

Seismic-Hazard Mapping in Arizona

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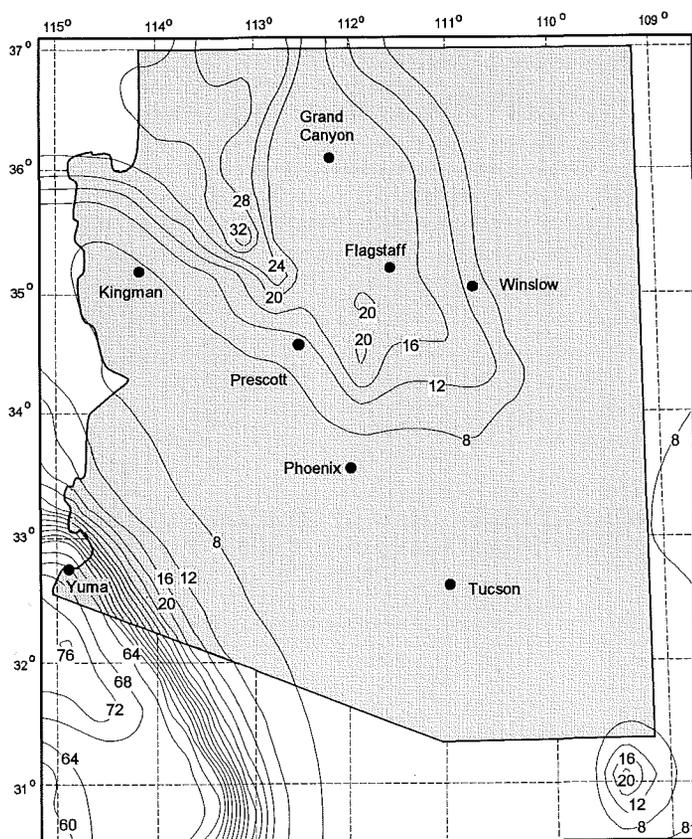
In 1985, the Arizona Earthquake Information Center (AEIC) was established at Northern Arizona University in Flagstaff. Since that time, the AEIC has compiled data, responded to requests for information from agencies and individuals, and published several documents related to seismic-hazard mapping in Arizona. These publications are described below and may be purchased from the AEIC.

AEIC PUBLICATIONS

Bausch, D.B., Brumbaugh, D.S., Morrison, S.J., and Daughton, T., 1993, State ground-acceleration map, 100-year conditional probability: scale 1:1,000,000.

In 1991, the Arizona Division of Emergency Management contracted with the AEIC to prepare seismic-acceleration maps for Arizona. This project was part of the Arizona Earthquake Preparedness Program, which was established

Figure 1. Earthquake acceleration contour map of Arizona and adjacent regions as a percentage of the force of gravity; contour intervals are 4 percent of gravity. Gravity is the acceleration of a freely falling body due to the attraction by the Earth and to the Earth's rotation about its axis. The acceleration level that is generally accepted as sufficient to damage weakly constructed structures is 10 percent of gravity (Richter, 1958). Contours are based on a 100-year conditional probability, defined as a 90-percent chance of not being exceeded within 100 years. For example, a value of 64 percent of the force of gravity in Yuma has a 90-percent chance of not being exceeded (or a 10-percent chance of occurring) during the next 100 years.



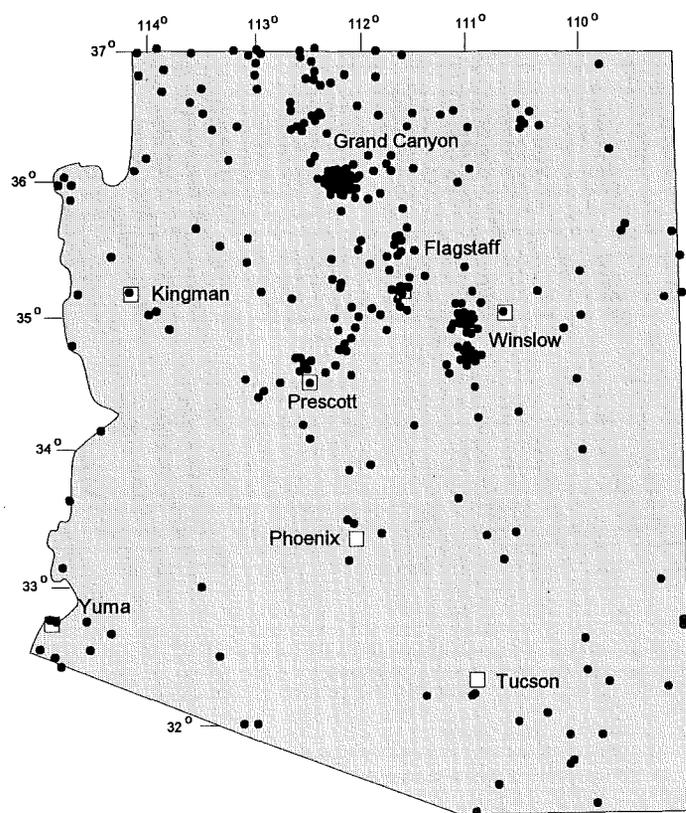
to build a foundation for earthquake-hazard mitigation and preparation in Arizona (Yates, 1992). The maps provide emergency planners, engineers, public officials, and others with guidelines to evaluate these hazards.

Seismic-acceleration contour maps show the force of ground shaking that may occur during an earthquake. The contour lines define ground motion of a certain level that will probably occur within a specific time (Euge, 1993). The AEIC determined the level of ground shaking that has a 90-percent chance of not being exceeded (or a 10-percent chance of occurring) within the next 100 years (Figure 1). Euge (1993) described the development of acceleration contour maps based on 50- and 250-year intervals.

The AEIC divided regions in Arizona and adjacent areas into **seismic source zones** (zones that are capable of producing earthquakes) based upon differing seismic characteristics. For example, the Colorado Plateau and Basin and Range Province are separate source zones. The most recent catalog of Arizona earthquakes published by the AEIC was used to define rates of earthquake occurrence within each source zone. The rate of occurrence is based on an observed number of earthquakes of a given magnitude per time period and was determined for each fault and seismic source zone. Where data were limited, the rates of occurrence were based on interpretation.

The high values for the Yuma area (Figure 1) are the result of high earthquake-occurrence rates for the faults that form the boundary of the North American and Pacific Plates within southern California and northern Mexico. Although the Yuma region has the highest acceleration values within Arizona (100-year acceleration of 60 percent of the force of gravity), two other areas of the State also have relatively high values: (1) southeastern Arizona, near the 1887 Sonoran

Figure 2. Epicenters of earthquakes (magnitude 0.5 to 6.2) that occurred in Arizona from 1830 through 1992, based on the most current AEIC catalog. Earthquake epicenters are represented by dots.



earthquake epicenter (DuBois and Smith, 1980); and (2) a zone that extends from the Prescott-Flagstaff area through northwestern Arizona. The latter zone includes the Verde, Big Chino, Aubrey, and Hurricane fault systems, as well as a northwest-trending belt of earthquake epicenters.

The 100-year conditional-probability map is published as a color plot at a scale of 1:1,000,000. General 50-, 100- and 250-year acceleration contour maps are also available at small scales printed on 8.5" x 11" sheets. Because the database for these maps contains approximately 4,000 data points, sorting techniques may be used to produce enlarged regional and areal maps.

Morrison, S.J., Brumbaugh, D.S., and Daughton, T., 1991, State of Arizona maximum-intensity ground-shaking map (1887-1987): scale 1:1,000,000.

This map illustrates the maximum Modified Mercalli intensity levels for Arizona during the period between 1887 and 1987. These levels range from V to IX. The highest levels are near Yuma and in southeastern Arizona because of California earthquakes and the 1887 Sonoran earthquake, respectively (DuBois and Smith, 1980). The primary source of intensity data was DuBois and others (1982).

Acceleration describes the force of an earthquake, generally measured on bedrock, whereas intensity describes actual earthquake effects on human structures. Acceleration typically decreases with distance from an earthquake; intensity, however, may be influenced by unfavorable local geologic conditions, such as loose sandy soils or high ground water. This influence was clearly demonstrated by the devastation in the San Francisco Marina District about 60 miles north of the epicenter of the 1989 Loma Prieta earthquake (Bonilla, 1991). Similar geologic conditions in Yuma Valley increased the damage due to liquefaction and ground settlement during the 1940 Imperial Valley earthquake (U.S. Bureau of Reclamation, 1976). In populated areas that are underlain by high ground water and loose sandy soils, intensity maps may represent earthquake hazards more accurately than bedrock acceleration maps. A color plot of this map is available at a scale of 1:1,000,000.

Brumbaugh, D.S., Morrison, S.J., and Bausch, D.B., 1993, Arizona earthquakes, 1830-1992, catalog and map: 10 p., scale 1:1,000,000.

The catalog of earthquakes maintained by the AEIC contains locations, origin times, and magnitudes for 475 Arizona earthquakes (Figure 2). The catalog's database

format allows sorting by date, time, location, or magnitude. In addition to locating Arizona earthquakes each year (see article on pages 2 and 3), the AEIC relocates earthquakes that occurred before the seismic network was established. The AEIC completes this task by retrieving the raw data (e.g., seismograms and phase arrival times) from various regional sources (e.g., the California Institute of Technology and the U.S. Geological Survey), combining these data with the network data, and using the most current crustal-velocity model. Last year, about a dozen earthquakes that occurred during the 1950's and 1960's were relocated. Many of the epicenters were relocated from Arizona to California or Mexico.

A color plot of this map is available at a scale of 1:1,000,000. A printout of the complete catalog with a small-scale, 8.5" x 11" map may also be purchased.

ORDERING INSTRUCTIONS

The color plots of the three 1:1,000,000-scale maps discussed above are available for \$20 each; the current catalog of Arizona earthquakes may be ordered for \$5; all prices include shipping costs. Earthquake- or acceleration-data sorting, such as epicenters by date, location, or magnitude, and enlarged regional acceleration maps may also be purchased. Send requests to the Arizona Earthquake Information Center, Northern Arizona University, P.O. Box 4099, Flagstaff, AZ 86011; tel: (602) 523-7197.

REFERENCES

- Bonilla, M.G., 1991, The Marina district, San Francisco, California: Geology, history and earthquake effects: Bulletin of the Seismological Society of America, v. 81, no. 5, p. 1,958-1,979.
- DuBois, S.M., and Smith, A.W., 1980, The 1887 earthquake in San Bernardino Valley, Sonora: Historic accounts and intensity patterns in Arizona: Arizona Bureau of Geology and Mineral Technology Special Paper 3, 112 p.
- DuBois, S.M., Smith, A.W., Nye, N.K., and Nowak, T.A., Jr., 1982, Arizona earthquakes, 1776-1980: Arizona Bureau of Geology and Mineral Technology Bulletin 193, 456 p., scale 1:1,000,000.
- Euge, K.M., 1993, Arizona develops new seismic-acceleration contour maps: Arizona Geology, v. 23, no. 1, p. 9.
- Richter, C.F., 1958, Elementary seismology: San Francisco, W.H. Freeman and Co., 768 p.
- U.S. Bureau of Reclamation, 1976, Record of earthquakes in the Yuma area, 1776-1976: Special Report, 191 p.
- Yates, R.A., 1992, Arizona Earthquake Preparedness Program: Arizona Geology, v. 22, no. 3, p. 4-5.

Arizonan Confirmed for Key Interior Position

Elizabeth Ann Rieke, Director of the Arizona Department of Water Resources since April 1991, has been confirmed as Assistant Secretary for Water and Science, one of six Assistant Secretary positions in the U.S. Department of the Interior. Former Arizona Governor Bruce Babbitt was recently confirmed as Secretary of the Interior.

Rieke began work on March 8. She administers the U.S. Geological Survey, U.S. Bureau of Mines, and U.S. Bureau of Reclamation.

From January 1987 to April 1991, Rieke worked for the law firm of Jennings, Strouss and Salmon. From 1982

through 1986, she served in the Legal Division of the Arizona Department of Water Resources as Deputy Counsel and Chief Counsel. She has participated in Colorado River negotiations, statewide water-planning activities, and negotiations that led to significant legislation affecting water management in Arizona. She recently served as Chair of the Governor's Task Force on Central Arizona Project issues.

Rieke graduated from Oberlin College in 1965 and received her law degree from the University of Arizona in 1981.