Predicting and Mapping Earthquakes

Most countries in which earthquakes occur have folklore methods that explain why earthquakes occur and how to predict them. Explanations range from divine intervention to planetary constellations. A popular belief in many cultures is that animals can predict earthquakes. In China and Turkey animal observers watch for specific signs of imminent earthquakes. In the United States Native American folklore describes snakes leaving their burrows before an earthquake. Nowadays in the United States many people describe behavioral changes in their pets (hiding, vocalization), cattle (moving to higher ground), and horses (increased pacing in pastures) before earthquakes. However, all of these descriptions have been verified only after the earthquake and as such have not proved to be reliable predictors of pending earthquakes. All of these behavior patterns also occur for many other reasons, so it would not be feasible to take earthquake-protective actions every time animals show these signs. In the United States scientific earthquake monitoring originated in the methods used to detect underground and submarine nuclear tests by foreign nations. In 1977 the Hazard Reduction Act among others was introduced to monitor and study the prediction of earthquakes. Many theories have been tested, such as increases in the volume of rock along fault lines, changes in P and S wave patterns, increases in the electrical resistance in rock, changes in the frequency of small earthquakes, release of radon gas, and the frequency of foreshocks. Many technologies are used to collect measurements on earthquakes. These include seismometers, creep meters, bore holes, strain meters, laser geodimeters, water wells, and magnometers. To date, despite some other countries' claims, short-term prediction of the time and place of earthquakes is not possible. Future research may overcome this deficiency. For example, the historical study of major earthquakes shows an association between foreshocks and major earthquakes. However, this information has been shown only after an earthquake, never before one.

Table 8-4 History of methods used to predict earthquakes throughout the United States

1928	Maps of area over which earthquake could be felt
1935	Uniform Building Codes: Zones of approxiamtely equal seismic probability
1952	Uniform Building Codes: Zones of probable damage based on seismic probability
1958	Richter Map, distribution of Richter scale magnitudes
1969	Zones of damage
1976	Algermissen-Perkins map of peak ground rock accelerations
1994	Maximum 1.0-second spectral response acceleration

Today earthquake monitoring in the United States is conducted by the U.S. Geological Survey, the National Oceanic and Atmospheric Administration (NOAA), and universities throughout the United States. Historical fault lines are studied by seismologists to estimate the frequency with which faults rupture. Geologic research indicates that many faults rupture at characteristic intervals. Based on this information the average rate of rupture over several thousand years can be used to estimate the probability that faults will rupture in the future.

Current earthquake predictions are compiled in maps that take known faults, their historical probability, soil conditions, and other factories into account. These are produced as part of the National Earthquake Hazards Reduction Program (NEHRP). Two basic types of maps give the likelihood of an earthquake occurring in every county of the United States, called the “likelihood of exceedence.” One type of map indicates the predicted peak acceleration (greatest movement) to occur in an earthquake of a given magnitude. The other gives the peak velocity of the surface movement that is predicted for an earthquake of given magnitude. These are referred to as Effective Peak Acceleration (EPA) and Effective Peak Velocity (EPV) maps, respectively (Figs. 8-5 and 8-6).

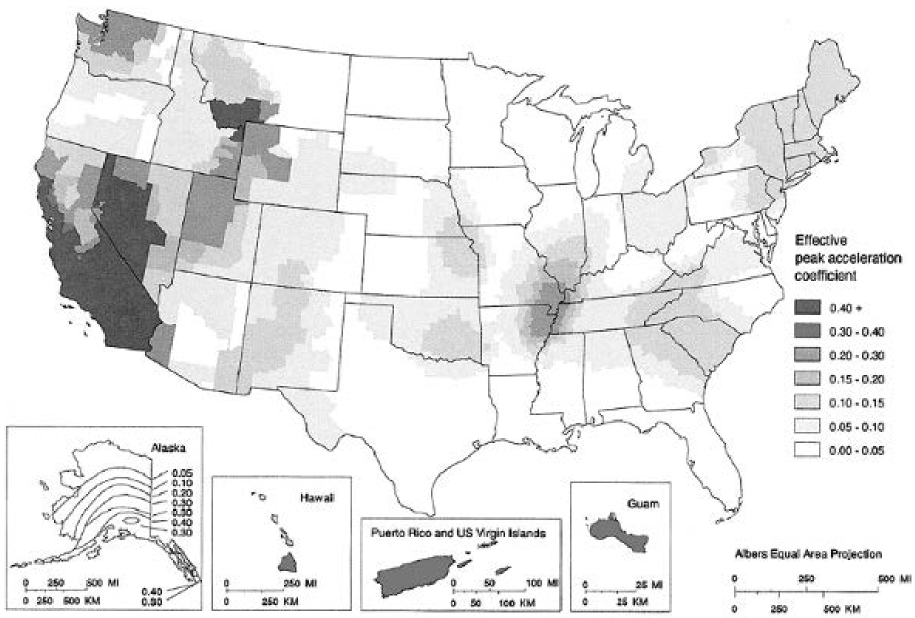

FIG. 8-5 Spatial variation in the effective peak acceleration coefficient (A_a) by county. (From Federal Emergency Management Agency: *Multi-hazard identification and risk assessment: a cornerstone of the national mitigation strategy,* Washington, DC, 1997, FEMA.)

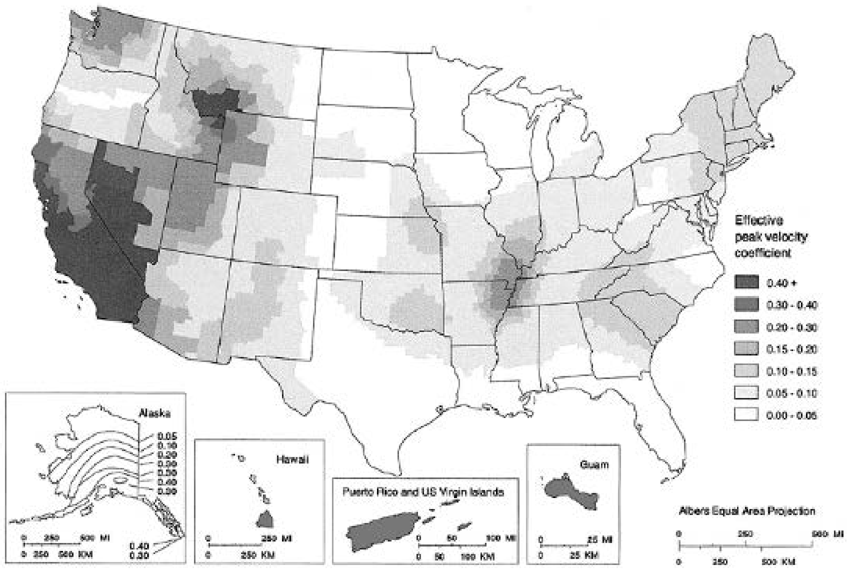

FIG. 8-6 Spatial variation in the effective peak velocity coefficient (A_v) by county. (From Federal Emergency Management Agency: *Multi-hazard identification and risk assessment: a cornerstone of the national mitigation strategy,* Washington, DC, 1997, FEMA.)

Mapping Earthquakes

Currently the greatest threats from earthquakes are the following:

- A 50% probability of an earthquake of magnitude 6.0 along the New Madrid Fault in the Midwest before the year 2000
- A 60% probability of a magnitude 7.0 or greater along the San Andreas Fault in Southern California before 2025
- A 60% probability of a magnitude 7.0 or greater along the San Andreas Fault or the - Hayward Fault in the San Francisco area before the year 2025

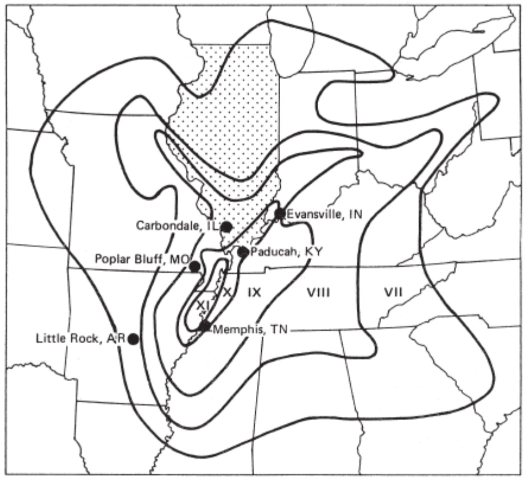

FIG. 8-1 Geographic distribution of intensities (Mercalli Modified Intensity scale) of an earthquake as severe as the 1811 earthquake—if the epicenter occurred along the New Madrid seismic zone. (Courtesy US Geological Survey.)

Table 8-1 Areas of greatest concern for major earthquakes in the United States

San Andreas Fault and associated blind thrust faults
Cascadian Subduction Zone
Aleutian Subduction Zone
Basin and Range
Rio Grande Rift
Intermountain Seismic Belt
Hawaiian Volcanic Chain
Marianas Subduction Zone

Earthquake Maps—Where to Get Information

Earthquake maps have undergone considerable revision since their inception about 100 years ago. Today earthquake maps include information on fault location, type of fault, the direction in which movement is likely to occur, and the soil type. Earthquake Fault Zone (EFZ) maps usually are readily available in areas where earthquakes occur frequently.

A common place to get copies of maps is city and county planning departments. Many real estate agents have copies or can advise where to get them because they are required by law to disclose information on earthquake faults when selling a property. Regrettably many homeowners are unaware of the risk of earthquake faults in their area. In one study it was shown that 77% of homeowners overestimated the distance to the nearest fault, and only 21% of them knew the correct name of the fault. The entire United States is coded according to EFZ maps, which are used as part of the Uniform Building Codes.