Circular 14

SEISMIC DISTURBANCES IN MICHIGAN

by

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Abstract

Reports of earthquakes in what is now the state of Michigan were documented as early as 1638. Tremors from earthquakes centered in adjacent regions are many times felt in Michigan but only 34 with epicenters actually located in this state have been recorded from 1872 to 1967. Most are believed associated with slippage along deep-seated faults and a few are related to man's activities. According to a seismic probability map prepared by the U.S. Coast and Geodetic Survey, Michigan lies in a region of low risk for earthquake occurrence. Though there appears to be no indication of active faults in Michigan, at relatively shallow depths and that extend to the surface, information on the seismicity of a local or regional area is pertinent in the selection of building sites and the proper design and construction of such installations as nuclear power plants, nuclear waste disposal and storage facilities, dams and many other types of installations. Attention should also be given to areas of karst development, abandoned mines, and solution-mining sites, active or abandoned.

Introduction

Reports of earthquakes in what is now the state of Michigan were documented as early as 1638 by French Jesuit missionaries (Hobbs, 1911). The earliest, well-recorded history of earthquake tremors felt in the Michigan Territory resulted from the great earthquakes centered in the lower Mississippi Valley near New Madrid, Missouri in 1811and 1812. As many as nine tremors from the New Madrid earthquake series were felt in the Detroit region (von Hake, 1973). At Orchard Lake, Michigan, it was reported that on December 17, 1811 "the Indians said the waters of the lake began to boil, bubble, foam and roll about as though they had been in a large kettle over a hot fire, and that in a few minutes up came great numbers of turtles and hurried to the shore, upon which they had a great turtle feast" (Hobbs, 1911). As late as February, 1976, several tremors of low intensity were again felt in the Detroit area, the epicenter or focal point of origin being unofficially located in northern Ohio.

Most people normally associate the term "earthquake" with seismic disturbances that arise from natural rather than artificial causes. Actually the term applies to any earth movement caused by a momentary disturbance of the elastic equilibrium of a portion of the earth, whatever the source of the disturbance may be. Used in this sense, some earth movements derived from man-related activities such as mining or excavating projects, geophysical exploration or research, may be considered to be earthquakes.

It is important that information on naturally occurring and man-made seismic events be made available for general public distribution and use. Information on the seismicity of a local or regional area is pertinent in the selection of building sites and the proper design and construction of such projects as nuclear power plants, nuclear waste disposal or storage facilities, dams and many other types of construction.

Because most earthquakes are related to movement of parts of the earth's crust along active fault zones, the location and extent of these fracture zones is important. Also of prime importance is the intensity of shock and probable resulting damage caused by an earthquake in a given locale. Not all seismic events are related to active faults; some are related to rock falls in underground mines, and others may be associated with man-made explosions.

This circular summarizes available information related to naturally occurring and man-related seismic events in Michigan. Tremors from earthquakes centered in adjacent regions are many times felt in Michigan, but only 34 earthquakes with epicenters actually located in this state have been recorded from 1872 to 1967. This includes 30 fault-slippage seismic events and 4 earthquakes due, in part, to mining operations.

Earthquakes Related to Faulting

Some fault zones in the Precambrian rock outcrop region of Michigan's western Upper Peninsula have been mapped where they are observed at the land surface or where they are intersected by mine shafts. Less is known about fault traces in the Paleozoic sedimentary rocks of the eastern Upper Peninsula and the Lower Peninsula of the state.

Figure 1. Approximate locations of Michigan earthquake epicenters

In these latter two regions, the bedrock is covered by a mantle of glacial deposits which obscures any surface evidence of faulting. In these areas fault zones are considered to be stable, most movement having occurred in the distant geologic past. It is thought that the 30 fault slippage earthquakes in Michigan's recorded seismic history had energy source depths ranging from 95 to 110 kilometers in the subsurface, and that this seismic activity did not involve faulting of the overlying Paleozoic sediments (Personal communication: G. D. Ells).

An historical record of earthquakes with epicenters in Michigan is shown on Table 1. The accompanying map (Figure 1) shows the approximate locations of these epicenters. Numbers shown near the location spots correspond to the events listed in Table 1. According to a seismic probability map prepared by the U.S. Coast and Geodetic Survey (Figure 2), Michigan lies in a region of low risk for earthquake occurrence. Shocks are characterized by intensities from I to VI on the Modified Mercalli Scale (Table 2). The nearest areas of severe earthquake damage potential are southern Illinois, southwestern Indiana, and upstate New York. Earthquakes with epicenters in these districts may be felt in Michigan.

Approximate Epicenter		Calculated Epicenter		Date of Seismic Disturbance	Intensity Modified Mercalli Scale
Map No.	Location	Latitude North	Longitude West		
1.	Wenona	43°40'	83°54'	February 6, 1872	IV
2.	Adrian	41°53'	84°03'	January 27, 1876	----
3.	Detroit	42°22' 42°22' 42°22'	83°10' 83°10' 83°10'	February 27, 1876 August 17, 1877 March 13, 1938	---- IV IV
4.	Southern Michigan	42.3°	85.6°	February 4, 1883	VI
5.	Niles	41°50'	86°16'	October 31, 1897	----
6.	St. Joseph	42°05'	86°31 '	October 10, 1899	IV
7.	Menominee	45°05' 45°08'	87°40' 87°40'	March 13, 1905 January 10, 1907	V
8.	Sault Ste. Marie	46°19' 46°29'	84°22' 84°24'	April 4, 1905 January 23, 1930	---- III
9.	Calumet	47°16' 47°16' 47°16' 47°16'	88°25' 88°25' 88°25' 88°25'	July 26, 1950 March 3, 1915 October 1, 1918 January 5, 1955	VII-VIII IV-V III IV
10.	Houghton	47°07' 47°07'	88°33' 88°33'	February 9, 1906 January 22-23, 1909	---- V
11.	Hancock	47°08' 47°08'	88°37' 88°37'	April 20, 1906 January 6, 1955	---- V
12.	Grand Rapids	42°57'	85°41'	May 19, 1906	----
13.	Keweenaw Peninsula	47.3°	88.4°	May 26, 1906	VIII
14.	Morrice	42°51'	84°11’	February 22, 1918	IV
15.	Port Huron	42°58'	82°28'	March 16, 1922	III
16.	Newberry	46°22’	85°31'	January 29, 1933	II
17.	Negaunee	46°30'	87°37'	October, 1935	II-III
18.	Escanaba	45°44’ 45°44’ 45°44’ 45°44’ 45°44’ 45°44’	87°05' 87°05' 87°05' 87°05' 87°05' 87°05'	July 18, 1939 August 1, 1939 February 15, 1943 November 16, 1944 December 10, 1944 May 18, 1945	II-III II-III ---- II-IV II-IV II
19.	South Central Michigan	42°00'	85°00'	August 9, 1947	VI
20.	Lansing	42°45’	84°35'	February 2, 1967	IV

Table 1. Recorded Seismic Disturbances with Epicenters in Michigan*

*Source: U.S. Dep't of Comm., N.O.A.A., Environmental Data Service and J. Docekal, 1970 (See references)

Damage from earthquakes in Michigan is generally limited to broken dishes, cracked plaster, and damaged chimneys, although two earthquakes with intensities of VIII on the Modified Mercalli Scale have been recorded. These two events are dealt with in more detail in the section of this report headed "Seismic Disturbances Related to Man's Activities."

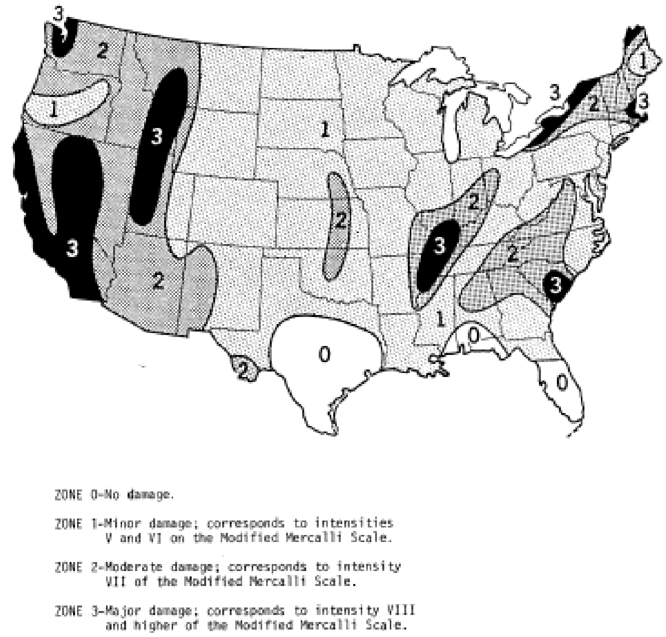

Figure 2. Seismic risk map (Source: U.S. Coast and Geodetic Survey)

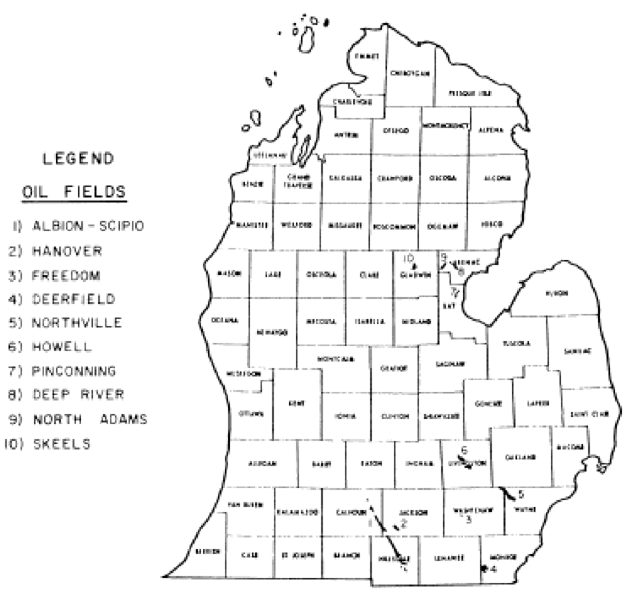

Figure 3. Fault related oil and gas fields

In areas where the bedrock is masked by glacial deposits, geological evidence for the existence of faults, such as brecciated zones or abnormalities in the depths to certain formations, is occasionally encountered during the drilling of oil and gas test wells. Since the well bore examines an area only a few inches in diameter, the full extent of these faults must be hypothesized from well bores along inferred structural trends. The major structural fabric in Michigan trends roughly northwest-southeast with minor trends at approximately right angles to this.

Several Michigan oil and gas fields are thought to result from the entrapment of hydrocarbons along healed and inactive fault zones in Paleozoic age rocks. The narrow, linear shape of many of these fields is sometimes cited as evidence that they are related to subsurface faulting. Some oil and gas fields included in this class are Albion-Scipio, Hanover, Northville, Howell, Pinconning, Deep River, North Adams, Skeels, Freedom, and Deerfield (Figure 3).

I. Not felt except rarely under especially favorable circumstances.

II. Felt indoors by some individuals, especially those on upper floors of buildings. Suspended objects may swing.

III. Felt indoors by many. Duration of tremor may be estimated. Standing vehicles rock slightly.

IV. Felt indoors by many, outdoors by some individuals. Some sleepers awakened at night. Dishes, windows, and doors rattled. Standing vehicles rock noticeably.

V. Felt by almost everyone. Dishes and windows broken. Small objects moved or overturned. Trees shaken slightly.

VI. Felt by everyone. Some cracked and fallen plaster noted. Heavy furniture moved.

VII. Everyone frightened. Some people find it difficult to stand. Noticed by people in moving vehicles. Trees shaken strongly. Waves seen on bodies of water. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built structures.

VIII. Damage slight in specially designed structures; considerable in ordinary buildings. Chimneys, factory smoke stacks, walls, and monuments fall. Heavy furniture overturned. Change noted in flow and temperature of water wells.

IX. Considerable damage to all structures. Ground cracked. Pipes broken.

X. Some wooden structures destroyed; most masonry buildings destroyed. Ground badly cracked. Rails bent.

XI. Few buildings remain standing. Bridges destroyed. Broad cracks in ground. Earth slumping occurs.

XIII. Damage total. Waves seen on ground surfaces. Lines of sight distorted. Objects thrown into air.

Table 2. Modified Mercalli Intensity Scale (Condensed)

Seismic Events Associated with Karst Regions

Several areas in Michigan show evidence of solution of the bedrock by groundwater activity. Sinkholes (Poindexter, 1935), disappearing streams, and intermittent lakes (Sherzer, 1900) have been noted in Schoolcraft, Mackinac, Presque Isle, Alpena, Montmorency, Otsego, Iosco, Cheboygan and Monroe counties. Regions of karst development where sinkholes, disappearing streams and other karst features are known are shown in Figure 4.

Sinkholes in the various counties range in size from conical holes that average 15 feet in diameter and 10 feet deep to much larger depressions. Sinkholes in Presque Isle and Alpena counties are the most spectacular, in some cases reaching depths of almost 150 feet (Poindexter, 1935). It has been theorized that coral reef development may have had an influence on the distribution and shape of the sinkholes in the areas underlain by the Traverse Group rocks (Cheboygan, Otsego, Montmorency, Presque Isle and Alpena counties). The purity of reef carbonates makes them more favorable to solution than the surrounding rocks, and the roughly dome-like shape of the reefs may account for the circular outline of the sinkholes (Poindexter, 1935).

Sinkholes form as a result of the dissolving of carbonate rocks by groundwater action. Overlying rock layers may subsequently collapse into the caves thus formed. If the collapse zone reaches the land surface, the result is a steep-walled sinkhole. Sudden collapse of the materials overlying subsurface caverns may cause slight, local earth tremors which may be reported as earthquakes.

Seismic Disturbances Related to Man's Activities

In the Upper Peninsula throughout 1905 and 1906, earthquakes were felt in the Keweenaw Peninsula copper mining district. During the evening of July 26, 1905, an earthquake occurred near Calumet which has an intensity of VIII on the Modified Mercalli Scale (Docekal, 1970). Chimneys were toppled and plate glass windows were broken in Calumet, and the shocks from the earthquake were sensed as far north as Copper Harbor (50 kilometers) and as far east as Marquette (105 kilometers) (Hobbs, 1911). It is thought that if the mining operations were not directly responsible for the earthquake, they at least facilitated rock slippage by creating avenues of weakness in the rocks of the subsurface. In May, 1906, similar shocks occurred just south of Houghton near the Atlantic Mine. Here, almost directly above the lode of the mine, railroad tracks were severely deformed and caving occurred at the ground surface. Two other earthquakes were also experienced during 1906 in this mining region. Lesser amounts of surface subsidence have also been noted in Michigan's western Upper Peninsula iron mining districts in areas overlying old mine shafts.

In the Lower Peninsula, subsidence has occurred in association with several types of mineral extraction activities. Settling over abandoned coal mine shafts was noted in the Saginaw-Bay City area (Lane, 1906). Subsidence has also been observed over shallow-depth gypsum mines near Grand Rapids. In more recent times, subsidence amounting to as much as 130 feet has occurred over salt caverns resulting from solution mining activities in the Detroit area (Personal communication, R. E. Ives). A similar phenomenon was reported for the Manistee area as early as 1906 by Lane. Broken water mains and land subsidence were noted and thought to be associated with salt-extraction activities. As in the case of sinkholes, unless subsidence of these types is rapid, shocks may not be detected.

Momentary, low intensity shocks may also be caused by geophysical exploration for hydrocarbon traps. Conventional seismic surveys employ the detonation of explosives to send sound waves into the subsurface rocks. Reflected signals give clues as to the subsurface structure in the area near the explosion. Shocks from such explosions may be felt as mild, local tremors. These blasts do not cause faults in the rocks underlying the shot-holes. Shocks from seismic surveys probably do not rate Scale I on the Mercalli Intensity Scale. Seismic surveys employing explosives are widely used throughout the Lower Peninsula and are a popular method for finding Silurian age oil-and-gas bearing reefs.

Figure 4. Location of karst features

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