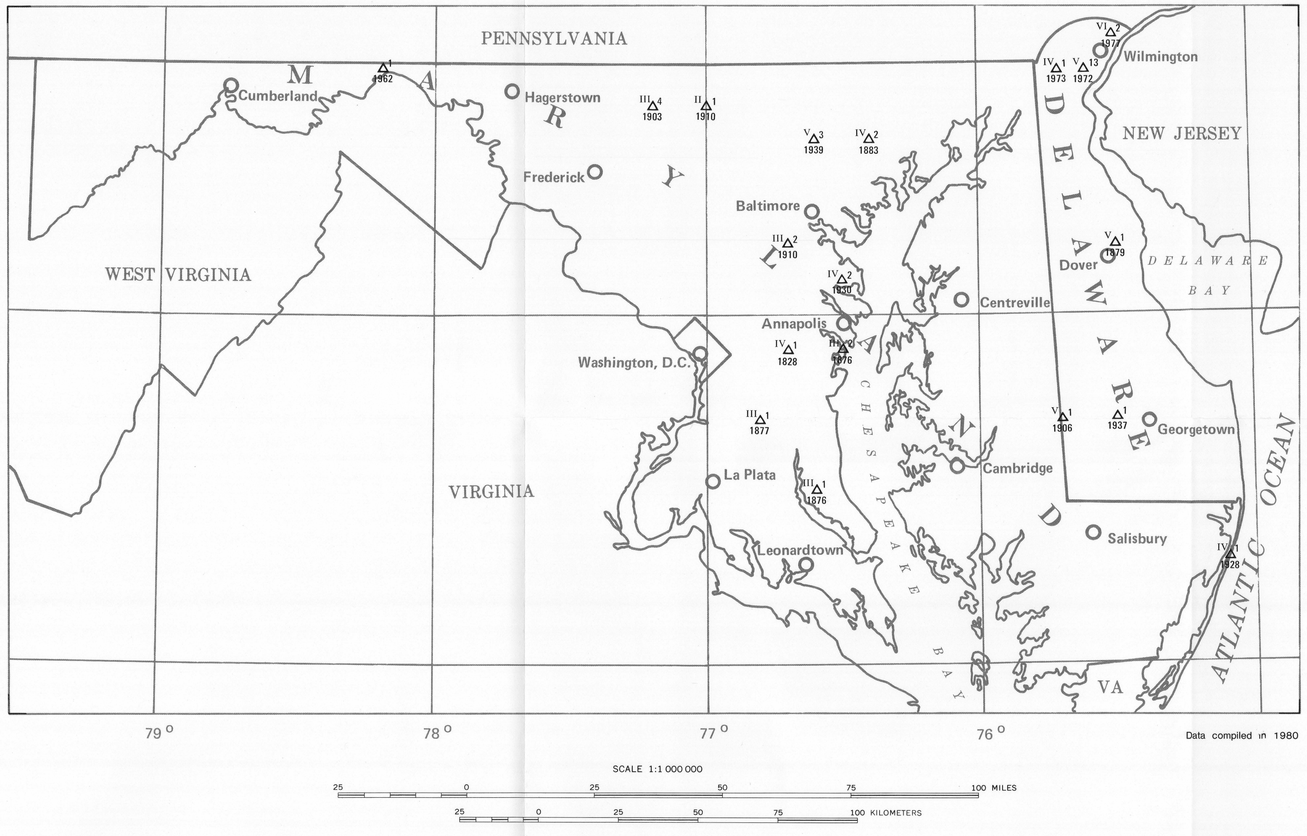
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1281
SEISMICITY, DEL. AND MD.



Data compiled in 1980

INTRODUCTION

The earthquake data shown on this map and listed in tables 1 and 2 are a list of earthquakes that were originally used in preparing the Seismic Risk Studies in the United States (Algermissen, 1969) which have been recompiled and updated through 1977. These data have been reexamined which resulted in some revisions of epicenters and intensities as well as assignment of intensities to earthquakes that previously had none assigned. Intensity values were updated from new and additional data sources that were not available at the time of original compilation. Some epicenters were relocated on the basis of new information. The data shown in tables 1 and 2 are estimates of the most accurate epicenter, magnitude, and intensity of each earthquake, on the basis of historical and current information. Some of the aftershocks from large earthquakes are listed but are incomplete in many instances, especially for ones that occurred before seismic instruments were in universal usage.

The data in tables 1 and 2 were used to compile the seismicity map. The latitude and longitude were rounded to the nearest tenth of a degree and sorted so that all identical locations were grouped together and counted. A triangle represents the epicenter plotted to a tenth of a degree. The number of earthquakes at each location is shown on the map by the number to the right of the triangle. A Roman numeral to the left of a triangle is the maximum Modified Mercalli intensity (Wood and Neumann, 1931) of all earthquakes located at that geographic position. The absence of an intensity value indicates that no intensities have been assigned to earthquakes at that location. A year shown below a triangle is the latest year for which the maximum intensity was recorded.

EXPLANATION OF THE TABLES

The data are listed chronologically in tables 1 and 2 in the following categories: date, origin time, N. latitude, W. longitude, depth, hypocenter quality and referenced data sources, magnitude, and intensity (Modified Mercalli) and intensity source references. Tables 1 and 2 have some basic limitations in terms of the size (magnitude or intensity) of the earthquakes listed. Prior to 1965 all recorded felt earthquakes are listed, after 1965 only felt earthquakes or those with magnitudes above the 2.5-3.0 range are listed; the lower magnitude levels apply mostly to the eastern United States. If no magnitude was computed and the earthquake was felt it was included in the earthquake list. The low magnitude events located in recent years with dense seismograph networks have not been included.

Listed below is an explanation of the symbols and codes used in the tables:

1. Leaders (..) indicate information not available.
2. Latitude and longitude are listed to a hundredth of a degree if they have been published with that degree of accuracy, or greater; however, most historical events have been published only to the nearest degree or tenth of a degree and are therefore listed at this accuracy in table 1. An asterisk (*) to the right of the longitude indicates that the latitude and longitude were not given in the source reference, but were assigned by the compilers of the data file. An (x) to the right of the longitude indicates that the event is an explosion, a suspected explosion, rockburst, or a nontectonic event; these have not been plotted on the map.
3. The letter code in the HYPOCENTER, QUAL column is defined below:
   a. Determination of instrumental hypocenters are estimated to be accurate within the ranges of latitude and longitude listed below; each range is letter coded as indicated:
      A 0.0°-0.1°
      B 0.1°-0.2°
      C 0.2°-0.5°
      D 0.5°-1.0°
      E 1.0° or larger
   b. Determination of noninstrumental epicenters from felt data are estimated to be accurate within the ranges of latitude and longitude listed below; each range is letter coded as indicated:
      F 0.0°-0.5°
      G 0.5°-1.0°
      H 1.0°-2.0°
      I 2.0° or larger
4. The reference identification numbers in the HYPOCENTER, REF and INTENSITY, REF columns indicate the sources of the hypocenter and intensity. They are listed in numerical order in table 3.
5. The magnitudes listed under "USGS" are mb values (Gutenberg and Richter, 1956) published in the Preliminary Determination of Epicenters (PDE) by the National Earthquake Information Service, U. S. Geological Survey and predecessor organizations. Associated with the magnitude values listed under "OTHER" are the source code and type. Type is defined by 1 = ML (Richter, 1958), 2 = mbLg (Nuttli, 1973), 3 = MS (Bath, 1966), 4 = mb (Gutenberg and Richter, 1956), and 5 = mbLg modified. The source codes are listed below:
   DEL - Delaware Geological Survey, Newark, Delaware.
6. An asterisk (*) in the INTENSITY, MM column indicates that the intensity was assigned by the compiler on the basis of the available data at the time the catalog was compiled.

REFERENCES

Algermissen, S. T., 1969, Seismic risk studies in the United States: Fourth World Conference on Earthquake Engineering, Santiago, Chile, January 13-18, 1969, Proceedings, v. 1, p.14-27.
Bath, Markus, 1966, Earthquake energy and magnitude, in v. 7 of Physics and chemistry of the Earth: Oxford and New York, Pergamon Press, p. 115-165.
Gutenberg, B. and Richter, C. F., 1956, Magnitude and energy of earthquakes: Annali di Geofisica, v. 9, no. 1, p. 1-15.
Nuttli, O. W., 1973, Seismic wave attenuation and magnitude relations for eastern North America: Journal of Geophysical Research, v. 78, no. 5, p. 876-885.
Richter, C. F.,1958, Elementary Seismology: San Francisco, Calif., W. H. Freeman and Co., Inc., 768 p.
Wood, H. O., and Neumann, F., 1931, Modified Mercalli Intensity Scale of 1931: Seismological Society of America Bulletin, v. 21, no. 4, p. 277-283.

Table 1.—Chronological listing of earthquakes for the State of Delaware

DATE			ORIGIN TIME(UTC)			LAT.	LONG.	DEPTH	HYPOCENTER		MAGNITUDE		INTENSITY	
YEAR	MONTH	DAY	H	M	S	(N.)	(W.)	(KM)	QUAL	REF	USGS	OTHER	MM	REF
1879	MAR	26	00	30	..	39.2	75.5	..	H	38	..	.. ..	V*	76
1906	MAY	08	17	41	..	38.7	75.7	..	G	38	..	.. ..	V*	38
1937	DEC	03	..	..	..	38.7	75.5	* ..	H	10	..	.. ..	...	..
1944	JAN	08	..	..	..	39.8	75.5	..	H	17	..	.. ..	V*	17
1971	JUL	14	..	..	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1971	DEC	29	..	..	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1972	JAN	02	07	08	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1972	JAN	03	00	..	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1972	JAN	07	03	45	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1972	JAN	22	06	40	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1972	JAN	23	01	35	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1972	JAN	23	07	22	..	39.7	75.6	* ..	G	207	..	.. ..	IV*	207
1972	FEB	11	00	16	30	39.7	75.6	* ..	G	207	..	.. ..	V*	207
1972	FEB	11	15	30	..	39.7	75.6	* ..	G	207	..	.. ..	...	..
1972	AUG	14	01	09	..	39.7	75.6	* ..	G	206	..	.. ..	IV	206
1972	AUG	14	01	55	..	39.7	75.6	* ..	G	206	..	.. ..	...	..
1973	JUL	10	04	38	02	39.7	75.7	..	G	223	..	.. ..	IV	223
1974	APR	28	14	19	20	39.7	75.6	* ..	G	47	..	.. ..	IV	47
1977	FEB	10	19	14	25	39.8	75.5	..	G	126	..	2.0DEL 2	VI	97

Table 2.—Chronological listing of earthquakes for the State of Maryland

DATE			ORIGIN TIME(UTC)			LAT.	LONG.	DEPTH	HYPOCENTER		MAGNITUDE		INTENSITY	
YEAR	MONTH	DAY	H	M	S	(N.)	(W.)	(KM)	QUAL	REF	USGS	OTHER	MM	REF
1758	APR	25	02	30	..	38.9	76.5	..	H	38	..	.. ..	...	..
1828	FEB	24	..	..	..	38.9	76.7	* ..	H	59	..	.. ..	...	..
1876	JAN	30	02	05	..	38.9	76.5	* ..	G	211	..	.. ..	...	..
1876	APR	10	..	..	..	38.5	76.6	* ..	H	211	..	.. ..	III*	211
1877	SEP	01	16	..	..	38.7	76.8	* ..	H	84	..	.. ..	III*	84
1883	MAR	11	23	57	..	39.5	76.4	..	H	38	..	.. ..	IV*	168
1883	MAR	12	05	..	..	39.5	76.4	..	H	38	..	.. ..	III*	168
1902	MAR	10	05	..	..	39.6	77.2	..	H	84	..	.. ..	III*	84
1902	MAR	11	10	30	..	39.6	77.2	..	H	84	..	.. ..	III*	84
1903	JAN	01	17	30	..	39.6	77.2	..	H	84	..	.. ..	III*	84
1903	JAN	01	22	45	..	39.6	77.2	..	H	84	..	.. ..	II*	84
1906	OCT	13	15	..	..	39.2	76.7	* ..	H	84	..	.. ..	III	84
1910	JAN	24	02	20	..	39.6	77.0	..	H	86	..	.. ..	II	84
1910	APR	24	02	..	..	39.2	76.7	* ..	H	84	..	.. ..	III*	84
1911	APR	08	01	..	..	38.3	75.5	x ..	H	84	..	.. ..	IV	84
1911	APR	08	04	11	..	38.3	75.5	x ..	H	84	..	.. ..	IV	84
1928	OCT	15	..	..	..	38.3	75.1	* ..	G	1	..	.. ..	IV*	1
1930	NOV	01	06	34	..	39.1	76.5	* ..	G	3	..	.. ..	IV	84
1930	NOV	01	07	02	..	39.1	76.5	* ..	G	3	..	.. ..	III*	84
1939	JUN	22	23	10	..	39.5	76.6	* ..	G	12	..	.. ..	III*	12
1939	NOV	18	02	33	..	39.5	76.6	* ..	G	12	..	.. ..	IV*	12
1939	NOV	26	05	20	..	39.5	76.6	* ..	G	12	..	.. ..	V*	12
1962	SEP	04	23	40	..	39.5	77.7	x ..	G	35	..	.. ..	IV	35
1962	SEP	07	14	00	45.9	39.7	78.2	038	C	74	..	.. ..	...	..

MODIFIED MERCALLI INTENSITY SCALE OF 1931

I. Not felt - or, except rarely under especially favorable circumstances. Under certain conditions, at and outside the boundary of the area in which a great shock is felt: sometimes birds, animals, reported uneasy or disturbed; sometimes dizziness or nausea experienced; sometimes trees, structures, liquids, bodies of water, may sway—doors may swing, very slowly.

II. Felt indoors by few, especially on upper floors, or by sensitive, or nervous persons. Also, as in grade I, but often more noticeably: sometimes hanging objects may swing, especially when delicately suspended; sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly; sometimes birds, animals, reported uneasy or disturbed; sometimes dizziness or nausea experienced.

III. Felt indoors by several, motion usually rapid vibration. Sometimes not recognized to be an earthquake at first. Duration estimated in some cases. Vibration like that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away. Hanging objects may swing slightly. Movements may be appreciable on upper levels of tall structures. Rocked standing motor cars slightly.

IV. Felt indoors by many, outdoors by few. Awakened few, especially light sleepers. Frightened no one, unless apprehensive from previous experience. Vibration like that due to passing of heavy or heavily loaded trucks. Sensation like heavy body striking building or falling of heavy objects inside. Rattling of dishes, windows, doors; glassware and crockery clink and clash. Creaking of walls, frame, especially in the upper range of this grade. Hanging objects swung, in numerous instances. Disturbed liquids in open vessels slightly. Rocked standing motor cars noticeably.

V. Felt indoors by practically all, outdoors by many or most: outdoors direction estimated. Awakened many, or most. Frightened few—slight excitement, a few ran outdoors. Buildings trembled throughout. Broke dishes, glassware, to some extent. Cracked windows—in some cases, but not generally. Overturned vases, small or unstable objects, in many instances, with occasional fall. Hanging objects, doors, swing generally or considerably. Knocked pictures against walls, or swung them out of place. Opened, or closed, doors, shutters, abruptly. Pendulum clocks stopped, started or ran fast, or slow. Moved small objects, furnishings, the latter to slight extent. Spilled liquids in small amounts from well-filled open containers. Trees, bushes, shaken slightly.

VI. Felt by all, indoors and outdoors. Frightened many, excitement general, some alarm, many ran outdoors. Awakened all. Persons made to move unsteadily. Trees, bushes, shaken slightly to moderately. Liquid set in strong motion. Small bells rang—church, chapel, school, etc. Damage slight in poorly built buildings. Fall of plaster in small amount. Cracked plaster somewhat, especially fine cracks chimneys in some instances. Broke dishes, glassware, in considerable quantity, also some windows. Fall of knick-knacks, books, pictures. Overturned furniture in many instances. Moved furnishings of moderately heavy kind.

VII. Frightened all—general alarm, all ran outdoors. Some, or many, found it difficult to stand. Noticed by persons driving motor cars. Trees and bushes shaken moderately to strongly. Waves on ponds, lakes, and running water. Water turbid from mud stirred up. Incaving to some extent of sand or gravel stream banks. Rang large church bells, etc. Suspended objects made to quiver. Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Cracked chimneys to considerable extent, walls to some extent. Fall of plaster in considerable to large amount, also some stucco. Broke numerous windows, furniture to some extent. Shook down loosened brickwork and tiles. Broke weak chimneys at the roof-line (sometimes damaging roofs). Fall of cornices from towers and high buildings. Dislodged bricks and stones. Overturned heavy furniture, with damage from breaking. Damage considerable to concrete irrigation ditches.

VIII. Fright general—alarm approaches panic. Disturbed persons driving motor cars. Trees shaken strongly—branches, trunks, broken off, especially palm trees. Ejected sand and mud in small amounts. Changes: temporary, permanent; in flow of springs and wells; dry wells renewed flow; in temperature of spring and well waters. Damage slight in structures (brick) built especially to withstand earthquakes. Considerable in ordinary substantial buildings, partial collapse: racked, tumbled down, wooden houses in some cases; threw out panel walls in frame structures, broke off decayed piling. Fall of walls. Cracked, broke, solid stone walls seriously. Wet ground to some extent, also ground on steep slopes. Twisting, fall, of chimneys, columns, monuments, also factory stacks, towers. Moved conspicuously, overturned, very heavy furniture.

IX. Panic general. Cracked ground conspicuously. Damage considerable in (masonry) structures built especially to withstand earthquakes: Threw out of plumb some wood-frame houses built especially to withstand earthquakes; great in substantial (masonry) buildings, some collapse in large part; or wholly shifted frame buildings off foundations, racked frames; serious to reservoirs; underground pipes sometimes broken.

X. Cracked ground, especially when loose and wet, up to widths of several inches; fissures up to a yard in width ran parallel to canal and stream banks. Landslides considerable from river banks and steep coasts. Shifted sand and mud horizontally on beaches and flat land. Changed level of water in wells. Threw water on banks of canals, lakes, rivers, etc. Damage serious to dams, dikes, embankments. Severe to well-built wooden structures and bridges, some destroyed. Developed dangerous cracks in excellent brick walls. Destroyed most masonry and frame structures, also their foundations. Bent railroad rails slightly. Tore apart, or crushed endwise, pipe lines buried in earth. Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI. Disturbances in ground many and widespread, varying with ground material. Broad fissures, earth slumps, and land slips in soft, wet ground. Ejected water in large amounts charged with sand and mud. Caused sea-waves ("tidal" waves) of significant magnitude. Damage severe to wood-frame structures, especially near shock centers. Great to dams, dikes, embankments often for long distances. Few, if any (masonry) structures remained standing. Destroyed large well-built bridges by the wrecking of supporting piers, or pillars. Affected yielding wooden bridges less. Bent railroad rails greatly, and thrust them endwise. Put pipe lines buried in earth completely out of service.

XII. Damage total—practically all works of construction damaged greatly or destroyed. Disturbances in ground great and varied, numerous shearing cracks. Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive. Wrenched loose, tore off, large rock masses. Fault slips in firm rock, with notable horizontal and vertical offset displacements. Water channels, surface and underground, disturbed and modified greatly. Dammed lakes, produced waterfalls, deflected rivers, etc. Waves seen on ground surfaces (actually seen, probably, in some cases). Distorted lines of sight and level. Threw objects upward into the air.

Table 3.—List of data sources

1. Heck, N. H. and Bodle, R. R., 1930, United States Earthquakes 1928, U. S. Coast and Geodetic Survey, Serial No. 483, p. 1-28.
3. Neumann, F. and Bodle, R. R., 1932, United States Earthquakes 1930, U. S. Coast and Geodetic Survey, Serial No. 539, p. 1-25.
10. Neumann, F., 1940, United States Earthquakes 1937, U. S. Coast and Geodetic Survey, Serial No. 619, p. 1-55.
12. Bodle, R. R., 1941, United States Earthquakes 1939, U. S. Coast and Geodetic Survey, Serial No. 637, p. 1-69.
17. Bodle, R. R., 1946, United States Earthquakes 1944, U. S. Coast and Geodetic Survey, Serial No. 682, p. 1-43.
35. Lander, J. F. and Cloud, W. K., 1964, United States Earthquakes 1962, U. S. Coast and Geodetic Survey, p. 1-114.
38. Coffman, J. L. and von Hake, C. A., 1973, Earthquake History of the United States, National Oceanic and Atmospheric Administration, No. 41-1(through 1970), p. 1-208.
47. Coffman, J. L. and Stover, C. W., 1976, United States Earthquakes 1974, National Oceanic and Atmospheric Administration and U. S. Geological Survey, p. 1-135.
59. Brigham, W. T., 1871, Historical notes on the earthquakes of New England, 1638-1869: Mem. Boston Society of Natural History, v. 2, p. 1-28.
74. U. S. Geological Survey, Preliminary Determination of Epicenters, Monthly Listing and associated Earthquake Data Report, April 1966 to December 1977 (formerly by U. S. Coast and Geodetic Survey, Environmental Science Services Administration, and National Oceanic and Atmospheric Administration).
76. Smith, W. E. T., 1962, Earthquakes of eastern Canada and adjacent areas, 1534-1927, Publications of the Dominion Observatory Ottawa, v. 26, no.5, p. 271-301.
84. Woollard, G. P., 1968, A catalogue of earthquakes in the United States prior to 1925 based on unpublished data compiled by Harry Fielding Reid and unpublished sources prior to 1930, Hawaii Institute of Geophysics, University of Hawaii, Data Report No. 10.
86. Bollinger, G. A., 1975, A catalogue of southeastern United States earthquakes 1754 through 1974, Department of Geological Science, Virginia Polytechnic Institute and State University, Research Bulletin 101, p. 1-68.
97. Simon, R. B., Stover, C. W., and Reagor, B. G., 1979, Earthquakes in the United States, January-March 1977, U. S. Geological Survey Circular 788-A, p. 1-31.
126. Chiburis, E. F., 1979, Seismicity, recurrence rates, and the regionalization of the northeast United States and adjacent areas, Weston Observatory Report (unpublished).
168. Rockwood, C. G., 1884, Notes on American earthquakes, no. 13, American Journal of Science, v. 27, 3rd series, p. 358-364.
206. Woodruff, K. D., Jordan, R. R., and Pickett, T. E., 1973, Preliminary report of the earthquake of February 28, 1973, Delaware Geological Survey, Open-File Report, p 1-16.
207. Jordan, R. R., Pickett, T. E., and Woodruff, K. D., 1972, Preliminary Report of Seismic events in northern Delaware, Delaware Geological Survey, Open-File report, p 1-15
211. Rockwood, C. G., 1876, Notices of recent American earthquakes-no. 6, American Journal of Science, v. 112, third series, p. 25-30.
223. Delaware Geological Survey, 1973, Preliminary notes on earthquake of July 10, 1973, Information release by the Delaware Geological Survey, July 10, 1973.

SEISMICITY MAP OF THE STATES OF DELAWARE AND MARYLAND

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