7.1.5.

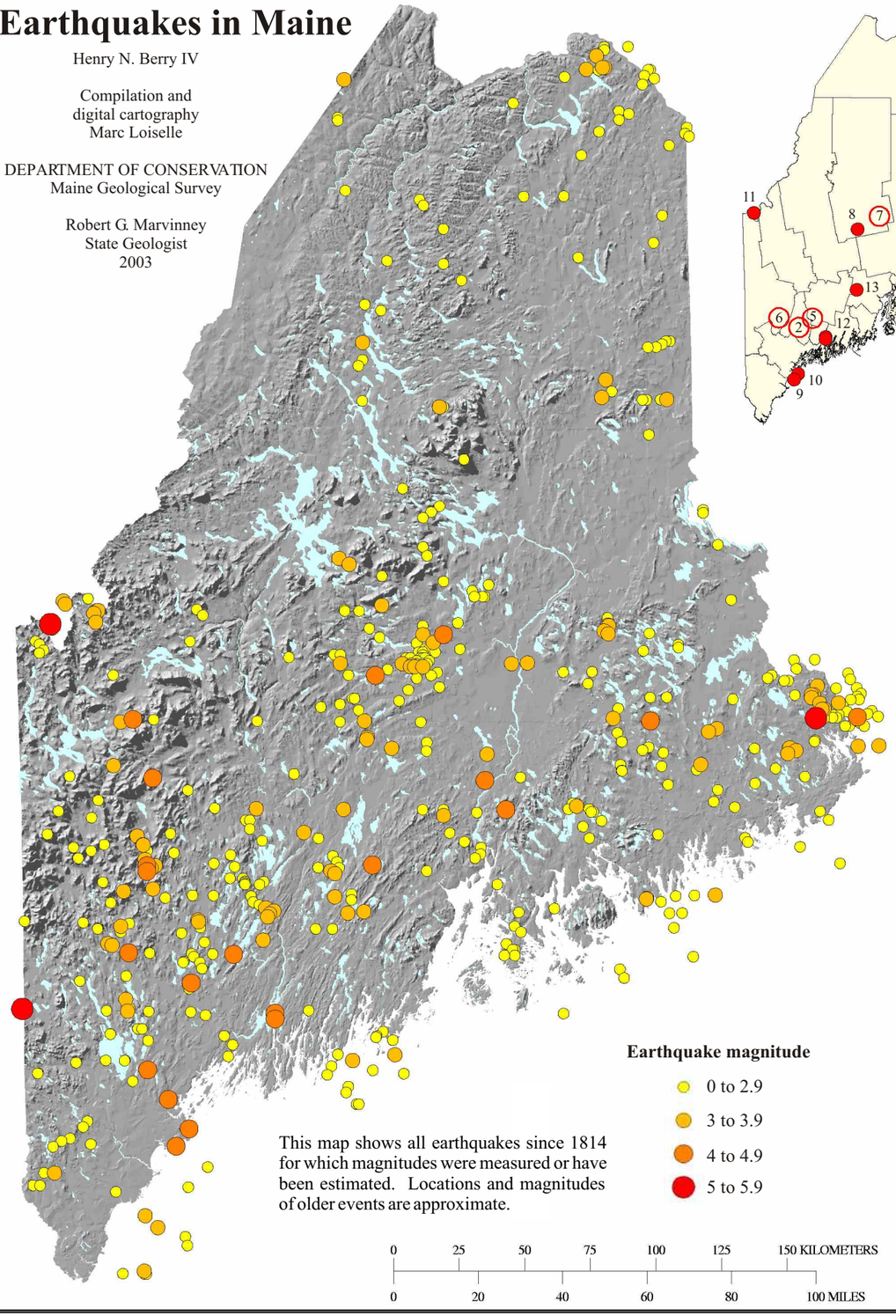
Earthquakes in Maine

Henry N. Berry IV

Compilation and
digital cartography
Marc Loiselle

DEPARTMENT OF CONSERVATION
Maine Geological Survey

Robert G. Marvinney
State Geologist
2003



Notable Events in Maine

	Year	Size*	Location†
1.	1817	VI	Passamaquoddy Bay
2.	1857	VI	Lewiston
3.	1869	VI	Passamaquoddy Bay
4.	1904	VII	Eastport area
5.	1905	VI	Sabbatus
6.	1918	VI	Norway
7.	1928	VI	Milo
8.	1943	4.2	Dover-Foxcroft
9.	1957	4.2	Portland
10.	1958	4.0	Cape Elizabeth
11.	1973	4.8	Bowmantown Twp.
12.	1979	4.0	Bath
13.	1988	4.0	Albion

* Maximum intensity before 1940, magnitude after 1940.
† Locations of earlier events are uncertain.

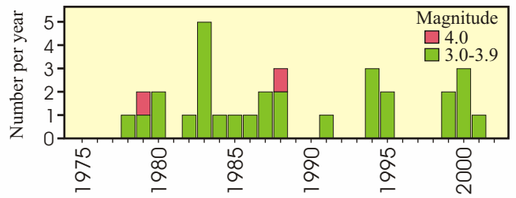
I. Maine's earthquake history

Maine does not have many earthquakes compared with geologically active areas, and the ones we have are mostly small. But Maine does have earthquakes. There is a history of continual, low-level activity in the state, with larger ones every once in a while. Hundreds of earthquakes are recorded since 1766, and many more went unrecorded before modern instruments were installed in 1975. The large map to the left shows that most earthquakes since 1814 have been small, many too small to be felt. The pattern is widely scattered, though some regions - easternmost Maine, central Maine, and southwestern Maine - have had somewhat more than other areas. The significance of these diffuse regional clusters remains a mystery.

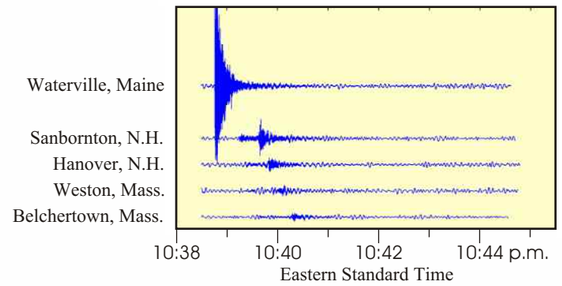
The largest Maine earthquake, felt across New England and southeastern Canada in 1904, was centered in the Eastport area where it toppled some chimneys and caused minor damage to buildings. Several other events since the early 1800's have rattled dishes, broken windows, and caused minor damage, especially to brittle materials like mortar, plaster, and unreinforced concrete.

Smaller earthquakes are much more frequent than larger ones. Since 1975, Maine has had about one magnitude 3.0-3.9 earthquake every year, and a magnitude 4 earthquake every 10 to 15 years or so. They occur randomly, with five in some years and none in others, so average frequencies are not very helpful in predicting how many will occur in a particular year. Larger earthquakes are even less frequent, and therefore even less predictable. By one statistical calculation, Maine could get a magnitude 6 earthquake every 300-400 years. Such long time spans make it impossible to understand these larger earthquakes.

Magnitude 3 or Larger Earthquakes in Maine, 1975-2002



Seismic Records from the Magnitude 3.6 Earthquake, Winslow, Maine. February 25, 1999, 10:38:43 p.m.

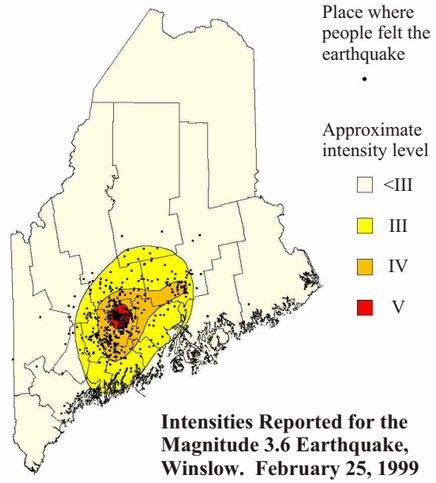


The motion measured by seismic instruments is greater and begins earlier at stations closer to the epicenter.

II. What happens during an earthquake?

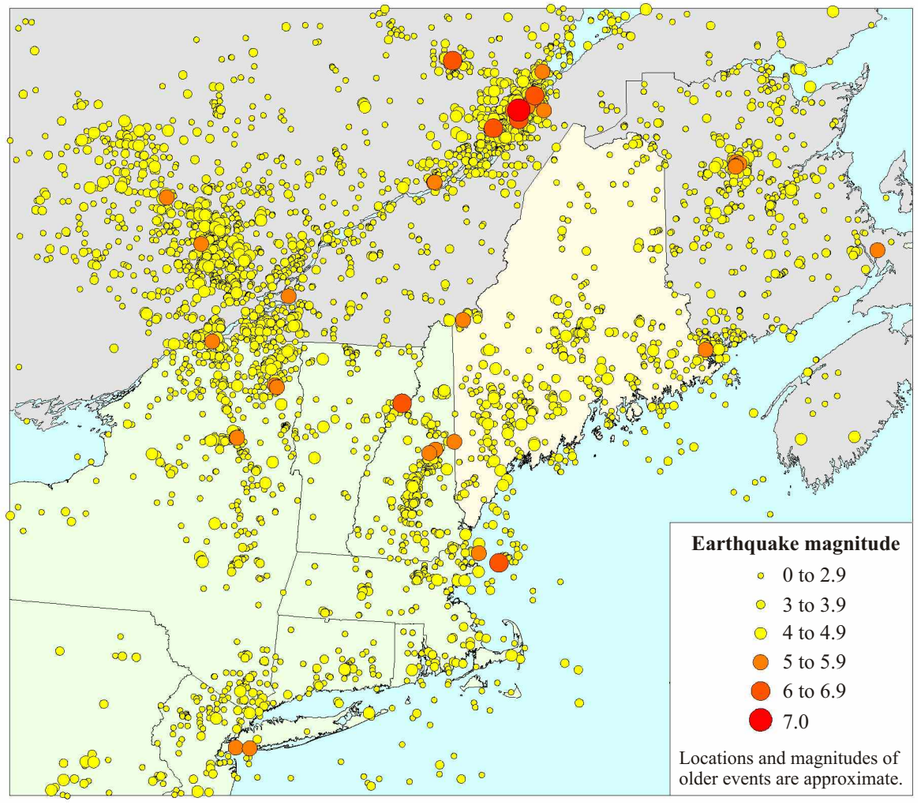
An earthquake is a complex set of ground motions caused by sudden dislocation of rock in the earth's crust. A variety of *seismic waves* travel out in all directions through the surrounding rock. From the motions recorded by instruments at seismic monitoring stations, seismologists can calculate the *magnitude*, or amount of energy released at the center of an earthquake. The magnitude scale is logarithmic, so each whole number increase represents ten times the ground motion, and about 30 times the energy. Thus a magnitude 5 event is 30 times more powerful than a magnitude 4, and a magnitude 6 is nearly a thousand times more powerful than a 4. Earthquakes below about 2.5 are usually not felt; minor damage to buildings starts to occur about magnitude 5.

A more meaningful way to measure earthquake size is by an *intensity* scale, which describes the effect of earthquake motion. In general, the intensity is greatest directly above the earthquake source, at the *epicenter*, and decreases farther away. But intensity is influenced by many factors. More rigid geologic materials, such as solid bedrock, vibrate rapidly and transmit seismic waves with relatively little shaking. Softer materials, such as wet mud, actually amplify seismic waves and shake more violently. Upper floors of buildings can shake more than lower floors. Certain types of structures, such as brick and concrete, are more brittle and crack more easily than wood or metal frame buildings.



Intensities Reported for the Magnitude 3.6 Earthquake, Winslow. February 25, 1999

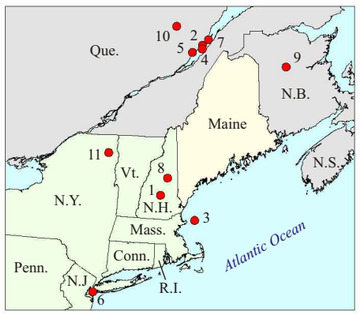
The intensity scale is assigned Roman numerals. At low intensities (I and II), the gentle rolling or swaying motions are ignored by most people. The map at left shows relatively few reports outside the intensity III zone. Intensities III and IV are widely felt, though loud noises, rumbles, and booms are as noticeable as the shaking. Intensity V may cause plaster or windows to crack; intensity VI may move heavy furniture and cause chimney damage; intensity VII damages poor structures and may damage some ordinary structures. The scale continues up to XII (total destruction), but nothing above VIII has been reported from New England since the 1500's.



III. Regional seismicity

It is important to look at Maine in the context of its neighbors. Geology does not stop at the border! In the regional view, Maine's seismicity is relatively diffuse. While the earthquake clusters in central Maine and easternmost Maine are still evident at this scale, there are similar or larger clusters around New York City, the southern New England coast, central New Hampshire, and northern New Brunswick. But the two most active regions by far are in adjacent Canada, the Western Quebec Seismic Zone, from northern New York State northwest through Montreal, and the Charlevoix Seismic Zone northeast of Quebec City. These areas not only have had the most earthquakes, they also have had the largest ones. The Charlevoix zone has had five earthquakes over magnitude 6 since 1663, and had more than 2500 magnitude 1 to 5 earthquakes from 1977 to 1999. The western Quebec zone, which has an earthquake about every week, has had three quakes over magnitude 5.5 since 1732.

Several other damaging earthquakes have occurred near Maine, including 1755 off Cape Ann, Massachusetts, 1884 in New York City, 1940 in Ossipee, central New Hampshire (two damaging earthquakes in four days), and 1982 in northern New Brunswick. As with Maine earthquakes, there is not enough information on larger earthquakes in the rest of New England to see a pattern in their location and timing.



Notable Events Near Maine

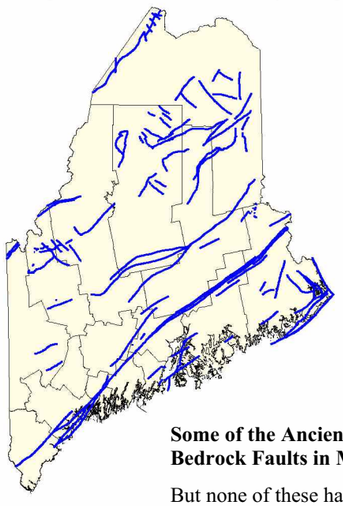
1.	1638	*6.5**	Central New Hampshire(?)
2.	1663	*7.0*	Charlevoix area, Quebec
3.	1755	*6.0*	Cape Ann, Massachusetts
4.	1860	*6.0*	Charlevoix area, Quebec
5.	1870	*6.5*	Charlevoix area, Quebec
6.	1884	*5.2*	New York City
7.	1925	6.2	Charlevoix area, Quebec
8.	1940	5.5	Ossipee, New Hampshire
9.	1982	5.8	Miramichi, New Brunswick
10.	1988	5.9	Charlevoix area, Quebec
11.	2002	5.1	Au Sable, NewYork

* Magnitudes in *italics* are estimates.

IV. What causes earthquakes in Maine?

Geologically (not to mention in other ways), Maine and California are worlds apart. For example, California is at an active boundary between tectonic plates, whereas Maine is in the middle of a large geologic plate. So-called "within-plate" earthquakes are much different from plate boundary earthquakes, primarily because there is no obvious relationship between earthquakes and mapped faults. A *fault* is a break along which rock has moved. Hundreds of ancient faults have been recognized in the northeast, most related to formation of the Appalachians more than 300 million years ago, and some related to rifting of the continent Pangea to form the modern Atlantic Ocean in the Mesozoic Era. But unlike some faults in California, no Maine faults demonstrate the recurring movement that generates earthquakes. Instead, Maine earthquakes seem to break on a different fault every time, many of which are underground and not mapped. In a general way, the old faults may act as inherited zones of weakness. Even in the Charlevoix Seismic Zone, where a large meteor impact (350 million years ago) and an ancient rift zone have produced many faults, earthquakes are not related in an obvious way to the bedrock structure.

The forces that cause our old crust to break may be related to the ongoing slow westward movement of the North American tectonic plate, and to gradual rebound of the underlying mantle after recent melting of the last great ice sheet about 12,000 years ago.



Some of the Ancient Bedrock Faults in Maine

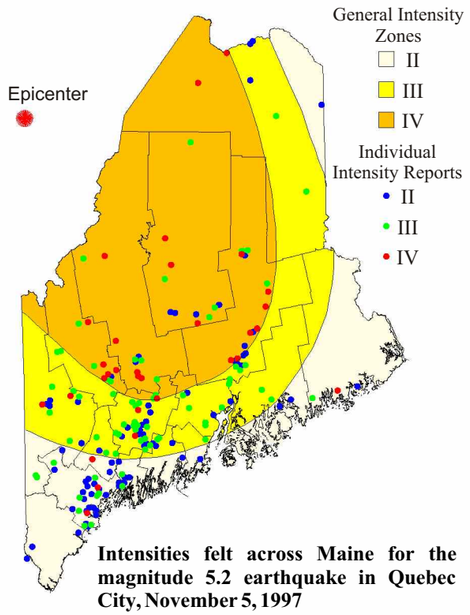
But none of these have been correlated with modern earthquakes.

V. What is the earthquake hazard in Maine?

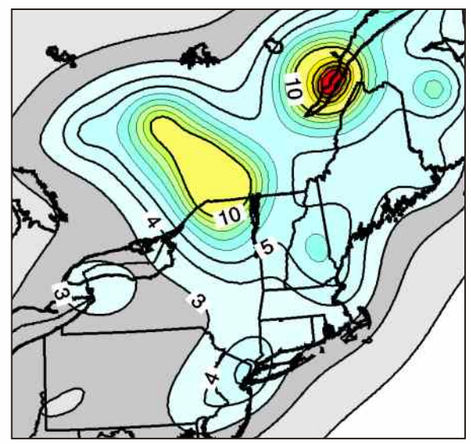
The chances of having a small earthquake somewhere in Maine in any year are actually quite good. But the probability of larger events is much less. From the standpoint of intensity, people in Maine may be affected by a larger earthquake centered in the surrounding region as well as the smaller ones common here. For example, the map to the right shows effects of the magnitude 5.2 earthquake centered in Quebec City in 1997. It caused intensity IV shaking over a large part of Maine. This contrasts with the effects of the smaller earthquake centered in Winslow, illustrated on the front page, that was not even noticed in most of the State. So for larger events, the epicenter may be from away and still shake us here at home.

Another important aspect displayed on the Quebec City earthquake map is that the pattern of individual reports is complex. The shaded regions indicate that in general, areas closer to the epicenter experienced higher intensity. But the dots, each representing an individual intensity report, show that intensities felt at neighboring places may be quite different. This is particularly true for larger earthquakes, where the intensity zones are spread out over large areas.

The U. S. Geological Survey has estimated the combined effects of earthquakes of various sizes that are likely to occur in a 50 year period, and constructed maps to show the result. One such map for the northeastern U. S. is shown to the right. The contour lines indicate the greatest amount of ground shaking expected at any place. Notice that the lines follow the areas of higher seismic activity shown on the Regional Seismicity map. Also notice that the expected probabilities bear no relationship to ancient Maine faults. The example shown here is for earthquake intensities that have a 10% chance of occurring. For reference, a value of 10 on this map corresponds approximately with intensity VII, capable of producing minor damage like the largest Maine earthquake, in 1904. According to the map, all of Maine is below this value. Most people are comfortable with a factor of safety greater than 90%. But to others, even a small chance of a damaging earthquake in Maine is surprising and a bit unsettling.



Intensities felt across Maine for the magnitude 5.2 earthquake in Quebec City, November 5, 1997



Size of the largest earthquake shaking expected in any 50-year period. (90% probability estimate).

DATA SOURCES:
1. WESTON OBSERVATORY OF BOSTON COLLEGE.
2. CANADIAN SEISMIC NETWORK.
3. U. S. GEOLOGICAL SURVEY.
4. MAINE GEOLOGICAL SURVEY.

Earthquake records: (1, 2, 3).
Seismograms: (1).
Modified Mercalli Intensity: (4).
Maine bedrock geology: (4).
Probability map in %g at 10% PE: (3).

For further information about earthquakes, please contact

Maine Geological Survey, 22 State House Station, Augusta, ME 04333. www.maine.gov/doc/nrimc/mgs/mgs.htm
Weston Observatory of Boston College
Maine Emergency Management Agency
Geological Survey of Canada, National Earthquake Hazards Program
U. S. Geological Survey, Earthquake Information Center
Federal Emergency Management Agency
Southern California Earthquake Center