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The 1887 Sonoran Earthquake: It Wasn't Our Fault

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On May 3, 1887 Arizona and the Southwest experienced a major earthquake that had an estimated magnitude of 7.2 on the Richter scale (DuBois and Smith, 1980). The epicenter was in Sonora, Mexico approximately 40 miles south of Douglas, Arizona. The earthquake caused several dozen deaths, damaged buildings as far away as Phoenix, generated rockfalls and fires triggered by rockfalls in the mountains, and caused panic among the population. This year is the 100th anniversary of the only earthquake that caused considerable damage in Arizona in historic times.

Although earth scientists know much more now regarding the mechanisms of earthquakes than they did 100 years ago, reliable earthquake prediction is still in its infancy. It is known that the crust and uppermost mantle of the earth is divided into approximately a dozen major sections or "plates" that are slowly moving. Rates of relative movement range up to several inches per year. It is along the plate boundaries that the most earthquakes occur. The San Andreas fault of California is a plate boundary along which the Pacific plate is moving northwestward with respect to the adjacent North American plate. Because of friction along plate boundaries, plates do not smoothly slip past each other. As a consequence, resistance to movement allows stress to accumulate. When stress builds to the point at which it overcomes the resisting forces, energy is released causing ground motion, or an earthquake.

Although southeastern Arizona is several hundred miles from the San Andreas fault system, it is not immune to earthquakes. No region can be considered completely earthquake free; in fact, worldwide there are approximately 1 million detectable earthquakes annually (Gilluly and others, 1968). The majority of these are small shocks that cause no damage. The large, dangerous earthquakes occur less frequently, on the average of only several per year, and are usually concentrated along plate boundaries. By the time the surface waves of these large events reach southeastern Arizona, the energy has dissipated so that little or no motion is felt except by sensitive recording devices.

The 1887 event was, however, close enough and strong enough to cause major damage and loss of life in the southern portion of the State. The earthquake occurred along a south-trending fault approximately 30 miles in length located south of Douglas, Arizona (Figure 1). This surface rupture, named the Pitaycachi (pronounced Pĭ tĭ′ kə chē) fault, is one of several surface faults in the region that are thought to have been active during the last 100,000 years (Pearthree, 1986). These faults are located along the margins of south-trending ranges in the southeastern Arizona—southwestern New Mexico border region and extend into Sonora, Mexico.

It is estimated that the 1887 Sonoran earthquake released twice as much energy as any of the other earthquakes recognized in this region

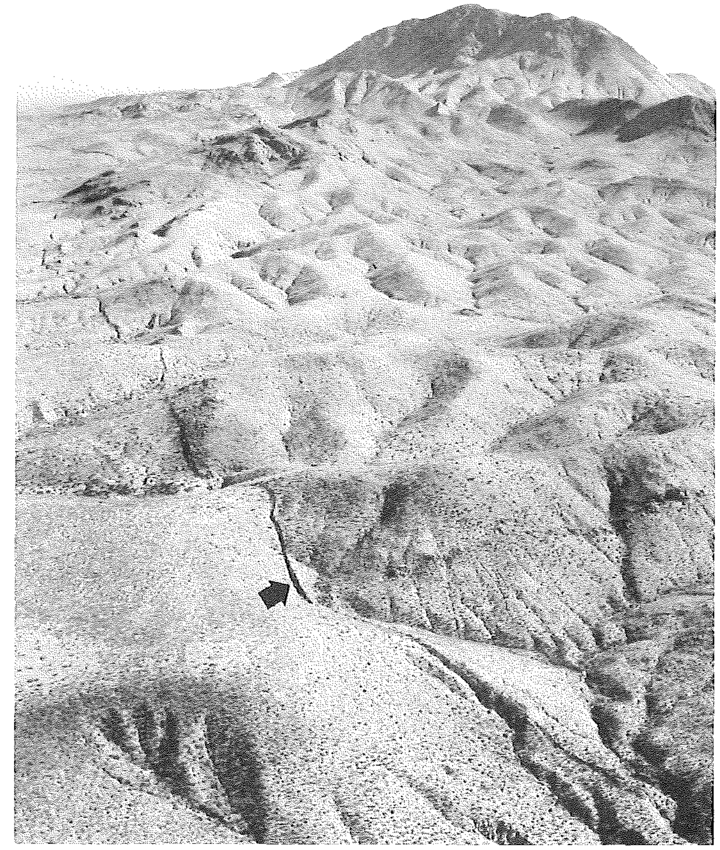

Figure 1. Aerial view, looking northward, of 1887 scarp along Pitaycachi fault, Sonora, Mexico. The fault extends from about 8 kilometers south of the Arizona border for 50 kilometers to and beyond Colonia Morales in the San Bernardino Valley. Photo by Peter Kresan.

(Pearthree, 1986). Firsthand accounts reported that two violent shocks were preceded by low rumbling noises. This rumbling sound was reported in Tucson and as far away as Phoenix (Figure 2). Estimates of the duration of ground motion vary from a few seconds to approximately 10 minutes, with 1 to 3 minutes being the time most frequently reported. People throughout the region ran into the streets, some fainted, and others were thrown to the ground (DuBois and Smith, 1980). Numerous rockfalls were reported in the mountain ranges of southeastern Arizona and northern Sonora. Sparks from the crashing boulders ignited dry brush and grass, and fires quickly spread to the forests. Nearly all the valleys experienced changes in water conditions. Wells that had been excellent

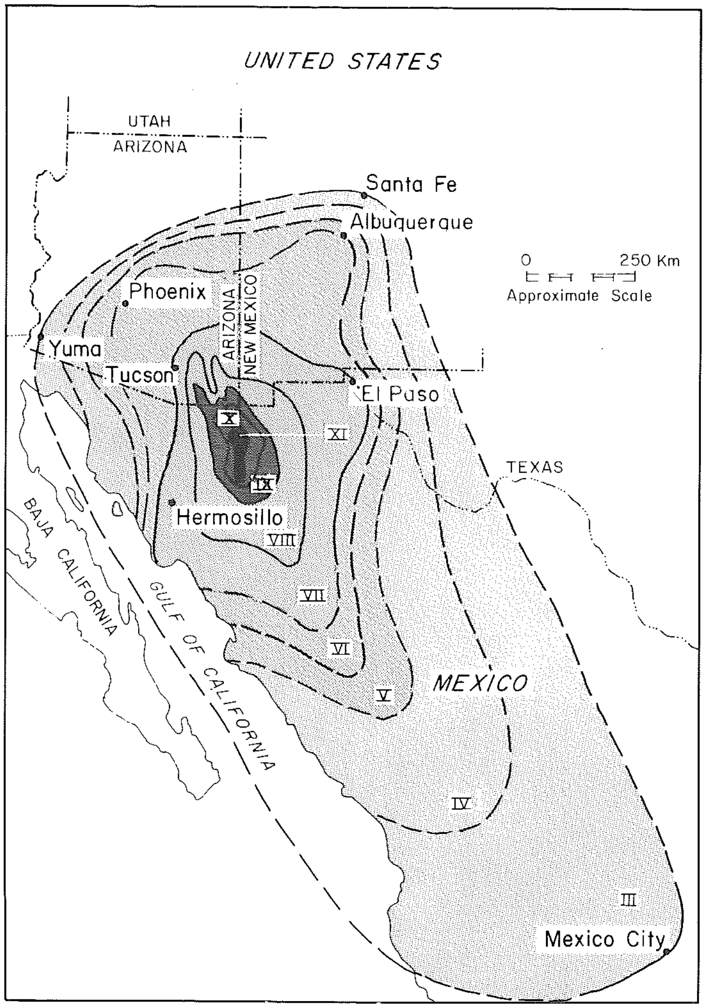

Figure 2. Isoseismal map of the 1887 earthquake (from DuBois and Smith, 1980). Isoseismal lines connect points on the Earth's surface at which earthquake intensity is the same; they are usually closed curves around the epicenter (the black oval-shaped area shown in the map). The severity of an earthquake can be expressed in two very different ways: by magnitude and by intensity. Magnitude measures the amount of seismic energy released at the focus of an earthquake. It is determined from the logarithm of the amplitude of earthquake waves recorded by seismographs. Magnitude is expressed on the Richter scale in whole numbers and decimal fractions (e.g., 7.2, the magnitude of the 1887 earthquake). Theoretically this scale has no upper limit; however, the largest earthquake ever recorded, in Chile in 1960, had a magnitude of 9.5 (DuBois, 1979).

Intensity is an arbitrary measure of the observable effects of an earthquake on humans and structures at a specific site. It varies from place to place depending on the strength of the earthquake (magnitude), the distance from the epicenter, and the local geology. The intensity scale currently used in the United States is the Modified Mercalli (MM) Intensity Scale. This scale, composed of 12 levels of intensity that range from imperceptible shaking (I) to catastrophic destruction (XII), is designated by Roman numerals, as shown in the map above. The lower numbers of the MM intensity scale generally deal with the manner in which the earthquake is felt by persons; the higher numbers are based on observed structural damage. For instance, the MM rating of III, recorded in Yuma during the 1887 earthquake, is based on the following MM characteristic: "Felt noticeably indoors, but not always recognized as earthquake." The rating of VI, recorded in Phoenix, is based on these observations: "Felt by all, many frightened and run outdoors; falling plaster, moving furniture; damage slight." Tucson was assigned an MM intensity level of VII during the 1887 earthquake: "Everybody runs outdoors; damage to buildings varies depending on quality of construction." At the epicenter, which was assigned an intensity rating of XI, observers reported the following: "Few structures remain standing; bridges destroyed; fissures in ground; pipes broken; landslides; rails bent."

sources of water went dry, whereas artesian conditions and temporary lakes were created in other areas. One of the more colorful descriptions of the event came from Charleston, Arizona (near Sierra Vista), where "the walls of the saloon did a two-step and the floor did a shimmey" (Weiss, unpub.).

Could such a large earthquake happen again in southeastern Arizona and could it be predicted? It is easier to predict that earthquakes will occur repeatedly along plate boundaries, where movement is well documented, than to predict recurrence in a plate interior, where southeastern Arizona is located. Fortunately, large and destructive earthquakes do not occur frequently in this region. Geologic evidence suggests that the amount of activity along surface ruptures here is very low. During the last 20,000 years, there have been approximately five surface-rupture faulting events with estimated recurrence intervals of 3,000 to 4,000 years in the region of extreme southeastern Arizona, southwestern New Mexico, and northeastern Sonora, Mexico (Pearthree, 1986, p. 7 and fig. 4). Evidence suggests that the Pitaycachi fault, source of the 1887 earthquake, is not likely to be the origin of a large earthquake in the foreseeable future (Bull and others, 1981).

Scientists worldwide are working on concepts that will allow long-range prediction of earthquakes and short-range warning. A variety of methods are being tested; however, a reliable technique is still years away from development. Until that day, earth scientists can only make "educated" guesses as to when another "big one" will occur.

In Arizona, earthquakes are being monitored by the Arizona Earthquake Information Center (AEIC), which was established in Flagstaff in November 1985 (Brumbaugh, 1986). For information on recent tremors in Arizona, write to AEIC, Box 5620, Northern Arizona University, Flagstaff, AZ 86011, or call (602) 523-7197.

The Arizona Bureau of Geology and Mineral Technology has several publications on seismicity and recent faulting in Arizona. Special Paper 3 (DuBois and Smith, 1980) focuses on the 1887 earthquake. It describes the characteristics of the Pitaycachi fault, quotes historical accounts from newspapers and other writings of that period, and analyzes the intensity patterns of the earthquake and its significance in terms of current seismic hazards in Arizona. Bulletin 193 (DuBois and others, 1982) is a compilation of data on the magnitude, source, distribution, and intensity of earth movements in Arizona from 1776 to 1980. Map 22 (Scarborough and others, 1986) identifies the youngest faults, folds, and volcanic rocks in Arizona. Open-File Report 86-8 (Pearthree, 1986) analyzes the scarp morphology and surface displacement of late Quaternary faults, identifies the locations of Holocene and late Pleistocene faulting events, and assesses the seismic hazards in southeastern Arizona, southwestern New Mexico, and northeastern Sonora, Mexico. Two earlier issues of *Fieldnotes* (Sumner, 1976; DuBois, 1979) provide general information about earthquakes such as where they occur, how they are measured, and if they can be predicted. For information on ordering these or other Bureau publications, contact the Bureau offices at 845 N. Park Ave., Tucson, AZ 85719, or call (602) 621-7906.

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