Bibliography of Earthquake Hazards in Arizona

by

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Arizona Geological Survey
Open-File Report 94-3

January 1994

Arizona Geological Survey
416 W. Congress, Suite #100, Tucson, Arizona 85701

Funding for this project was provided by
the Federal Emergency Management Agency
the Arizona Division of Emergency Management
and the Arizona Geological Survey

This report is preliminary and has not been edited
or reviewed for conformity with Arizona Geological Survey standards

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Introduction

Arizona has suffered relatively modest amounts of damage and destruction resulting from earthquake shaking during its historical period. There is cause to be concerned about earthquake hazards in Arizona, however. Many earthquakes ranging in magnitude up to about 6 have occurred within Arizona, and portions of the State have experienced strong shaking resulting from earthquakes that occurred in California and Mexico. Geologic investigations indicate that at least 20 faults in Arizona have been active in the past 100,000 years, and thus may be considered potential sources for large earthquakes. This bibliography represents an attempt to develop a reasonably comprehensive list of references pertaining to all aspects of earthquake hazards in Arizona. We hope that this bibliography will be useful for planners, engineers, scientists, emergency-management officials, and government agencies concerned about earthquake hazards in Arizona. In addition to the bibliography, we provide a short summary of seismic hazard in Arizona after this introduction.

This bibliography of earthquake hazards was compiled from a variety of sources. Many references were obtained from the publications *Bibliography of North American Geology* and *Bibliography and Index of Geology*, searching index categories such as Arizona -- maps, environmental geology, geologic hazards, seismology, geophysical surveys, structural geology, and tectonics. Additional references were taken from bibliographies and publication catalogs of the Arizona Geological Survey, from the publications of the Arizona Earthquake Information Center at Northern Arizona University, from lists of theses and dissertations from the University of Arizona, Arizona State University, and Northern Arizona University, and from the reference lists of other entries. The references listed in this bibliography were compiled in a database developed using the Superbase program, version 2.01 (copyright Software Publishing Company, 1986-1992). The digital bibliographic database, which contains standard bibliographic information, keywords, and geographic information, will be released as part of the Arizona Geological Survey Digital Information (DI) Series in mid-1994. References in this open-file report were extracted from the bibliographic data base.

References in this bibliography are grouped into nine topical categories to allow users to focus on particular areas of interest or concern. These categories are: (1) computer codes or files, (2) engineering and seismic design, (3) historical seismicity, (4) late Cenozoic tectonics, (5) maps, (6) Quaternary faulting, (7) reservoir-induced seismicity and dam safety, (8) seismic hazard assessment, and (9) seismology. References are listed alphabetically within each subject area. References that pertain to more than one topic are listed under each category. The bibliography also contains selected references on earthquake hazards in adjoining states and northern Mexico, as well as some general references on earthquake engineering and design. Although we attempted to make this bibliography thorough with regard to Arizona seismic hazard, we recognize that it is not completely comprehensive. We therefore welcome any suggested additions to this bibliography.

A Short Summary of Seismic Hazard in Arizona

Seismic hazard in Arizona can be considered from the perspective of the distribution and size of historical earthquakes or the distribution of potentially active faults that might generate large earthquakes but have not ruptured historically. Until quite recently, seismic hazard analysis relied almost exclusively on the historical seismic record. In the past several decades, evidence has accumulated that most potentially active faults have recurrence intervals (times between major fault ruptures) that are much longer than the historical period. Faults may therefore pose a significant threat even if they have generated no historical earthquakes. Modern seismic hazard analysis integrates both historical seismic activity and paleoseismic information derived from geologic investigations of young faults in order to give a fairly complete assessment of the potential seismic hazard in a region.

Historical Seismicity. Arizona has experienced low to moderate levels of seismic activity during the past 150 years or so. Generally, earthquake activity has been highest in northern and northwestern Arizona and the Yuma area. Some earthquakes have occurred in central, southeastern, and northeastern Arizona. Very few earthquakes have occurred in southwestern Arizona outside of the Yuma area. The largest historical earthquakes in Arizona (three events about magnitude 6) occurred in the Flagstaff - Grand Canyon region in the early 1900's. Each of these events was felt widely across northern and central Arizona and caused minor damage. None of these earthquakes was clearly associated with a mapped fault, and it is not certain whether surface rupture occurred during any of these earthquakes. The largest earthquake recorded by relatively modern seismic instruments was a magnitude 5.5 to 5.75 event in 1959 located near Fredonia, just south of the Utah border. Many other small to moderate earthquakes have occurred in northern Arizona in this century, especially in the Grand Canyon area.

The greatest amounts of earthquake damage in Arizona have resulted from much larger earthquakes that occurred in northern Mexico and southern California. The largest earthquake to affect Arizona occurred in 1887 in northeasternmost Sonora, Mexico. This earthquake, with an estimated magnitude of about 7 1/4 to 7 1/2, devastated many villages in northern Mexico and caused significant damage and destruction of buildings across southeastern Arizona. Large earthquakes that have occurred on portions of the San Andreas fault system of southern California have caused significant damage in southwestern Arizona. The Yuma - Somerton area experienced substantial damage as a result of the magnitude 7.1 Imperial Valley earthquake of 1940, and lesser damage as a result of the magnitude 7 El Centro earthquake of 1979.

The historical seismic record indicates that Arizona is subject to low to moderate seismic hazard from earthquakes originating within its borders, but seismic hazard posed by earthquakes occurring near Arizona is probably greater. Based solely on the historical record, one would conclude that (1) much of Arizona has low seismic hazard; and (2) seismic hazard is highest in the Yuma area, north-central and northwestern Arizona, and southeastern Arizona.

Paleoseismology. Geologic studies of young faults, or paleoseismic investigations, can reveal the locations of large prehistoric earthquakes and give us an idea about where they might occur in the future. In Arizona, earthquakes larger than about magnitude 6.5 probably rupture the land

surface, producing distinct topographic features that may be recognized a hundred thousand years or more after the earthquake occurred. Documenting the existence of these topographic features, called "fault scarps", identifies which faults have generated large earthquakes in the geologically recent past. Detailed studies of these fault scarps may reveal when the latest large earthquake occurred on the fault, the approximate size of the earthquake, and how frequently large earthquakes occur on the fault.

Paleoseismic investigations have produced quite a bit of information about the distribution of young faults in Arizona and how frequently they generate large earthquakes. There are at least 23 faults in Arizona that have likely generated large earthquakes in the past 100,000 years, and therefore are considered potentially active. Nearly all of these faults are located within a broad band stretching from northwest to southeast across the State. The greatest density of potentially active faults is found in northwestern and north-central Arizona, a region extending from approximately Flagstaff and Prescott to the Utah border. A lesser concentration of potentially active faults exists in southeastern Arizona and adjacent portions of New Mexico and Sonora. The Yuma area is on the eastern margin of active faults associated with the San Andreas system. The most active faults in Arizona are found in the northwestern portion of the State and the Yuma area. These faults probably generate large earthquakes on average every 10,000 to 20,000 years. Faults in north-central Arizona rupture somewhat less frequently. Very long (100,000+ yrs) recurrence intervals are characteristic of faults in central and southern Arizona. Although recurrence intervals on individual faults may seem quite long, at least 15 large earthquakes have likely occurred within Arizona in the past 20,000 years, and others have occurred immediately adjacent to Arizona.

Paleoseismic investigations indicate that large earthquakes do not occur frequently in Arizona, but nonetheless have occurred in many parts of the State in the past few tens of thousands of years. Based on geologic information, seismic hazard is highest in the Yuma area because of its proximity to the very active San Andreas fault and its subsidiary faults. Northwestern and north-central Arizona have moderate seismic hazard, based primarily on the large number of potentially active faults. Central and southeastern Arizona have fairly low seismic hazard, but large earthquakes are possible in these areas. Seismic hazard from large earthquakes is very low in northeastern and southwestern Arizona (excluding the Yuma area).

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