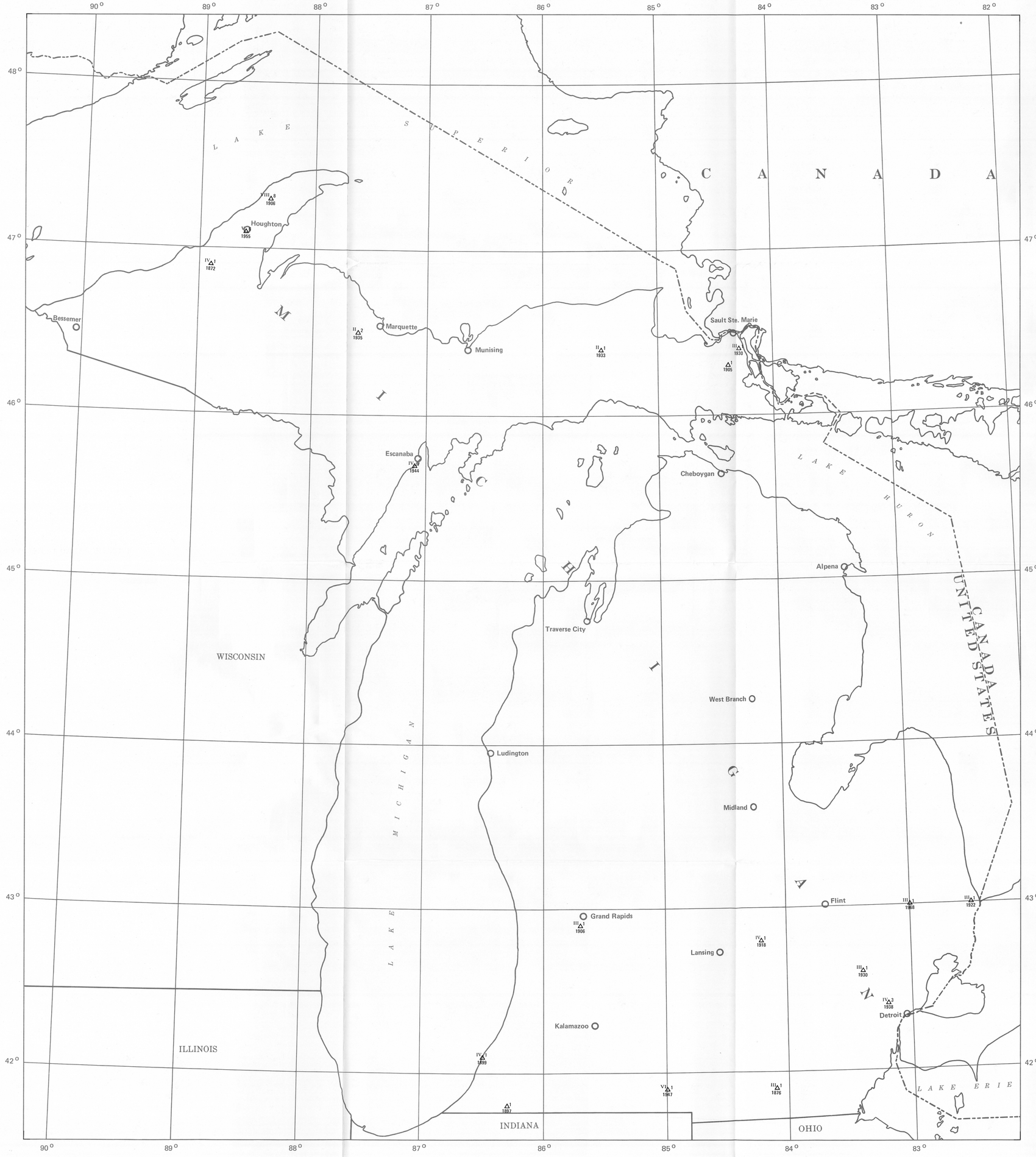
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1228
SEISMICITY, MICHIGAN



SCALE 1:1 000 000

25 0 25 50 75 100 MILES

25 0 25 50 75 100 KILOMETERS

SEISMICITY MAP OF THE STATE OF MICHIGAN

By

C. W. Stover, B. G. Reagor, and S. T. Algermissen

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INTRODUCTION

The earthquake data shown on this map and listed in table 1 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 table 1 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 table 1 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 table 1 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. Table 1 has some basic limitations in the accuracy of the latitude 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. Many earthquakes have occurred in the northern Great Lakes area for no magnitude was computed and the earthquake was felt it is included in the earthquake list. 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. Time, depth, and latitude 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 tenth of a degree. Longitude is listed to the nearest tenth of a degree.
3. 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 (a) 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.
4. The letter code in the HYPOCENTRY, 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 HYPOCENTRY, REF and INTENSITY, REF columns indicate the sources of the hypocenter and intensity. They are listed in numerical order in table 2.
5. The magnitudes listed under "MAGN" 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 "MAGN TYPE" are the following codes: 1 = mb (Gutenberg and Richter, 1956); 2 = mbLg (Nuttli, 1973); 3 = ML (Richter, 1966); 4 = mb (Gutenberg and Richter, 1956), and 5 = mbLg modified. No magnitudes were published for earthquakes in Michigan.
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.

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Table 1.—Chronological listing of Earthquakes for the State of Michigan

DATE YEAR	MONTH	DAY	ORIGIN TIME(UTC) H	M	S	LAT. (N.)	LONG. (W.)	DEPTH (KM)	HYPOCENTER QUAL	HYPOCENTER REF	MAGNITUDE MAGN	MAGN TYPE	MAGN OTHER	INTENSITY MM	INTENSITY REF
1872	FEB	06	14	00	..	46.6	88.0	..	G	105	..	..	..	IV	105
1875	FEB	27	..	..	..	45.9	84.1	..	H	105	..	..	..	III	105
1876	FEB	27	..	..	..	42.4	83.2	..	H	105	..	..	..	III	105
1877	AUG	17	16	50	..	42.4	83.2	..	G	105	..	..	..	IV	105
1897	OCT	31	..	..	..	41.8	86.3	..	G	116	..	..	..	..	..
1899	OCT	11	02	06	..	42.1	84.5	..	G	105	..	..	..	IV	105
1905	JUN	04	..	..	..	46.1	84.4	..	H	105	..	..	..	..	..
1905	JUL	27	00	20	..	47.3	88.4	..	G	38	..	..	..	VII*	38
1905	JUL	27	02	24	..	47.3	88.4	..	G	105	..	..	..	..	..
1906	FEB	09	..	..	..	47.1	88.6	x ..	G	105	..	..	..	..	..
1906	FEB	09	..	..	..	47.1	88.6	x ..	G	105	..	..	..	..	..
1906	MAY	19	09	26	..	42.9	85.7	..	G	105	..	..	..	III*	105
1906	MAY	25	13	16	..	47.1	88.6	..	G	105	..	..	..	..	..
1906	MAY	26	14	30	..	47.3	88.4	..	G	38	..	..	..	VII	38
1906	AUG	08	..	..	..	47.3	88.4	..	G	116	..	..	..	IV*	130
1906	NOV	09	..	..	..	47.3	88.4	..	G	105	..	..	..	..	..
1909	JAN	23	03	15	..	47.1	88.6	..	G	105	..	..	..	V	38
1909	JAN	23	03	41	..	47.1	88.6	..	G	105	..	..	..	..	..
1909	JAN	23	07	02	..	47.3	88.4	..	G	105	..	..	..	..	..
1909	JAN	24	07	49	..	47.3	88.4	..	G	105	..	..	..	III	116
1915	OCT	04	14	02	..	47.1	88.6	..	G	105	..	..	..	IV	105
1918	FEB	22	..	..	..	42.8	84.2	..	H	105	..	..	..	IV	105
1918	OCT	01	07	30	..	47.5	88.9	..	G	105	..	..	..	III	105
1922	MAR	16	09	36	..	43.0	82.5	..	G	105	..	..	..	III	105
1930	JAN	24	03	45	..	46.4	86.0	..	G	105	..	..	..	III	105
1930	NOV	20	..	..	..	42.6	83.4	..	G	77	..	..	..	III	77
1931	JAN	29	..	..	..	46.4	85.5	..	G	105	..	..	..	..	..
1934	APR	07	03	15	..	46.4	87.6	..	F	73	..	..	..	..	..
1934	OCT	17	15	..	..	46.5	87.6	..	G	105	..	..	..	II*	8
1935	OCT	31	04	30	..	46.5	87.6	..	G	8	..	..	..	II	8
1938	MAR	13	16	18	..	42.4	83.2	..	G	105	..	..	..	IV	105
1939	AUG	01	..	..	..	45.7	87.1	..	G	105	..	..	..	III*	105
1939	NOV	07	10	00	..	45.7	87.1	..	G	105	..	..	..	III	105
1944	NOV	16	18	45	..	45.7	87.1	..	G	105	..	..	..	III*	17
1944	DEC	10	11	00	..	45.7	87.1	..	G	105	..	..	..	IV	105
1944	DEC	18	14	26	..	45.7	87.1	..	G	105	..	..	..	II	105
1947	AUG	10	01	44	41.3	41.93	85.00	002	A	201	..	..	..	VI	30
1955	JAN	05	20	32	..	47.3	88.4	..	G	105	..	..	..	IV	28
1955	JAN	13	03	56	01	45.1	89.0	033	A	105	..	..	..	V	28
1964	OCT	10	08	30	00.3	47.4	89.8	x 000	C	74	..	..	..	..	..
1964	OCT	10	08	30	00.3	47.4	89.8	x 000	C	74	..	..	..	..	..
1966	JUL	07	13	00	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	08	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	08	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	09	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	09	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	10	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	10	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	11	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	11	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	12	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	12	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	13	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	13	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	14	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	14	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	15	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	15	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	18	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	18	10	00	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	19	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	19	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	20	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	20	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	21	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	21	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	22	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	22	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	23	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	23	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	24	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	24	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	25	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	25	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	26	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	27	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	27	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	28	08	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1966	JUL	28	09	30	00.0	47.5	88.9	x 000	B	74	..	..	..	..	..
1967	FEB	02	06	30	..	42.7	84.6	x ..	G	105	..	..	..	IV	40
1968	OCT	31	..	..	..	43.0	83.0	..	G	120	..	..	..	III	116

Table 2.—List of data sources

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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 few, 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 swing, 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, frightened few, impelled many to run 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. Fell 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. Fell of brick from chimneys, factory stacks, monuments, towers, elevated tanks 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 (some-less damaging roofs). Fell 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 pale trees. Ejected sand and mud in small amounts. Changes: temporary, permanents 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.