Earthquakes

What Causes Earthquakes?

Intense ground shaking caused by large earthquakes can result in widespread damage. Nearly all death and destruction associated with earthquakes is caused by failure of human-built structures. It is critical to understand the potential earthquake hazard in an area to ensure that buildings and other structures are designed and constructed to withstand expected levels of shaking without collapsing.

Earthquakes are concentrated near the boundaries of the great tectonic plates that make up the outer skin of the Earth. In the United States, earthquake activity is greatest along the West Coast because of the plate boundaries that extend through California and near the coast of the Pacific Northwest. Through southern and central California, the Pacific plate is sliding northwestward relative to the rest of North America at a rate of about two inches per year along the San Andreas fault system. Farther north, the North American plate is overriding the Pacific plate. Earthquakes also occur at distances from plate boundaries. In the U.S., damaging earthquakes have occurred throughout the West, in the Mississippi Valley region, New England, and in Charleston, South Carolina.

Faults are zones of the Earth's crust that are weaker than the surrounding rock. As stress increases in the crust because of movement of the tectonic plates, the zone of weakness eventually fails. One side of the fault slips relative to the other side and then stops because of friction. The amount of movement might be as little as a fraction of an inch in a small earthquake or as much as 30 feet in a truly great earthquake. The sudden movement generates vibrations in the Earth (seismic waves) that cause the ground to shake. Earthquakes relieve some of the stress in the crust, but stress eventually builds up again and triggers recurrent fault movement and earthquakes.

An earthquake's magnitude is related to the amount of energy released into the surrounding earth. The familiar Richter Scale is the most common way to portray the size of an earthquake. Earthquake magnitude depends primarily on the area of the fault plane that ruptures and the amount of movement that occurs during the rupture. Each increase of one unit of magnitude on the Richter Scale represents a 10-times increase in ground motion and about a 32-times increase in the energy released in the earthquake.

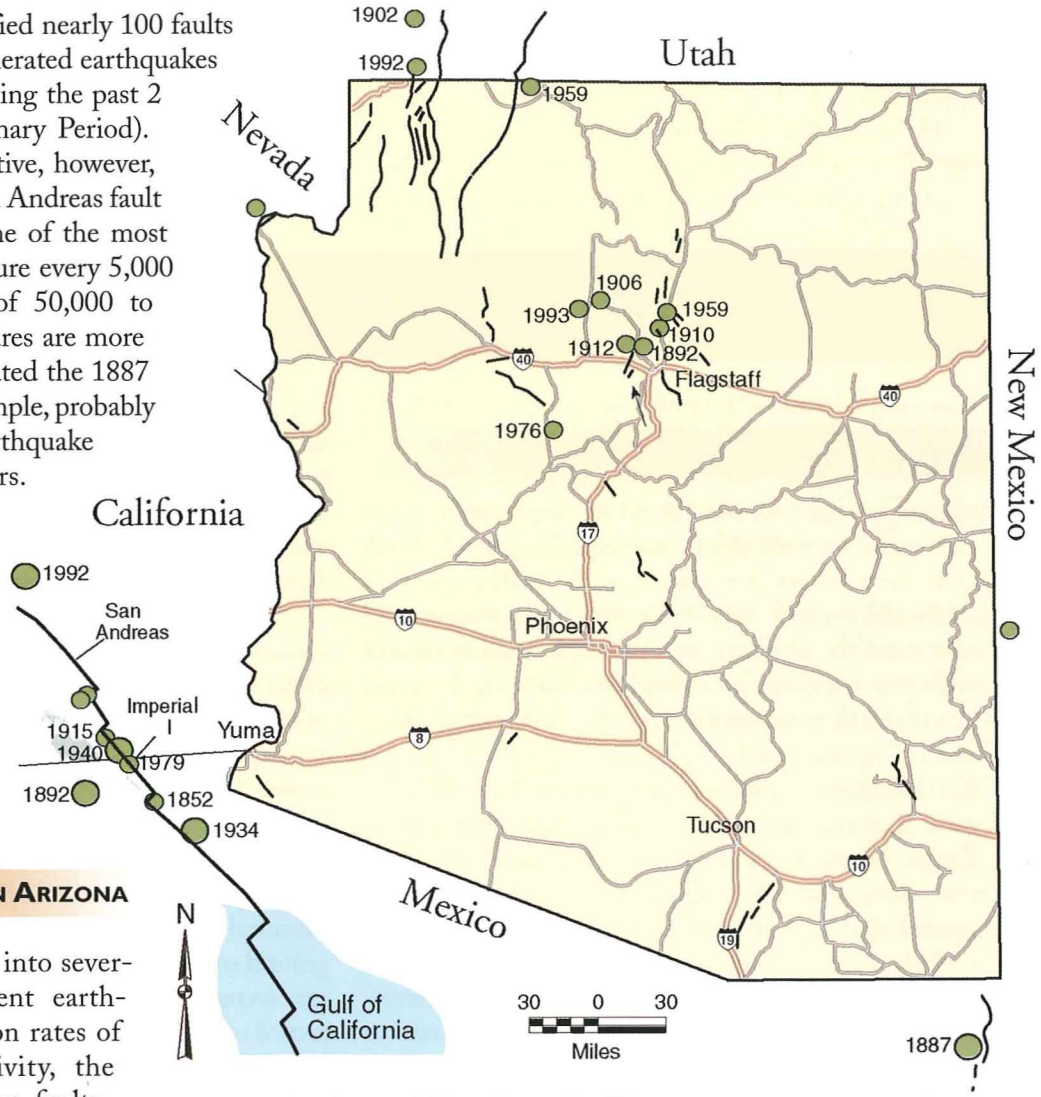
Scientists assess earthquake potential by analyzing historical earthquake patterns and studying evidence for prehistoric ruptures along faults. Historical earthquakes provide a wealth of information about the damage that earthquakes cause and some information about where future earthquakes may occur. However, the historical record of earthquakes is extremely short in comparison with the recurrence interval of major earthquakes, and there are many potentially active faults that have not ruptured historically. Large earthquakes that rupture the ground surface along faults leave evidence that geologists can recognize thousands of years later. A much longer record of large earthquakes in a region can be developed by studying these faults and determining the age of large prehistoric earthquakes.

Earthquakes And Young Faults In Arizona

Over the past 150 years, more than 20 earthquakes having magnitudes greater than 5 have occurred in or near Arizona, and all of Arizona has experienced at least moderate earthquake shaking. The magnitude 7.4 Sonoran earthquake of 1887, which was centered about 40 miles southeast of Douglas, caused 51 deaths in Sonora and extensive property damage throughout southeastern Arizona. The Yuma area has experienced repeated damage from earthquakes that occurred in southern California or northern Mexico. The most damaging event was the magnitude 7.1 Imperial Valley earthquake of 1940. The Flagstaff area experienced damage three times during the early 1900's from magnitude 6 earthquakes. A broad area extending from near Winslow through Flagstaff and northwest into Utah continues to experience moderate levels of earthquake activity.

Although no earthquakes in Arizona have ruptured the surface in historic time, many potentially active faults

exist. Geologists have identified nearly 100 faults in Arizona that probably generated earthquakes of magnitude 6 or larger during the past 2 million years or so (Quaternary Period). These faults are not very active, however, when compared with the San Andreas fault in California. Although some of the most active faults in Arizona rupture every 5,000 to 10,000 years, intervals of 50,000 to 100,000 years between ruptures are more typical. The fault that generated the 1887 Sonoran earthquake, for example, probably had not caused a similar earthquake for at least 100,000 years. Geologic studies indicate that rupture on eight faults has probably occurred in Arizona within the past 15,000 years. These studies show that although large earthquakes do occur in Arizona, they do not occur frequently.



Young Faults and Earthquake Epicenters in or near Arizona

Explanation of Symbols

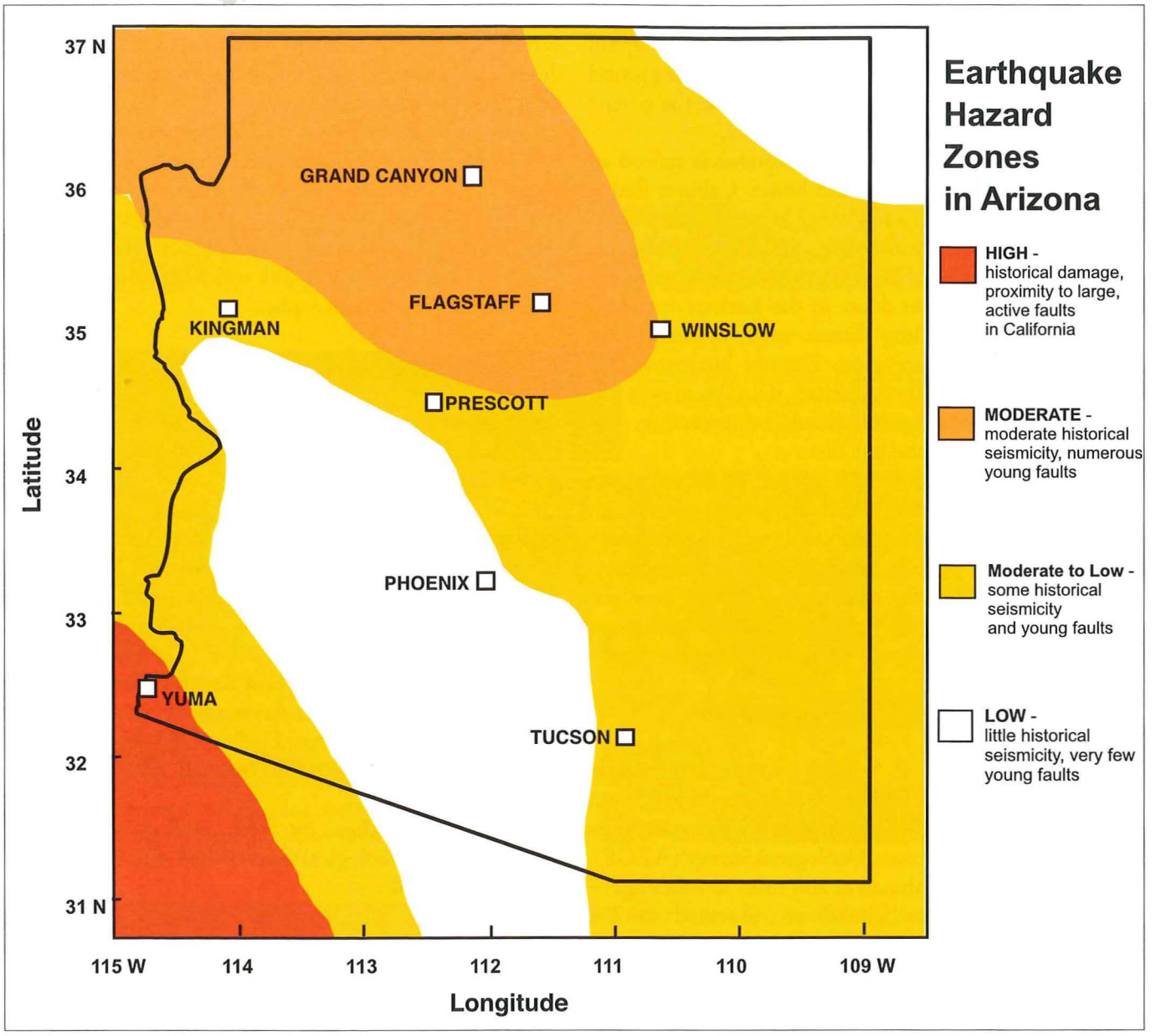
- Known young earthquake faults active in the past 130,000 years.
- Historical earthquake epicenters; magnitude 5-7 (medium) >7 (large)
- Interstate highway

Earthquake Hazards In Arizona

Arizona can be divided into several zones that have different earthquake hazard levels based on rates of historical earthquake activity, the number of potentially active faults, and the estimated slip rates for these faults. Earthquake hazard levels across the state are generally low to moderate.

Although seismic hazard is fairly low in much of Arizona, it is relatively high in the Yuma area. Yuma is close to active faults in the Imperial Valley in southern California and northern Mexico that have generated numerous magnitude 6.5 to 7.0 earthquakes during the last 150 years. To make things worse, parts of the area have potential for liquefaction—that is, when the ground shakes, shallow, unconsolidated, water–saturated deposits of silt and sand may temporarily lose strength and flow. The resulting ground failure can cause major damage to structures. During the 1940 Imperial Valley earthquake, for example, liquefaction caused bridges to buckle and irrigation ditches to collapse in the Yuma area. The potential for liquefaction damage in the Yuma area is increasing because urban development is extending into low-lying areas adjacent to the Colorado and Gila rivers.

The Flagstaff–Grand Canyon area is considered to have a moderate hazard level. Although the area has not experienced any large, surface–rupturing earthquakes in the last 120 years, earthquakes in 1906, 1910, and 1912 caused damage in Flagstaff. Much of the area was shaken by the magnitude 4.9 and 5.3 Cataract Creek earthquakes of 1993. Swarms of quakes ranging up to magnitude 4.5 have shaken Grand Canyon Village during the past several decades. The Flagstaff-Grand Canyon region is broken by many faults that have been active within the past few hundred thousand years and have potential to generate large earthquakes. Considering the whole region, large earthquakes may occur on average once every 1,000 to



5,000 years. Because of fairly frequent historical earthquake activity and the presence of many potentially active faults, earthquake hazards should be considered in building construction and emergency-management planning in Flagstaff and the Grand Canyon area.

Earthquake hazard is low in the Sonoran Desert of southern Arizona, where few historical earthquakes have occurred. Because the few Quaternary (young) faults in this region are short, the largest earthquakes that might occur are estimated to be about magnitude 6.5. Earthquake hazard is low to moderate in southeastern and central Arizona, including much of the Phoenix and Tucson metropolitan areas. Many potentially active faults scattered across this region are fairly long and could generate magnitude 6.5 to 7.2 earthquakes. However, these faults have displayed low slip rates and had very long intervals between ruptures. Levels of historical earthquake activity have been low in this region, except for the major 1887 Sonoran earthquake. This event showed that large earthquakes do occur in this region, but the geologic record indicates that they occur infrequently.

Preparing For Earthquakes

Even though the probability of experiencing a large, damaging earthquake is fairly low in most of Arizona, it is wise to be aware of the possibility. Earthquakes may damage structures directly by shaking them, or indirectly by triggering landslides or rockfalls. Homeowners need to be aware of the potential dangers from slope failures triggered by earthquakes, even those centered far

away. In steeply sloping areas that have loose boulders, walls or other barriers may be constructed on the uphill side of a property. In areas near rivers where the ground is underlain by unconsolidated, wet sediment, the potential for liquifaction needs to be considered.

Some of the damage from earthquakes is caused by movement of objects within the home. Cabinet doors, appliances, bookshelves, and other loose objects should be secured to prevent movement during an earthquake. Bookshelves and file cabinets may tip over and seriously injure a person. Cabinet doors in the kitchen or pantry may swing open, spilling dishes, small appliances, or canned goods on an occupant. Pictures hung on walls can fall; this is especially dangerous if a picture is at the head of a bed. Water heaters should be secured to prevent rupture of water and gas lines.

Because the location and size of earthquakes are impossible to predict and the damages associated with large earthquakes are great, standard homeowners insurance does not include coverage for earthquakes. Insurance for earthquake damage is available, however. Check with your insurance agent for availability and cost to add coverage to your policy for earthquake damage.

Where To Go For More Information

Several agencies in Arizona provide information about earthquake hazards, preparedness, and mitigation. Reports and maps showing areas that have known faults are available at the Arizona Geological Survey (AZGS). Information about earthquakes and links to other agencies involved with earthquakes are provided on the AZGS website.

The Arizona Earthquake Information Center (AEIC) at Northern Arizona University maintains a regional seismic network in northern Arizona and collects data, distributes information, and conducts research on Arizona earthquakes. AEIC personnel monitor earthquake activity, identify potential hazards to residents and facilities, and maintain an archive of more than 10,000 earthquake records.

Arizona's Department of Emergency and Military Affairs, Division of Emergency Management, in Phoenix, sponsors the Arizona Earthquake Preparedness Program (AEPP). The program seeks to reduce Arizona's vulnerability to damaging earthquakes through public awareness and education programs, and coordination of Federal, State, and local emergency plans.

Selected References

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