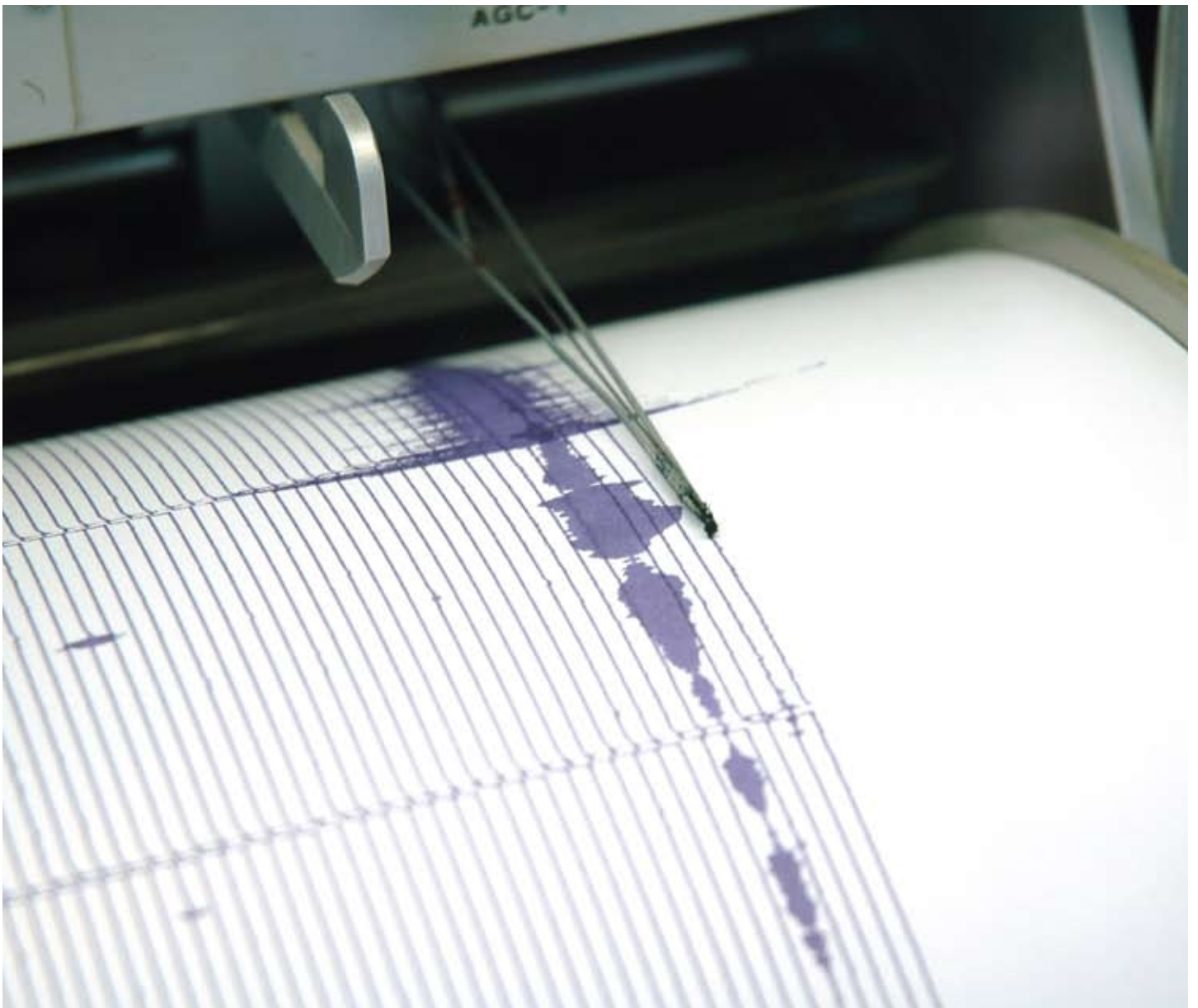


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US EARTHQUAKE RISK

In the second in a series of articles concerning US earthquake risk, Kenneth Campbell and Mahmoud Khater discuss seismic risk in the Pacific Northwest and Central US regions.

Pacific Northwest earthquakes

The tectonic setting of western North America is dominated by the collision of three tectonic plates along the Pacific Coast: the North American plate, the Pacific plate and the Juan de Fuca plate. In most of California, the North American and Pacific plates slide past one another along the San Andreas Fault System. This fault system extends 1,100 kilometres from the Gulf of California in Baja Mexico to Cape Mendocino in northern California. The extreme northern end of the San Andreas Fault veers to the west to form the southern offshore boundary of the Juan de Fuca plate along the Mendocino Fracture Zone.

North of Cape Mendocino, California, in what is known as the Pacific Northwest (PNW), the Juan de Fuca plate subducts beneath the North American plate along the coasts of northern California, Oregon, Washington and British Columbia, forming the 1,100-kilometre-long Cascadia Subduction Zone (CSZ). The point at which the Juan de Fuca plate begins to subduct beneath the North American plate is indicated by the barbed line in the figure below. Intermediate-depth Wadati-Benioff earthquakes associated with the subducting Juan de Fuca plate are most numerous beneath the Cape Mendocino area of north-western California and the Puget Sound region of north-western Washington.

Tectonic setting of western North America

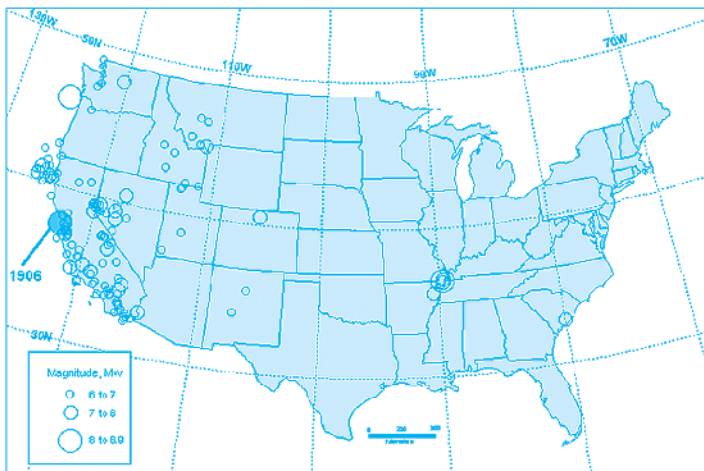


Figure 1: Earthquakes of the United States of Mw 6.0 and larger, 1532 to 2006

Historical seismicity

The historical seismicity of the PNW and its relationship to the seismicity of the remainder of the US is illustrated in the Figure 1. This figure displays all earthquakes of Mw 6.0 and larger that are known to have occurred between 1534 and 2006.

The largest known earthquake in the PNW was the Great Cascadia earthquake, estimated to have occurred on January 26, 1700 on the CSZ, with a wave magnitude (Mw) of approximately 9. This event ruptured the entire length of the CSZ from Cape Mendocino to about three-quarters of the way up Vancouver Island.

If the Great Cascadia earthquake event of 1700 were to happen today, the resulting insured loss would be between \$50 billion and \$70 billion,

AREAS OF HIGHER SEISMICITY

New Madrid Seismic Zone

Charleston Seismic Zone
South Carolina

Wabash Valley Seismic Zone
southern Illinois and southern Indiana

Eastern Tennessee Seismic Zone

Giles County Seismic Zone
Virginia

Charlevoix Seismic Zone
western Maine and Canada

due to the current value of properties, businesses and infrastructure in the affected area.

The costliest recent earthquake in the PNW was the 2001 Nisqually earthquake (Mw 6.8), which is believed to have caused over \$2 billion in total economic loss, largely in the Puget Sound region of Washington, including insured losses of approximately \$330 million. Although about the same size as the Mw 6.7 Northridge earthquake, the Nisqually earthquake caused significantly less loss because of its occurrence in a less densely populated area and because of its 52-kilometre depth within the Wadati-Benioff zone of the subducting Juan de Fuca plate.

Central United States earthquakes

The tectonics of the Central and Eastern United States, and its relationship to the tectonics of the Western United States (WUS), is illustrated in Figure 2. East of the Rocky Mountains and extending to the Atlantic coast, the presence of ancient continental crust and the absence of significant plate boundary forces results in a tectonically stable and seismically quiet region, referred to as the Central and Eastern United States (CEUS).

Earthquakes in this region are believed to be the result of frictional forces between the earth's mantle and the North American plate, caused by a passive boundary between the continental crust of the North American plate and oceanic crusts of the Atlantic Ocean basin.

Pockets of relatively higher seismicity occur in areas of weakness within the relatively stable North American crust. Most notable among these are the New Madrid Seismic Zone, the Charleston Seismic Zone (South Carolina), the Wabash Valley Seismic Zone (southern Illinois and southern Indiana), the Eastern Tennessee Seismic Zone, the Giles County Seismic Zone (Virginia) and the Charlevoix Seismic Zone (western Maine and Canada).

These seismic zones are the sites of the largest earthquakes known to have occurred in the CEUS, either historically or from paleoseismic investigations. The New Madrid Seismic Zone, located at the junction of Arkansas, Missouri, Kentucky and Tennessee, is arguably the best known of the CEUS seismic zones because of the occurrence of the New Madrid earthquakes (variously assigned magnitudes of Mw 7.3 to 8.0) in this zone in the winter of 1811-1812.

In contrast to the Western United States (WUS), earthquakes in the CEUS cannot be easily associated with specific faults. Contemporary seismicity appears to be illuminating some of the faults responsible for the New Madrid earthquakes. Paleoseismic investigations have identified prehistoric earthquakes on the New Madrid faults, the Meers fault in south-western Oklahoma, the Cheraw fault in south-eastern Colorado and the Commerce fault in south-eastern Missouri. No other known faults can be unequivocally associated with historic or paleoseismic earthquakes. A map indicating the tectonic features, including tectonic plates, fault systems, seismic zones and quaternary faults (small fine lines in the US interior), taken from the US Geological Survey, affecting the seismic activity in the United States is shown in Figure 2.

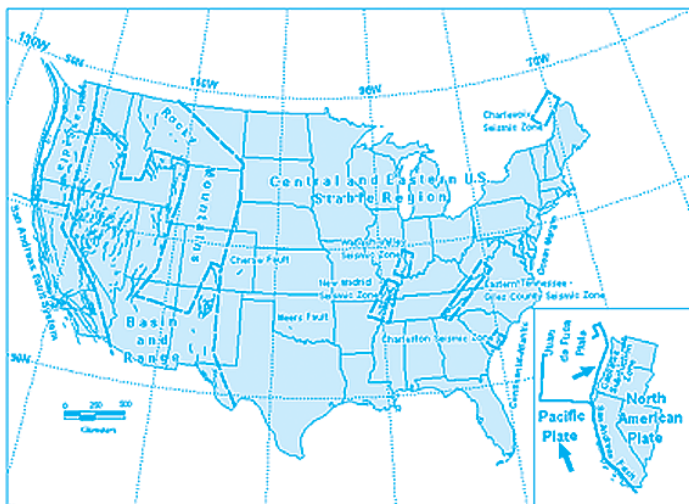


Figure 2: Tectonic features affecting the seismic activity in the United States

Pockets of relatively higher seismicity occur in areas of weakness within the relatively stable North American crust.

Historical seismicity

The historical seismicity of the CEUS, and its relationship to the historical seismicity of the WUS, is illustrated in Figure 3. This figure displays all earthquakes of Mw 6.0 and larger that are known to have occurred between 1534 and 2006. Next to the great 1700 Cascadia event (Mw 9.0), the 1811-1812 New Madrid earthquakes (Mw 7.3 to 8.0) are arguably the largest historical earthquakes that have occurred in the United States.

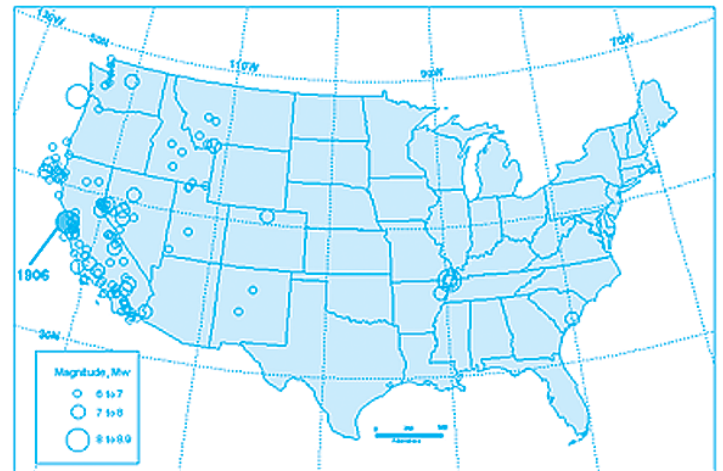


Figure 3: Earthquakes of the United States of Mw 6.0 and larger, 1534-2006

These earthquakes caused significant damage hundreds of kilometres away in Saint Louis and Cincinnati. The New Madrid region was sparsely populated at the time, but the few communities that existed sustained catastrophic damage. The small river port town of New Madrid had to be relocated because much of it sank beneath the Mississippi River. There was widespread liquefaction throughout the Mississippi lowlands. If the 1811-1812 earthquake event were to happen today, the resulting insured loss would be between \$120 billion and \$150 billion, due to the size of the affected area and the vulnerability and construction quality of older structures in the affected area. ■

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