *The Lancaster Intelligencer*, 29 Sep. 1886.
17. *The Philadelphia Evening Bulletin*, 9 Mar. 1889.
18. *Ibid.*
19. Armbruster and Seeber, *op. cit.*
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21. *The Lancaster Intelligencer*, 9 Mar. 1889.
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23. H. F. Reid and G. P. Wollard, *A Catalogue of Earthquakes in the United States Prior to 1925* (Honolulu: Univ. of Hawaii Inst. of Geophysics, Data report 10, 1968), cited in: Abdypoor and Bischke, *op. cit.*, 143.
24. R. R. Bodle, *United States Earthquakes 1939* (Washington: U. S. Coast and Geodetic Survey, Serial no. 637, 1941).
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27. Abdypoor and Bischke, *op. cit.*, 265.
28. *The Reading Eagle-Times*, 9 Dec. 1972, quoted in: Abdypoor and Bischke, *op. cit.*, 282.
29. Charles K. Scharnberger, The Lancaster County earthquake of July 16, 1978, *Pennsylvania Geology* 9(5), 2-5.
30. Charles K. Scharnberger, Another Lancaster County earthquake, *Pennsylvania Geology* 9(6), 2-5.
31. Armbruster and Seeber, *op. cit.*; Charles K. Scharnberger, Lancaster's Easter earthquake, *Pennsylvania Geology* 15 (3), 2-5; Charles K. Scharnberger and Benjamin F. Howell, Jr., Intensities and structural setting of the earthquakes of 19 April and 23 April, 1984, Lancaster County, Pennsylvania, *Earthquake Notes* 56(2), 43-46.
32. *The Lancaster Intelligencer-Journal*, 19 Sep. 1984.

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