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THE 1887 EARTHQUAKE in San Bernardino Valley, Sonora:

Historic accounts and intensity patterns in ARIZONA

by
Susan M. DuBois and Ann W. Smith



Special Paper No. 3

**State of Arizona
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THE 1887 EARTHQUAKE in San Bernardino Valley, Sonora:

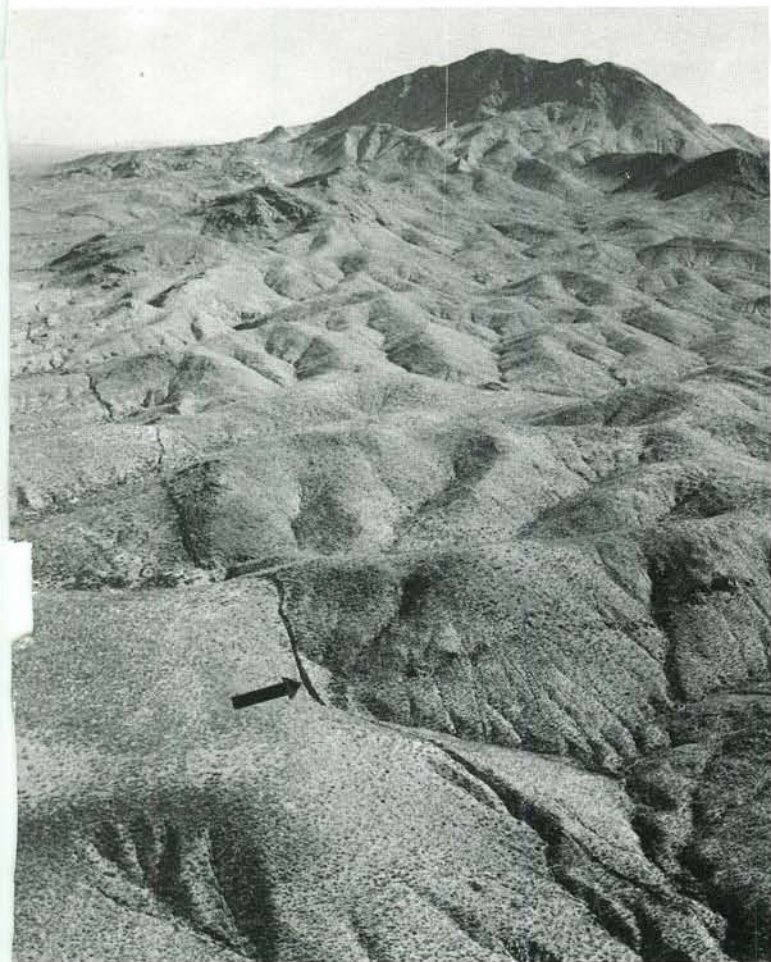
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State of Arizona
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Tucson, Arizona

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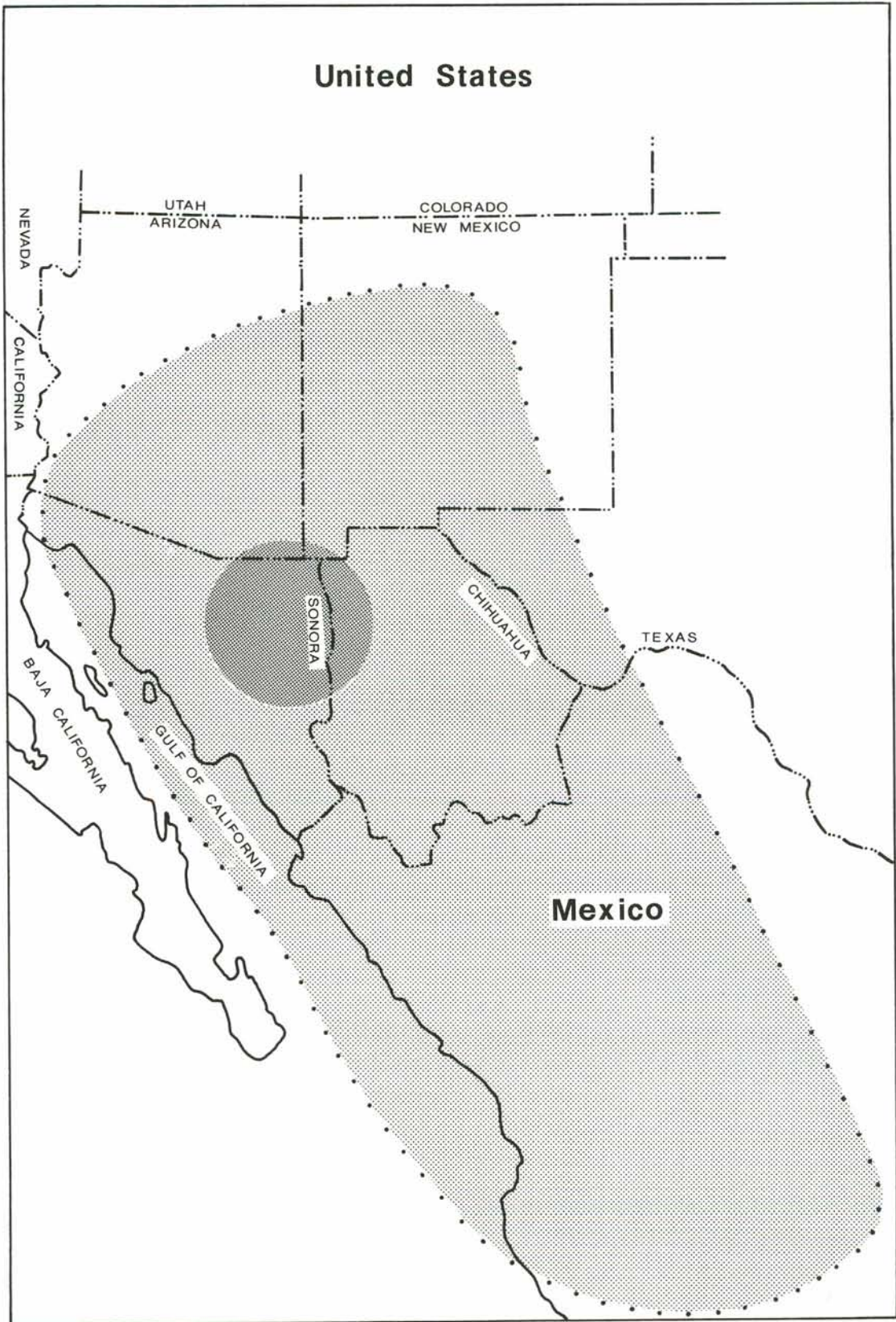


Figure 1A. Region in which effects of the 1887 earthquake were felt or observed.

INTRODUCTION

On May 3, 1887, a major earthquake shook much of the southwest United States and Mexico, an area of nearly two million square kilometers (Figure 1). This seismic event, with an estimated magnitude of 7.2 (DuBois and Sbar, in press), caused 51 deaths in northern Sonora, and major destruction of property in southeast Arizona, as well as adjacent portions of Mexico. Moderate damage also occurred in New Mexico.

The 1887 epicenter was south of the Arizona-Mexico border in the San Bernardino Valley along the western front of the Sierra Madres Mountains (Figure 1). The northern end of the fault scarp formed during this earthquake is located only eight kilometers south of the present town site of Douglas, Arizona. The fault extends over 50 kilometers southward, with an average observed vertical displacement of three meters. In terms of magnitude, surface faulting and damage, the Sonoran earthquake ranks among the largest seismic events on record in the western United States, exclusive of California. Historically, it is the largest earthquake known to have caused damage in Arizona.

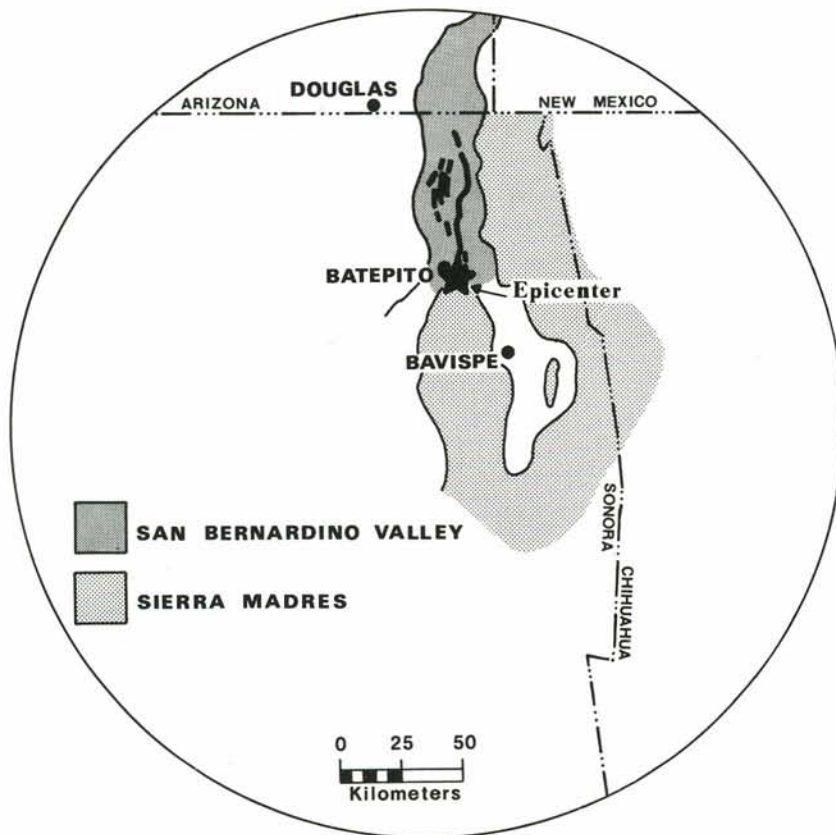


Figure 1B. Close up of epicentral area.

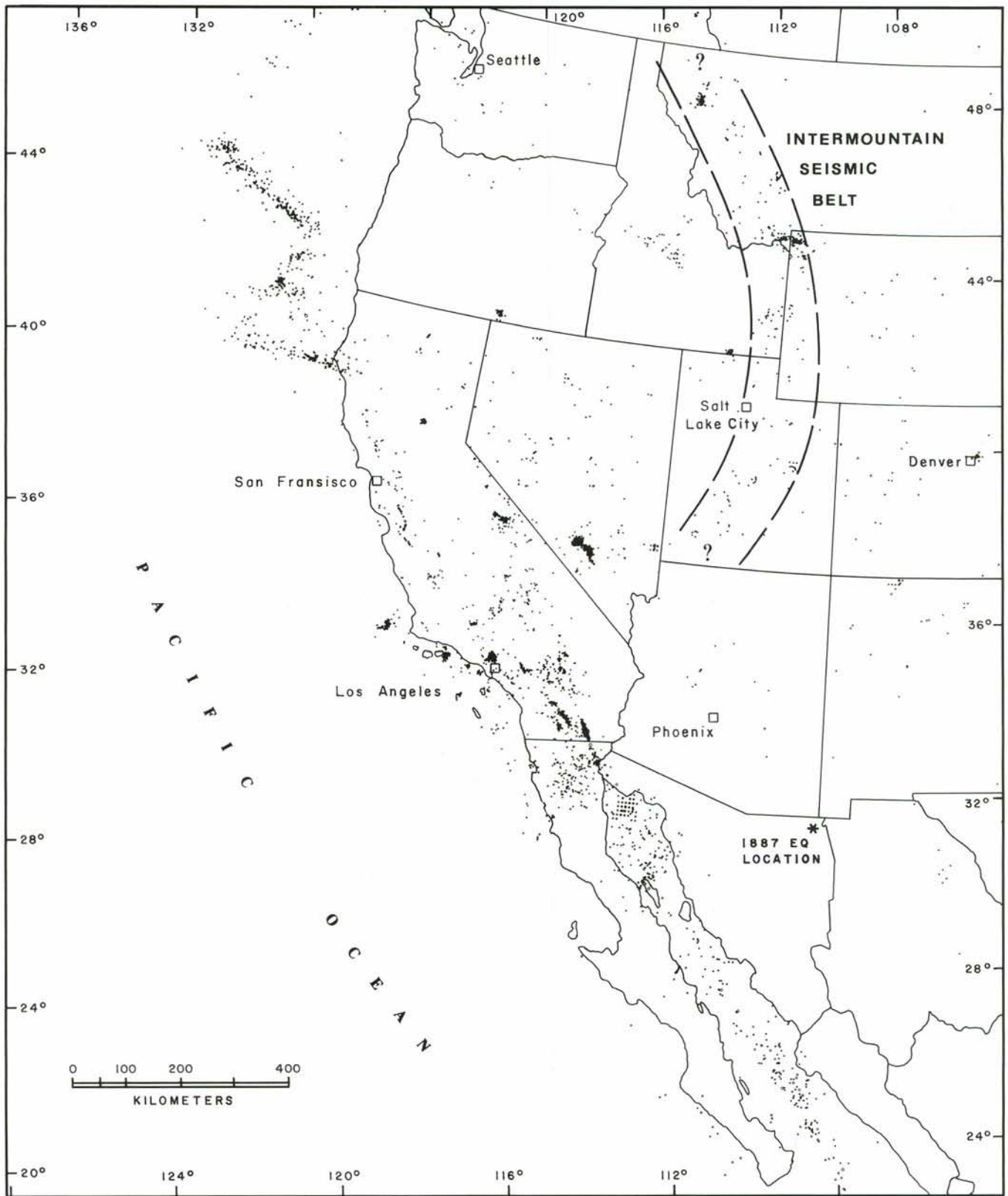


Figure 2. Western United States seismicity, 1966-1979. Epicenters with Mag. > 3 reported by 10 or more stations. Intermountain seismic belt is delineated (base supplied by NOAA). * denotes location of 1887 earthquake.

REGIONAL SETTING

The tectonic relationship of the 1887 earthquake to other features in Arizona and Mexico is unclear. Figure 2 shows epicenters of earthquakes with magnitude 3.5 and greater throughout western North America, between 1966 and 1979. The 1887 epicenter, superimposed on the map in Figure 2, does not correlate with the plate boundary marked by the San Andreas fault zone. The intermountain seismic belt, defined by Smith and Sbar (1974), is within the plate and follows the boundary between the Basin and Range and Colorado Plateau physiographic provinces in Utah, southeast Idaho and further north. However, the extension of this seismic zone south through Arizona and into Sonora remains questionable.

A seismicity map of Arizona compiled by Sumner (1976) shows epicenters of earthquakes that occurred between 1850 and 1976 (Figure 3). Revision of this map is forthcoming; much new information has been collected on the historical seismicity in Arizona (DuBois and Smith, in progress). Sumner postulates a seismic belt which extends northwest from the region of the 1887 earthquake through Arizona, ultimately joining the intermountain seismic belt. The epicentral data suggest that a region of low seismicity exists between the center of the state and the 1887 epicenter, indicating that strong evidence of a *continuous* seismic zone decreases southeast of Phoenix. However, the 1887 earthquake apparently was caused by reactivated normal faulting along a pre-existent Basin and Range fault, similar to other faults characteristic of southern Arizona and northern Sonora, including the region of low historical seismicity. Also,

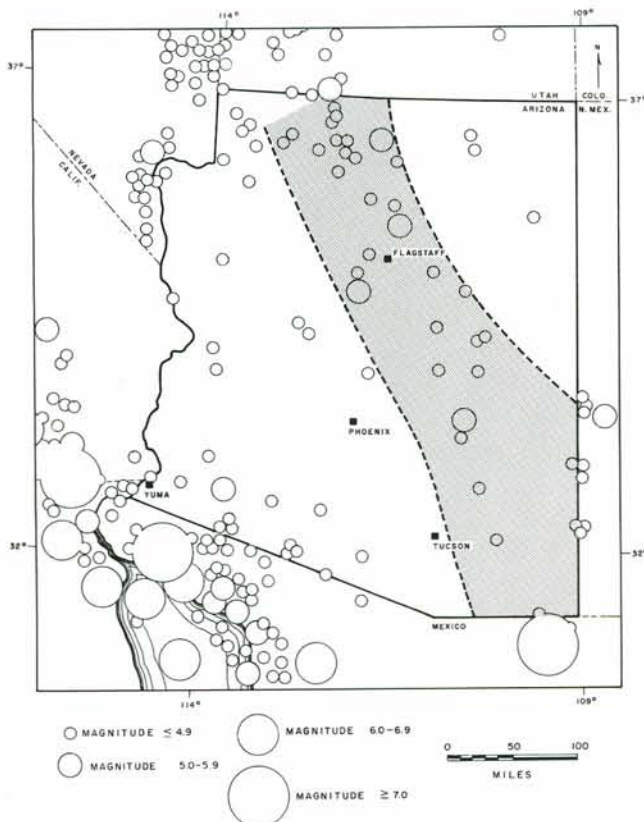


Figure 3. Map of historical earthquake epicenters and sizes in or near Arizona, 1850-1976 (from Sumner, 1976).

the period of historical record (130 years) is insufficient to establish that seismic activity has effectively ceased between Phoenix and the 1887 epicenter. Additional geophysical and geomorphic studies are needed to further assess the possible relationship of the 1887 faulting to the tectonic setting of southern Arizona.



4A

FAULT CHARACTERISTICS

Previous Field Studies

Faulting associated with the 1887 earthquake has been described by many previous workers. In 1887, Dr. George E. Goodfellow of Tombstone, Arizona and Professor Jose G. Aguilera of the Mexican Exploring Commission were sent by their respective governments to investigate the earthquake effects. Dutton (1904) and Richter (1958) later referred to the findings of these earlier scientists. Gianella (1960) studied the fault scarp in the late 1950s and returned to the site with Shakel (personal communication) in 1973 for a field reconnaissance trip.



Figure 4A & 4B. Aerial views of 1887 fault scarp in Sonora. Views northward. Fault begins roughly 8 kilometers south of Arizona border and continues 50 kilometers to and beyond Colonia Morales in the San Bernardino Valley. Photos courtesy of Peter Kresan.



Figure 5. View eastward of fault scarp. Photo taken soon after the 1887 earthquake, just south of the Arizona border. Photo courtesy of the Bisbee Mining and Historical Museum, Brophy Collection.

Since then, Natali, Sbar, DuBois, Bull and others from the University of Arizona have visited the scarp. Various seismic and geomorphic studies are currently in progress.

Fieldwork along the 1887 scarp has been hampered by unavailability of air photos, inaccurate roadmaps, extremely poor roads necessitating four-wheel drive vehicles or horses, isolation of the area from food and water supplies, difficulty in obtaining permission to work in Mexico, and inclement weather. Rainy seasons alternating with extremely hot, dry periods have considerably reduced the number of feasible working days in the field during the past century.

Observations and conclusions of various workers are summarized below.

Goodfellow (1888)

The 1887 scarp begins at the northern end of the San Bernardino Valley, a few miles south of the international boundary in Elias Creek, a tributary of the San Bernardino River. The general fault trend is north to south, although it has a winding course, following the tortuous, sinuous line of the base of the ranges extending to the Yaqui River, and approximately 20 miles into the Teras Mountains. Along this southern portion, the course of the scarp runs more directly into the heart of the mountains, no longer hugging their bases.

The average offset is a little over seven feet. At Pitaicachi Peak, the slip exceeds 20 feet. It is the only known location where offset bedrock, rather than alluvium, was observed. On the

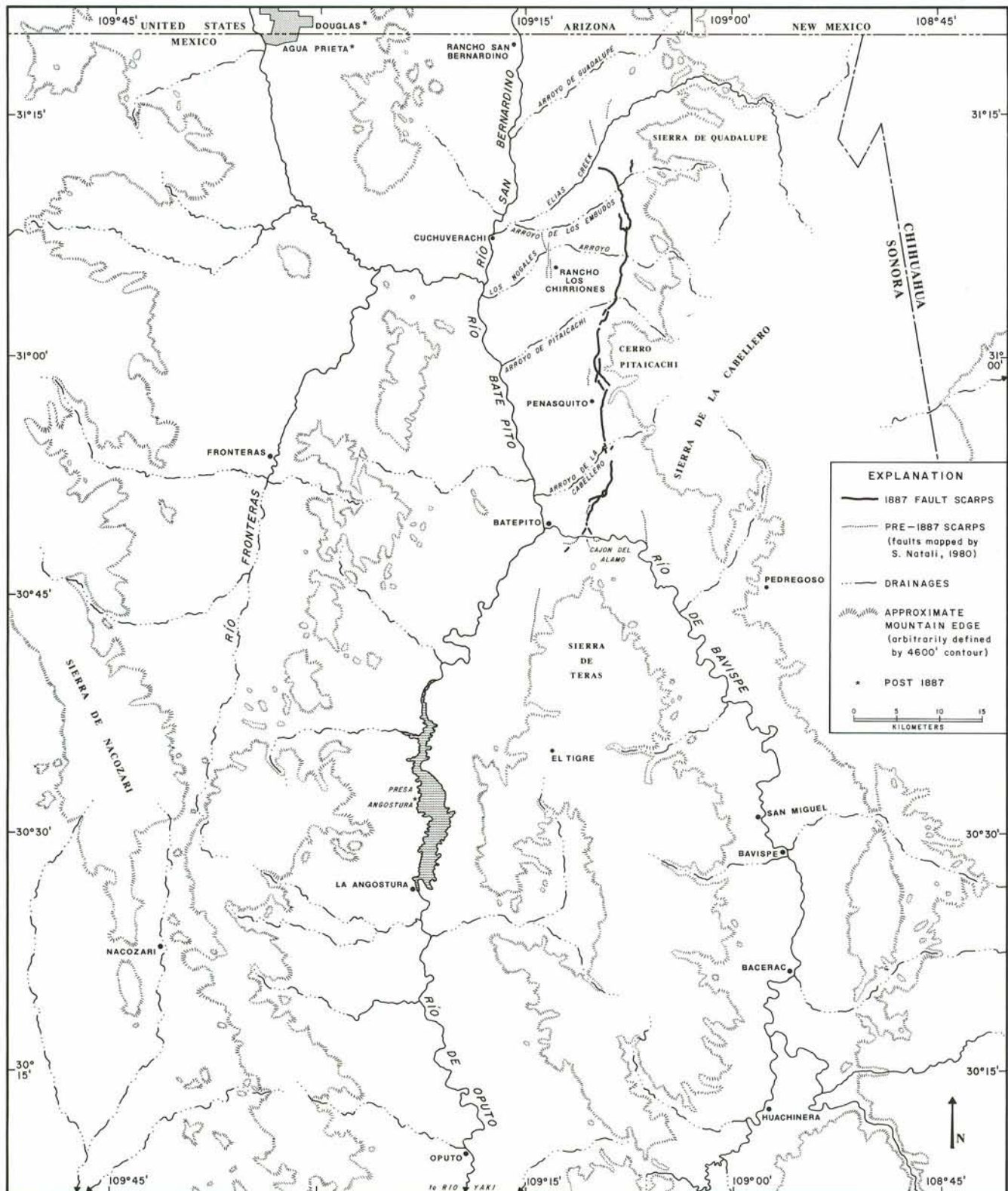


Figure 6. San Bernardino Valley and surrounding areas, in Sonora. Shown are local place names referenced in this chapter and in the Felt Reports.

Chihuahua side of the Espuelos Mountain and Pitaicachi Peak, a duplicate of the San Bernardino fault was reported by Colonel Kosterlitzky of Bavispe. Normal faulting occurs north of the Yaqui junction. However, two miles south of the junction, the hanging wall is elevated a trifle more than three feet.

Splays occur at each bend along the 1887 fault. Opposite the Cabellera Mountains, a triplicate division over a mile in length occurs. The appearance of the footwall of the slip in many places is a polished and striated surface, as if the same place had been the seat of similar perturbations in the past.

Aguilera (1888, 1920)

The fault begins 100 meters from the right (east ?) bank of the Bavispe River in Cajon del Alamo. It follows the slope of the small hills which is the northern continuation of the Teras Range. Further north, it appears as a sinuous line along the mountains of La Cabellera, Pitaicachi and Los Embudos.

At the fault junction with the Batepito road, the western wall has dropped 2.7 meters, with an observed dip angle of 75°. However, rains and aftershocks had undoubtedly altered the original inclination. At La Cabellera gorge, an 8 meter drop of the western wall and a N 20° W strike were observed. From La Cabellera Mountain to Pitaicachi Mountain the fault strike changes to N 22° W, always maintaining a 4 meter downthrow of the western side. At Los Nogales Arroyo, the fault bends, trending N 10° W. Vertical offset continues to range from 1.80 meters to 2.5 meters, with a dip of nearly 80° W. In Los Embudos Canyon, the fault runs N 30° W with a throw of 2.5 meters. At Guadalupe Mountains, the fault changes direction to N 40° W. It ends on the bank of the Cuchuverachi ravine with a N 42° W trend and about 0.20 meter offset.

The scarp is formed in alluvial drift. It is accompanied by a large number of second and third order fissures varying in length from a few meters to 2,000 or 3,000 meters. The second order cracks are either parallel to the main fault or they form acute angles with it, no greater than 15° to 20°. The direction of the third order fissure is nearly perpendicular to that of the main fault.

Gianella (1960, 1973)

[Douglas Shakel of Pima College has generously provided access to his personal collection on the 1887 earthquake. His file includes a letter from Vincent Gianella, dated March 15, 1973, from which the following information was taken.]

The fault extends southerly about 50 miles through the Cinco de Mayo mining district and beyond. Right-lateral movement of up to 20 feet displaces andesites and leaves scarps up to 20 feet high just northeast of Colonia Morales (formerly Batepito). Twenty miles north of the Bavispe River junction with the fault, scarps up to 21 feet were measured.

Faulting displaced bedrock at the surface and extended to and possibly north of the international boundary. From aerial reconnaissance, Gianella concluded that the 1887 fault continued south to the east of Presa Angostura and offset a road which probably led up to the El Tigre gold mine. Also there was an older fault associated with some mine at or near Cinco de Mayo.

Sumner (1977)

In December, 1972, the 1887 scarp was observed from the air along its 50 kilometer length. Study of air photos revealed numerous additional scarps not mapped by previous workers and paralleling the main fault trace. These scarps appear to represent active faulting over the previous several thousand years. They maintain vertical steps in alluvial materials.

Older scarps range from steep-sided steps to gentle changes in slope. No apparent lateral offset of stream channels or alluvial fans was observed across the fault scarps. The greatest number of scarps were observed between the 1887 trace and Hacienda Cuchuverachi, in the vicinity of Rancho Los Chirriones. All but one appear to have the downthrown side to the west.

A two-dimensional geologic model of gravity traverses shows a north-trending basin, 15 kilometers wide, filled with 3.5 kilometers of alluvial and lake deposits. The basin is bounded on the east by a fault coincident with the 1887 trace. The west side of the basin is less steeply bounded, indicating numerous smaller offsets over a wide area or a simple eastward tilt of the basement. A basement high underlies the west side of the valley, extending from the San Bernardino River westward for approximately 10 kilometers.

Current Studies

Based upon observed fault parameters (Figure 6), DuBois and Sbar (in press) have calculated a seismic moment of 7.9×10^{26} dyne-cm. Seismic network data collected and analyzed during 1978 and 1979 by Natali and others (1979) in the San Bernardino Valley provided the focal depth of 15 kilometers used in the *moment** calculation. The moment value was used to determine an estimated magnitude of 7.2 (DuBois and Sbar, in press).

Bull and others (personal communication) are studying soil profiles and terrace levels along the 1887 fault in order to estimate recurrence intervals for earthquakes over the past million years. Evidence of post-1887 seismic activity is also emerging from current studies (DuBois and Smith, in preparation; Natali and others, 1979).

*Seismic moment is a measure of the physical size of an earthquake. It can be estimated from physical parameters, such as fault displacement and area. A moment value appears to be the most accurate measure of earthquake size over the full range of earthquake sizes.



7A



7B.

Figure 7A & 7B. Close-up views of the 1887 fault scarp in Sonora showing two meter offset.

HISTORICAL ACCOUNTS

Sources of Information

A year-long search for documentation of damage and felt effects of the 1887 earthquake produced many contemporaneous accounts from a variety of sources: Newspapers, pioneer journals, Mormon diaries, military reports, scientific journals and personal correspondence. Data were most complete and most accurate from southern Arizona and northern Sonora, primarily because of the proximity to the earthquake center. The bulk of historical accounts was found at the Arizona Historical Society (Tucson), University of Arizona libraries and the Arizona State Museum (Tucson), the State Capitol Library and Archives (Phoenix), and the National Archives (Washington, D.C.). Geologists Doug Shakel, Peter Kresan, Dan Lynch and Anthropologist, Emil Haury contributed additional information from personal files.

Although some Mexican news accounts were investigated, very little effort was made to seek out other Spanish records. The meticulous task of translating Spanish Mission records might yield further information; Dr. Charles Polzer and students at the Arizona State Museum are currently indexing and cross-referencing these files. A major disappointment was the failure to locate the results of a United States Geological Survey questionnaire conducted soon after the earthquake and an original scientific report sent by Dr. George Goodfellow to Captain C. E. Dutton of the USGS.

Fortunately, several of the pictures taken by C. S. Fly, a photographer who accompanied Goodfellow during the 1887 investigation, have been found. They are published here, along with some photos by Arvisa, Cohn, Douglas and Eckhardt, courtesy of the Arizona Historical Society, the Arizona State Museum, the Bisbee Mining and Historical Museum and the Douglas Memorial Mining Museum. Additional photographs were provided by Ken Matesich, Peter Kresan, Wes Peirce, John Schaefer and the Arizona Bureau of Tourism.

Assignment of Intensity Values

Historical accounts of the 1887 earthquake collected over the past year have been analyzed. A maximum intensity value was assigned to each locality at which felt effects were reported.† The Modified Mercalli Scale of Intensity (Richter, 1958) and, when it seemed appropriate, modifications of the scale according to Brazee (1978) were used to rate the reports. An abbreviated version of the former is reproduced in Table 1.*

†The assigned value is based upon all accounts of earthquake effects at that locality (see Geographical Index for cross reference) which are included in the following felt report charts.

*Magnitude is an estimate of earthquake size based upon ground amplitude as measured on a calibrated seismograph, which is corrected to a particular distance from the epicenter. The relationship of magnitude to earthquake size becomes non-linear at large magnitudes, and therefore less reliable for assessing large earthquakes (> Mag. 7). Whereas the magnitude value quantifies the amount of energy released at the origin of the shock waves, intensities are assigned to measure observed surface effects at various points within the "felt" area of an earthquake. Intensity values vary according to distance from the epicenter, type of material at the site occupied by the observer, and the nature of intervening geologic structure (i.e., bedrock variations, faults, folds, etc.).

To avoid ambiguity of language, the quality of masonry, brick or otherwise, is specified by the following lettering: Masonry A, B, C, D. These letters have no connection with the conventional Class A, B, C construction.

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

- I. Not felt. Marginal and long-period effects of large earthquakes.
- II. Felt by persons at rest, on upper floors, or favorably placed.
- III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
- IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame crack.
- V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
- VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken.
- VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, tiles, cornices, etc. Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
- VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
- IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged; general damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.
- X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
- XI. Rails bent greatly. Underground pipelines completely out of service.
- XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Table 1. Modified Mercalli Intensity Scale of 1931, abridged and rewritten (from Richter, C. F., 1958, *Elementary Seismology*: W. H. Freeman & Co., p. 136–138).

Quality of Data

Accuracy and completeness of the historical accounts are variable, because of non-technical observations, lack of scientific instrumentation and contradictory and/or missing reports. Although words and phrases indicating direction (SE = southeast), measurement (km = kilometer) and quantity (100 = one hundred) have been abbreviated, an attempt was made to use quotations verbatim, in the charts and lists which follow, thus minimizing the tendency to alter, correct or interpret the data through paraphrasing. Local journalists in frontier settlements often wrote colorful and exaggerated news accounts. It is hoped that the modern reader will easily distinguish most of the facts from fiction. Appendix II discusses some reports which have been discounted as erroneous or false.

Charts of Felt Effects

A compilation of the felt reports follows. The charts have been arranged alphabetically by specific locality. Spanish place name modifiers, such as, 'Rancho,' 'Hacienda,' 'Sierra,' 'Cañón,' which normally *follow* specific names in English translation, were alphabetized according to English usage (for example, *Sierra Madres* is listed under "Madres," since the English sequence would read 'Madres Mountains.'

State and county names are listed, along with assigned Modified Mercalli (MM) Intensity (in Roman numerals). The actual felt effects have been excerpted and organized internally according to the following categories:

Most Commonly Reported Data:

- a) Time of earthquake occurrence
- b) Estimated or recorded duration
- c) Estimated direction of wave motion
- d) Reported sounds associated with shock wave

Observed or Felt Effects:

- A. Effects upon objects or buildings
- B. Reactions of or effects on animals and people
- C. Alterations of the physical environment (soil, surface drainage, groundwater, bed-rock, vegetation, etc).
- D. Miscellaneous effects reported

Within each of the above categories, an attempt has been made to list reports in order of increasing MM intensity. If reports were not found in a particular category, the appropriate letter was omitted from the list. Arabic numbers have been placed in parentheses at the end of each report to correspond with specific references in the source listing which begins on page 71 .

A cross-index of place names (p. 103), referenced in the following Felt Report section has been developed to assist the reader in locating all reports from a particular area (such as, New Mexico, Maricopa County or Sulphur Springs Valley). In addition, reports of geologic effects (surface faulting, hydrologic alterations, ground failure and mass movement) have been indexed.

Figure 8. Fissuring along a river valley between Tombstone, Arizona and Bavispe, Sonora. The earthquake left vertical displacements of one to two feet in San Bernardino, Fronteras and Sulpher Springs Valleys. Original photo by C. S. Fly, the photographer who accompanied Goodfellow to Sonora. Photo courtesy of the Arizona Historical Society, Tucson.



I FELT REPORTS

In this section, each location from which seismic effects were reported has been alphabetically listed, assigned an intensity rating and cross-referenced to types of effects and sources of observations. The first entry in the *Felt Reports* section can be interpreted in the following manner: ABBOTT'S RANCH, AZ, in Cochise County, reported local effects of the 1887 earthquake which rated a MM IX–XI intensity. Quotes describing each felt report at Abbott's Ranch are listed under the capital letter 'C,' indicating that all subsequent reports describe 'alterations to the physical environment' (see categories on p. 19 of *Historical Accounts*). Numbers directly following the quotes refer to the sources of each reported event (in *Historical Accounts*, part II, *Sources*, p. 71). For example, the entry, "The ground began to undulate (10), was found in source number 10 (i.e., E. Fay Bennett, 1977, *An Afternoon of Terror: Arizona and the West*, v. 19, n. 2, p. 107–120).

ABBOTT'S RANCH, AZ

Cochise Co.

IX–XI

C. The ground began to undulate.(10)

Thirty witnesses participating in cattle roundup saw rocks falling and the dust rising on the western side of the valley first, and some seconds later the same phenomena on the eastern side. (4)

In one place far up the mountainside a stream of pure water 10 inches in diameter is belching forth, and at present shows no sign of ceasing. (39b)

The stream which was 10 inches in diameter created a shallow lake a mile wide. (10)

Water came bubbling from the hillsides, from where water has never been seen. (39b)

The extent of the water line is about one mi at the present time. Sufficient water is running to supply 100,000 head of cattle. (39b)

The parched earth opened in every direction. (10)

Geysers of water spurted as high as 2 ft in places, and in a short time, filled the neighboring washes. (10)

One and a half mi from C. S. Abbott's house the water shot up into the air to a considerable height, about 4 or 5 ft in width, and extended fully 100 ft in distance. Today, the flow was decreasing very fast, but for miles the plains were covered with water. (38e)

AGUA PRIETA VALLEY, MX

Sonora

IX

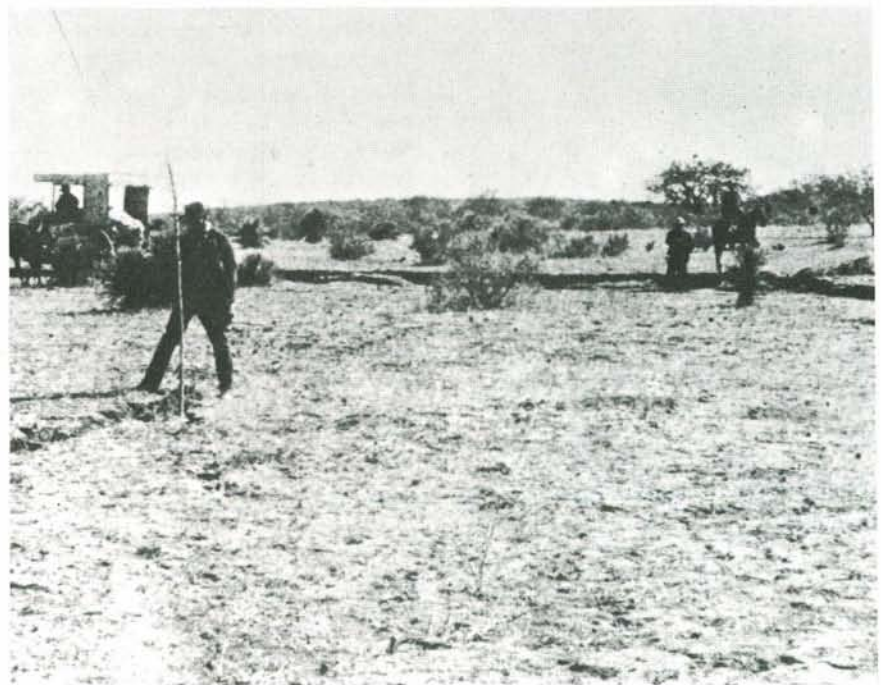
C. In the little valley of Agua Prieta are also found fissures 40 to 60 m long, with trends of N 37° W, N 55° W, and N 65° W, and with maximum width of 0.80 m, with dropping of the eastern border between 0.03 m and 0.50 m. Together with these and with parallel or slightly inclined fissures are other small cracks whose width scarcely exceeds a few centimeters. At the edge of the arroyo of Agua Prieta is another group of cracks whose direction is N 50° E, with the longest ones being 30 m with a maximum width of 0.50 m and a depth of 0.65 m, with exactly level borders. Together with these, at a distance of 50 m S, are smaller cracks, almost lines, running N and S. (7)

The valley from Porvenir to Agua Prieta had crevices in many places, spilling water forth in abundance, to the degree that it was like a flood which left the land swampy and impassable. (*Allc, A13*)



9A

Figure 9A & 9B. Effects of the 1887 earthquake near Agua Prieta Ranch. Eighteen inch vertical offsets along fissures formed by the earthquake. Original photo by James Douglas and party. Photo courtesy of Douglas Memorial Mining Museum, Jerome, Arizona (A) and Bisbee Mining and Historical Museum, Brophy Collection (B).



9B.

SIERRA LOS AJOS, MX
Sonora
VII

C. [The mountains] were covered with fire in their highest points [probably resulting from rockfalls]. (*Allc, A13*)

CAJON DEL ALAMO, MX
Sonora
XII

C. The large crack and slipping [fault] begins at a distance of 100 m from the right bank of the river Bavispe in Cajon del Alamo which connects the valley of Bavispe with that of Batepito. (8)

ALAMOS, MX
Sonora
III

B. Shocks felt (*25b*)

ALBUQUERQUE, NM
Bernalillo Co.
VI

- a. 3:13 pm (*25a, 38b*)
- b. 10 sec (*25a, 38b, 39a*)
- c. E-W (*25a, 38b, 39a*)
- A. Chandeliers vibrated. (*25a*)
Clocks in all parts of the city were stopped. (*25a*)
Plate glass windows of the First National Bank Building were cracked. (*25a*)
- B. Felt (*4, 23, A6*)
Horses were frightened. (*25a, 38b*)
People rushed into the streets. (*25a, 38b*)
People felt seasick. (*25a, 38b*)
- D. The earthquake consisted of two distinct but almost continuous vibrations. (*25 a, 38b*)

ALTAR, MX
Sonora
VII

- a. 2:45 pm (*39b*)
- b. 1 min (*39b*)
- c. N-S (*39b*)
- d. No noise except that of cracking walls (*39b*)
- A. Slight damage. (*39b*)
Walls running east and west show no marks, only the north and south ones. (*39b*)
All the two story and high single story walls were more or less damaged. (*39b*)
- B. No one was hurt. (*39b*)
Everyone was badly frightened and rushed into the streets. (*39b*)
- D. It consisted of two perceptible shocks, the interval between being two or three sec. (*39b*)

ARIVACA, AZ
Pima Co.
V

- b. 1 min (*38d*)
- c. W-SW (*38d*)
- d. Accompanied by a subdued roaring sound as of approaching wind or rumbling wagons (*38d*)
- D. Very distinct (*38d*)

ARIZPE, MX

Sonora

IX-XI

- A. The earthquake caused the fall of several houses, and cracks in many others including the church. (A13, A11c)
- C. Large boulders were seen falling from the tops of the mountains which raised clouds of dust upon reaching the bases. (A13)
In the plowed lands and low lying fields, various cracks/crevices were opened that had water flowing from them. (A13)

ASH CANYON, AZ

Santa Cruz Co.

VII

- C. The defile through Ash Canyon that was wide enough for a man on horseback simply disappeared. (28)

SIERRA AZUL, MX

Sonora

VII

- C. Smoke seemed to be coming from this range, as far as could be ascertained. (14e)

BABOCOMARI, AZ

Cochise Co.

VII

- A. The ranch house on the Babocomari was badly shook up and considerably damaged. (38c)
- C. A spring sufficient for the ranch house and for irrigation of a large garden dried up and never returned. (27)

BACADEHUACHI, MX

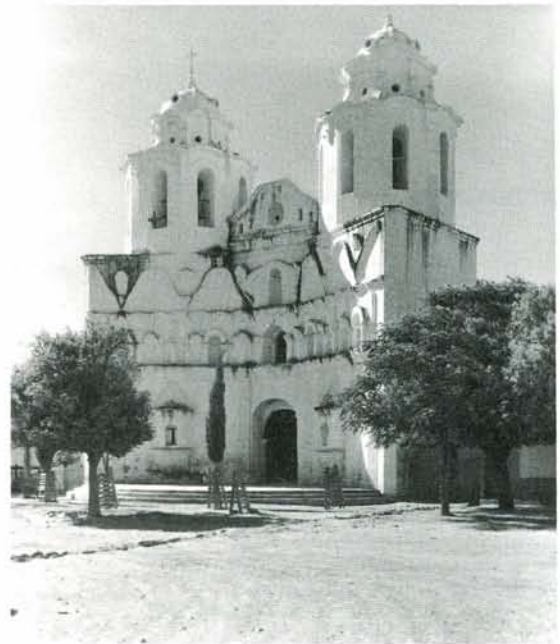
Sonora

VIII-IX

- A. Total damage was valued at 21,955.00 pesos. [See Table 2]
- C. In the range between Bacadehuachi and Granadas, there is a narrow line about halfway between the two towns where the rocks, shaley and crystalline, have been terribly broken up. (4)



10A



10B.

Figure 10A & 10B. The church of San Luis, Bacadehuachi, Mexico, after the 1887 earthquake (A) and in 1957 (B, original photo by Cohn). "It was severely damaged, but not completely destroyed." (A3) Notice that the reconstructed bell towers are only half the height of the former towers. Photos courtesy of the Arizona State Museum, University of Arizona, George B. Eckhart Collection, Tucson.

BACERAS, MX

AKA: Bacerac

Sonora

VIII-IX

- A. Town was uninjured (20)
Slightly damaged the buildings (A13)
The value of ruined crops was 5,301.00 pesos. (A11g)
The number of rooms destroyed was 435. The value of urban damage was 29,170.00 pesos, and of suburban damage, 12,752.00 pesos. The value of belongings lost was 8,976.00 pesos. (A11g)
Total damage was valued at 84,205.00 pesos. (A11g)
Suffered much damage (23)



Figure 11. Religious procession at Baceras, Mexico after the 1887 earthquake. Original photo by C. S. Fly. Photo courtesy of the Arizona Historical Society.

BACOACHI, MX

AKA: Bacoache

Sonora

X

- A. All the buildings were weakened. (A13)
The school, the church, and almost all the houses are in pieces. (A11c)
- C. Bernard MacDonald reported that shortly after the earthquake, he traveled the road that went through the old San Pedro custom house and along the easterly headwater branch of the Sonora River and the town of Bacuachi (sic). This road lies about 35 mi W of the Nacosari road, but it was just as badly fissured as was the Nacosari-Fronteras road. (26)
Large, deep holes were opened in the mountains, and in the river and the marshes, large crevices that threw forth torrents of water. (A13, A11c)

BADEHUACHI, MX

Sonora

IX

- C. Between the town of Fronteras and the ranch of Badehuachi are three fissures, trending N 80° W, forming a zone 15 m wide, sunken 0.40 m, 41 m long, and 0.35 m wide. (7)
From Badehuachi to Cuchuta are three cracks of which the largest is 80 m long, 0.25 m wide, 0.80 m deep; all of these have a common direction of N 20° E. (7)
The existing [springs] increased their volume of water considerably, water appearing in abundance even in those which were already dry because of the season. In *Badehuachi* and *Oputo*, because of the earthquake, three permanent sources of water in each village dried up. The volume of the water in the river increased considerably, because before the third there wasn't any more water in the irrigation ditches and canals and now there is. (A11g)
Between *Badehuachi* and Cuchuta, the whole area was covered with cracks and in many places the surface of the land has sunk. Water was coming from cracks in the ground and the hills were parted on their peaks. (A11c, A13)

BAROYECA, MX

Sonora

III

BATEPITO RANCH, MX**AKA: Batteto**

Sonora

IX-XI

BATEPITO RIVER VALLEY, MX

Sonora

IX-XII

B. Felt (13)

C. Fissuring is most marked about Batepito and Bavispe. (4)

Four in. of water covered an area two mi long by one mi wide immediately after the first shock. The flow ceased immediately after the shaking ended. (4)

D. The epicentrum of the earthquake is without doubt in the San Bernardino Valley in the neighborhood of Batepito and south. (A5)

C. The largest dislocations of the tremor are located on the eastern edge of the valley, between the Batepito River and the mountains. (10)

Among the phenomena that accompanied or followed the earthquake, the attention of the inhabitants of Sonora was called to the sudden, and unexpected increase in the flow of the tributaries of the Yaqui River, including the affluents (sic) of the Batepito, Fronteras, and Babispe Rivers and the appearance of some new springs and the disappearance of others. In speaking of the fissures we may be indicating the cause of this abundance of water in what is normally a dry season of the year in Sonora. The result of these small inundations of earth, which in some places have been greatly exaggerated, was the formation of light mist before sunrise in the days following the earthquake.

Most of the fissures have appeared in the valleys, in the immediate vicinity of the actual river channel; the most distant is scarcely 890 m from the river bank on land of diluvial (sic) deposits of sand and clay and always parallel to the course of the river. The most notable fissures are closest to the river, and the subsidence is proportionately greater as they are nearer to the river edge; by chance they form a kind of irregular series of steps distributed on the sides of the river bank. However, it is rare to find three successive depressions in the same direction; more frequently two are found, and rarely an isolated one.

On the eastern edge of the Batepito Valley, lying between the river of the same name, which runs the length of the valley, and the slope of the mountains that are a continuation of the Teras Range, the dislocations and other effects caused by the quake, are seen in their greatest intensity. It is in this part of the valley where we are able to place the epicenter of the seismic phenomena of May 3. On the valley floor, and very close to the left bank of the river, the ground is very irregularly fissured over an area of 2 sq. km. Here the vertical movements predominated over the horizontal movements, that is, the shock or percussion of the interior was transmitted vertically to the surface. Furthermore the land in this area has sunk and participated in the slipping that accompanied the opening of the great fissure or fault. (7)

BAVISPE, MX**AKA: Babispe**

Sonora

XI-XII

a. Reports varied: between 3 and 4 pm (14f), 3:50 pm (14f), midafternoon (7, 10), 3 pm (A13, A15)

b. The total duration of the strong shocks did not exceed 40 sec. The duration of the shocks was in proportion to their intensity, being 10 to 15 sec for the shock that toppled the buildings, and 5 to 10 sec for each of the succeeding earthquakes, and the intervals between shocks were very short—estimated not to exceed 4 or 5 sec. (7)

Thirty sec (A15)

c. The passage of the wave was from NW to SE, definitely inclined to the W. This last is accounted for by the interposition of the Teras Range between the epicentral region, which is NW of Babispe, and the town. The town of Babispe lies on the eastern slope of the range on a level area reached by the last branching spurs of the mountain as it invades the plain. (7)

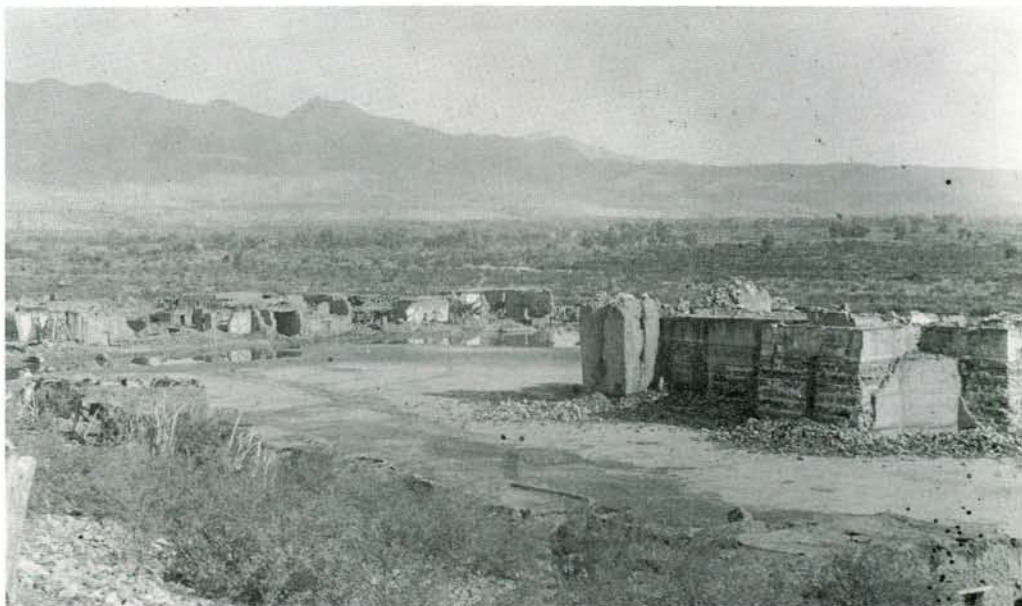
d. People heard a low subterranean roar, which seemed to come from the hills situated NW of Bavispe, then felt a sudden shaking beneath them. (7, 10)

A. Residences, stores and the church collapsed. (10, A15)

Bavispe was completely destroyed. (7, 20, 38i, 38j, A6)

The value of damage done to the church in Bavispe, constructed in the Gothic style, and to its ornaments and services, is estimated to be 60,000 pesos. (*Allg*)

There were all angles of emergence in one building—cracks ranging from ten degrees to vertical, with several diverging branches. Apparently the buildings are very substantial, being constructed of adobes 24×12 . These are laid double, which makes all walls 24 inches in width. The average height is 8 to 10 ft; only one in



12A



12B.

Figure 12A & 12B. Bavispe, Mexico destroyed by the 1887 earthquake. The town was situated on an elevated terrace approximately 30 feet above the main stream bed. View from two directions. Original photos by C. S. Fly. Photos courtesy of the Arizona Historical Society.



13A



13B.

Figure 13A & 13B. Church at Bavispe, exterior (A) and interior (B), after the 1887 earthquake. When the shakings began, many people rushed into the church whose walls separated, causing the roof to collapse. Presumably, most of the 42 deaths and 29 injuries occurred here. The walls had been constructed of adobe two feet thick. Goodfellow wrote: "The church is the most conspicuous monument of the devastating energy of the temblor. It was not, perhaps, as substantial a structure as some of our slighter but more civilized buildings, but it certainly could lay claim to the dignity of having withstood storms and prayers of at least two centuries." (4) Photos courtesy of the Arizona Historical Society (A) and the Arizona State Museum (B), University of Arizona, George B. Eckhart Collection.

the town having been greater, and that was 22 ft. The roofs are made by laying rafters, or 'vigas' as they are called, from one wall to the other; then covering these with cane, ocotilla (sic) or brush, and that with mud, to a thickness of at least six in. This makes an extremely heavy roof, but certainly the most suitable one for the climate. Above the vigas is built a slight coping, or fire wall; and at intervals are openings with wooden troughs to permit the passage of rain water.



Figure 14. In writing about the destruction at Bavispe, Goodfellow stated, "The remains of the building with the four corner posts standing are those of an exceptionally built one; and a very lucky exception it was in this case, for it saved the lives of four persons who were in it at the time." (4) The original of the photo shown was taken by C. S. Fly. Presumably, the building referenced above is the same as those remains appearing in the photo. Photo courtesy of the Arizona Historical Society.

Of the dwellings destroyed, the major portion were on the northern and eastern side of the plaza. All walls facing the plaza on its west side whose linear direction was north and south were thrown down, falling toward the east. These were from eight to 20 ft in width, averaging probably 10 ft. Of the houses on the south side of the plaza, which lie at the junction of the terrace on which the town is, with the foot of the mesa above, none were seriously damaged. They were more or less cracked, but were not prostrated.

The destruction of life was, in my opinion, largely due to the style of architecture. The walls were not held together. In some instances I found the north-and-south walls had separated and let the vigas down into the house on one side. This involved motion of at least a ft. The walls two ft thick, viga laid to cover the entire width was obliged to slip that distance before it could drop. The horizontal cracks at the base of the walls indicated the motion. All damage was done by the first shock. Of the walls thrown down, with two or three exceptions, all fell to the westward, though the upper portion of a few of the east-and-west walls had toppled over towards the south. Walls over 12 ft in length, with their linear axis east and west, suffered entirely in the east and west corners. Where they were shorter, they were thrown down, falling indifferently north or south. The characteristic damage received by all houses not prostrated was in the corners. (4)

It can be readily seen that the number of dwellings demolished is less in the western section than in the eastern section; and the dwellings situated north suffered more than the dwellings to the south.

Considering the walls one by one and taking into account only their orientation, it can be seen that those that ran E–W resisted the shock better than those running N–S. The order in which the walls should be listed, in terms of their destruction, is: 1st, the eastern walls of those buildings that had almost totally collapsed; 2nd, the western walls in the east part of town that fell in equal quantity as the eastern walls, but that in the west part of town offered slightly more resistance; 3rd, the southern walls whose destruction exceeded by a little the northern walls.



Figure 15. Bavispe, Mexico. Destruction rendered by the 1887 earthquake. Original photo by C. S. Fly. Photo courtesy of the Arizona Historical Society.

Invariably the walls running N–S fell to the E, and more frequently to the S for those walls running from E–W. Between these last are some walls, in the southern part of the plaza, which fell to the N—as though there had been a reflection of the ground wave against the hill which bounds Babispe in the latter direction.

On some walls the cracks were vertical, single on the lower part and forking in the upper part on meeting a row of bricks and thus forming a Y. The bricks offered more resistance than the adobe of which most of the dwellings are constructed in northern Sonora. At other times the cracks took an oblique direction; on one such wall the cracks had an inclination of 10°, 30°, and 45°, which in some cases were accompanied by other vertical cracks. All the inclined cracks dipped constantly towards the east.

I had no opportunity to see the truncations of building corners, but I did see much in the walls oriented from E–W and always on the eastern corner of the wall and never on the western. (7)

The number of rooms destroyed was 692. (A11g)

The ruins are considerably greater in the NW and the SW, while in the opposite direction, things are not nearly so bad. (A11g)

The value of damage done in Bavispe and San Miguelito was 133,994 pesos. (A11g)

B. Movement produced a kind of seasickness or vertigo. (7)

Thirty-five to 40 people were buried in the ruins and several were injured in the towns of Bavispe and Opusura. (17c, 38j)

Thirty-five deaths and 39 wounded, some fairly seriously (A13)

Thirty-five dead, 208 wounded (A15)

Forty-two killed, 25 injured (23)

Forty-two lost their lives and 29 suffered serious injuries. (7, 10, 20, A11g)

Forty-eight lives are reported to have been lost. (1)

Many of the people at the first shock rushed wildly to a church, which soon fell upon them. Forty-eight were killed and 58 injured, many gravely. (A7)

The entire population is said to be destroyed. (39b)

Editorial Note: See Appendix II for discussion of total casualties.

- C. The hills flamed up, burning the grasses and woods almost totally. (*Allg*)
 Large rocks continue to fall in high parts of the mountains. (*Allg*)
 Deep cracks appeared in the streets. (*10*)
 The principal openings in the ground are in the NW and SW, and there are also smaller ones in the E and W direction. (*Allg*)
 In the mornings and in the afternoons there is fog much like you see in seaports. (*Allg*)
 Deep pools of water now stand where once were the happy homes of three families. (*36a*)
 The ground sank in several places, and water flooded the depressed areas. (*10*)
 It took a relief pack train nine days to go a distance of 40 mi because the country between Huasabas and Bavispe is broken up by rents and chasms. (*36a*)
- D. The center of the shock seems to have been at San Bernardino, Batetto and Bavispe, with headquarters at Bavispe. (*36a, 45*)

BAVISPE RIVER VALLEY, MX

Sonora

VIII-XI

- C. Rock falls were also common on the watershed of the Bavispe Valley. (*7*)
 Opening of numerous fissures, generally N or NE in direction, from many of which water flowed abundantly. River swelled to volume usual in rainy season of summer. Fields had become green and air moist with prevailing fogs. (*23*)
 There is plenty of fissuring of the solid rock in many other places but no faulting. This is the case south of the bend of the Bavispe River as well as elsewhere. [the fault, however, extends south of this bend]. (*45*)
 The valley has apparently sunk from 2 to 4 ft above Bavispe and for some distance below. (*20*)
 [On the banks of the Bavispe River] abysses had opened with a width of 2-3 m and an unknown depth, from which hot water jetted, with *tongues of fire* which burned the neighboring vegetation; the woods of the mountains surrounding Bavispe caught on fire immediately. At the same time, the water in the river, where the water level had increased notably, had become muddy and almost boiling. (*415*)

BEAR SPRINGS, AZ

Cochise Co.

VII

- C. Bear Springs, near Ft. Bowie, are no more, the earthquake having knocked the bottom out of them. (*37e, 38e*)

BENSON, AZ

Cochise Co.

VIII

- a. Reports varied: 2:00 pm (*10, 25b*), 2:10 pm (*37a*), 3:10 pm (*37b*), 2:12 Pacific time, equal to 2:55 local time. (*47*)
- b. Reports varied: 2 min (*37b*), nearly 3 min (*1*)
- c. E and W (*37a*)
- A. Clocks stopped. (*37a*)
 Roger Bros. store suffered most, in comparison to other buildings in Benson (*37b*)
 Several buildings were damaged by serious cracks. (*14b, 39a*)
 The two-story adobe occupied by Johnny Colburn has a crack from four to six inches in the NE corner. The back of the building is slightly cracked. (*36c, 37a*)
 The Clark Bros. store is badly cracked. The brick front is still in good shape but the adobes suffered very much, in fact worse than any other in town. (*36c*)
 A Southern Pacific engine on the turntable was moved forward and backward with the brakes set. (*10, 14b, 25b*)

Losses are estimated on each building at from 200 to 1,000 dollars. (14b, 25b)
W. W. Baldwin, who owns most of the county buildings, sustains a loss of about \$1,000. (14b, 25b)

- B. Sleepers were aroused. (37a)
Women and children rushed from their homes. (37a)
People rushed frantic from their homes. (10, 25b, 37b)
The undulatory motion was sufficient to produce seasickness. (1)
A falling brick from K. of P. hall struck Mrs. Fountain on side of head cutting scalp badly. (37b)
- C. The motion was described as a rocking or heaving of the soil, unattended by violent shocks. (A7)
Cracked the ground in some places. (39a)
Not far from Benson several fresh streams of water were started out of crevices made by the shock. (38b)
The water supply in some instances was cut off entirely and others augmented. (39a)
- D. The motion of the earth was distinctly visible beneath the feet. (1)

BISBEE, AZ
Cochise Co.
VII-VIII

- a. Reports varied: 3:12 pm (37b), 2:20 pm (37b)
- b. Reports varied: 1½-2 min (37b), over 90 sec (23), 10 min (37b)
- c. Reports varied: from the NW (37b), from an easterly direction (37b), S-N (23), general E and W direction (1)
- d. There was rumbling and grumbling. (37b)
From the first sound it seemed as if heavy artillery had turned loose. (37b)
- A. Glass rattled in the windows at a fearful rate. (37b)
Billiard balls rolled from the racks. (37b)
The damage was slight. (37b)
Houses rocked as a cradle. (37b)
Dishes and bottles fell to the floor and smashed. (37b)
Plaster fell from walls and slight rents were made. (1)
A lantern chimney broke. (37b)
The Catholic church received a large crack in one corner. (37b)
Chimneys were thrown down on the surface. (34)
The foundation of the large Corliss engine was thrown slightly out of line. (1, A7)
Foundations were disarranged so as to require the resetting of engines. (34)
Ruptured adobe walls, though no house was thrown down (A1, A7)
- B. No lives were lost. (37b)
People rushed to the streets. (37b)
People were afraid to enter their stone and adobe structures for some time. (37b)
Miners 400 ft below the surface felt the shock plainly. (37b)
Underground the shock was felt and great alarm created but no racks or timbers were dislodged. (A1, A7)
- C. Stones tumbled down mountains' sides. (37b)
Clouds of dust were raised. (37b)
Some smaller boulders from nearby hills reached upper streets of the town. (37b)
The surface of steeper waste dumps seemed to be actually in motion, rocks were in many places dislodged and thundered down the hillsides in a cloud of dust. (1)
It was violent enough to dislodge loose rock from the waste heaps, to crack a slag dump resting on alluvial soil. (A1, A7)
The evening of the earthquake every mountain range within sight of Bisbee was on fire. (A1)

D. Little damage was done in the mines, where there were many miles of underground workings, including many large cavernous open stopes in the limestone, with little timbering. (34)

In Bisbee, and other towns built on the rocky range between the two valleys, a violent trembling of the earth was felt, accompanied with at least two distinct shocks in the interval of less than two min. (23, 47)

BISCUIT MT., AZ

Cochise Co.

VIII-IX

C. Biscuit Mtn. in the Mustang Hills is a monument to what an earthquake can do to a forested peak. (28)

BLOXTON'S RANCH, AZ

Santa Cruz Co.

VIII-IX

B. The earthquake gave the folks in that neighborhood quite a fright. (38j)

C. Thousands of tons of rock were shaken loose from the mountains and precipitated down the mountains. (38j)

BOLSON DE MAPIMI, MX

Chihuahua

III

B. Bolson de Mápimi was the eastern limit of the felt area. (7, 10)

BOWIE, AZ

Cochise Co.

VIII

B. The horses on the Globe stage fell on their knees and noses when it struck them. (17a)

BOX CANYON, AZ

Cochise Co.

VIII

C. Ramsey Peak in the Huachucas was left naked as its burden of soil and trees crashed down into Box Canyon. (28)

BUENAVISTA, MX

Sonora

III

B. Felt. (A13)

BURRO HILL, MX

Sonora

IX-XI

C. To the north of Baceras at a distance of 3,350 m along the road to Bavispe, is a series of cracks that occupy a zone 250 m wide between a low hill called Burro Hill and the left bank of the Bavispe River. These crevices form sinuous lines with a general direction of N 5° W, and some have a length in excess of 100 m. The largest is 170 m long; the greatest width is 5 m, and greatest depth 3 m. (7)

LA CABELLERA, MX

Sonora
XII

- C. The fault is somewhat closer to the rocks at this location, although succeeding rains and consequent temporary torrential flow [June 1887] has rapidly evened the break. (4)

The crack has a strike of 20° NW–SE with a width of two to three m and its western wall is depressed eight m. (8)

The great fault appears as a curving line on the slopes of La Cabellera, Pitaycachi, Los Embudos and Guadalupe Mountains. (8)

CABULLONA, MX

Sonora
V

- B. They felt the earthquake with much force. (A11c, A13)

SIERRA CABULLONA, MX

Sonora
VII

- C. Large rocks fell from the hill in Cabullona producing large noises. (A11c, A13)
Continued to spew forth smoke on the 5th of May (A11c, A13)

CALABASAS, AZ

Santa Cruz Co.
VII

- a. 2:10 pm (38b, 39a)
A. Houses were shaken very badly. (38b, 39a)
B. No one was injured. (38b, 39a)

GULF OF CALIFORNIA, MX

III

- B. The Gulf of California was the western limit of the felt area. (10, A5)

CALLEJON, MX

Sonora
IX–XI

- C. At Callejon, about 200 m from town, are the largest and deepest fissures in all the longitudinal (sic) valley in which are located the villages of Huachinera, Bacerac, and Bavispe. The dimensions of the largest are: length 270 m, width 4 m, and depth 3 m. According to what I was told by the inhabitants of these places, all the cracks emitted water accompanied by a fine yellowish sediment. I was able to see this at the sides of the walls of the fissures. It is a very fine sand identical to that of the river which passes by at a distance of 800 m. It was carried by the water which gushed out of the new openings immediately following the strong shock which began the series of earthquakes that have not yet ended. (7)

CAPE HARO, MX

Sonora
VI–VII

- C. A portion of the western side of Cape Haro, at the entrance of Guaymas Bay, fell into the gulf. The lighthouse was uninjured. (25b, A13)

CARR CANYON, AZ

Cochise Co.
VII

- C. Large boulders were loosened by the earthquake, some of which struck one of the Huachuca Water Company's mains and destroyed it. (37b)

CARRETAS RANCH, MX
Chihuahua
VII

C. Several important springs on the eastern side of the mountains, opposite Babispe in Chihuahua, were increased in size, notably Penuelas on the Carretas Ranch. (4)

CASAS GRANDES, MX
Chihuahua
VII

- a. 3 pm (A12c)
- b. 2 min (A12c)
- A. Many houses were left on the verge of ruin. (A12c)
- B. Felt the earthquake strongly. (A13)
- C. Grass fires were started by falling rocks in the mountains south of town. (14g)

CENTERVILLE, CA
Fresno Co.
?

- a. Reports varied: 7:12 am (25a), 8:12 am. (37b)
- c. N-S (25a, 37b)
- d. Preceded by a heavy rumbling explosion. (25a, 37b)

Editorial Note: This earthquake was reported felt in San Francisco. It is likely that a separate shock close to Centerville occurred, unrelated to the Sonoran earthquake, judging from times and intensities reported elsewhere.

CHARLESTON, AZ
Cochise Co.
IX-XI

- b. 30 sec (10, 31)
- A. The walls of the saloon did a two-step and the floor did a shimmy. (40)
Every window was smashed. (28)
Almost every house left standing had badly cracked walls. (10, 27, 28)
Much damage done to buildings (38c, 40)
Several walls of old adobe buildings were cracked, the cavity in some of them being from 3 to 5 in. wide. (37b)
Somewhat more dilapidated than it was before the catastrophe. A few more adobes out of place and the plastered walls are perhaps more mottled than they were. But even the shakiest house did not fall, one disreputable abandoned structure was rendered so dangerous that it has been deemed wise to pry it over since. (1)



Figure 16A. Charleston, Arizona, ca. 1890: "The earthquake left no building safe to live in. Already on the decline, this event helped to herald the end of Charleston." (31) Original photo by C. S. Fly. Photo courtesy of the Arizona Historical Society.

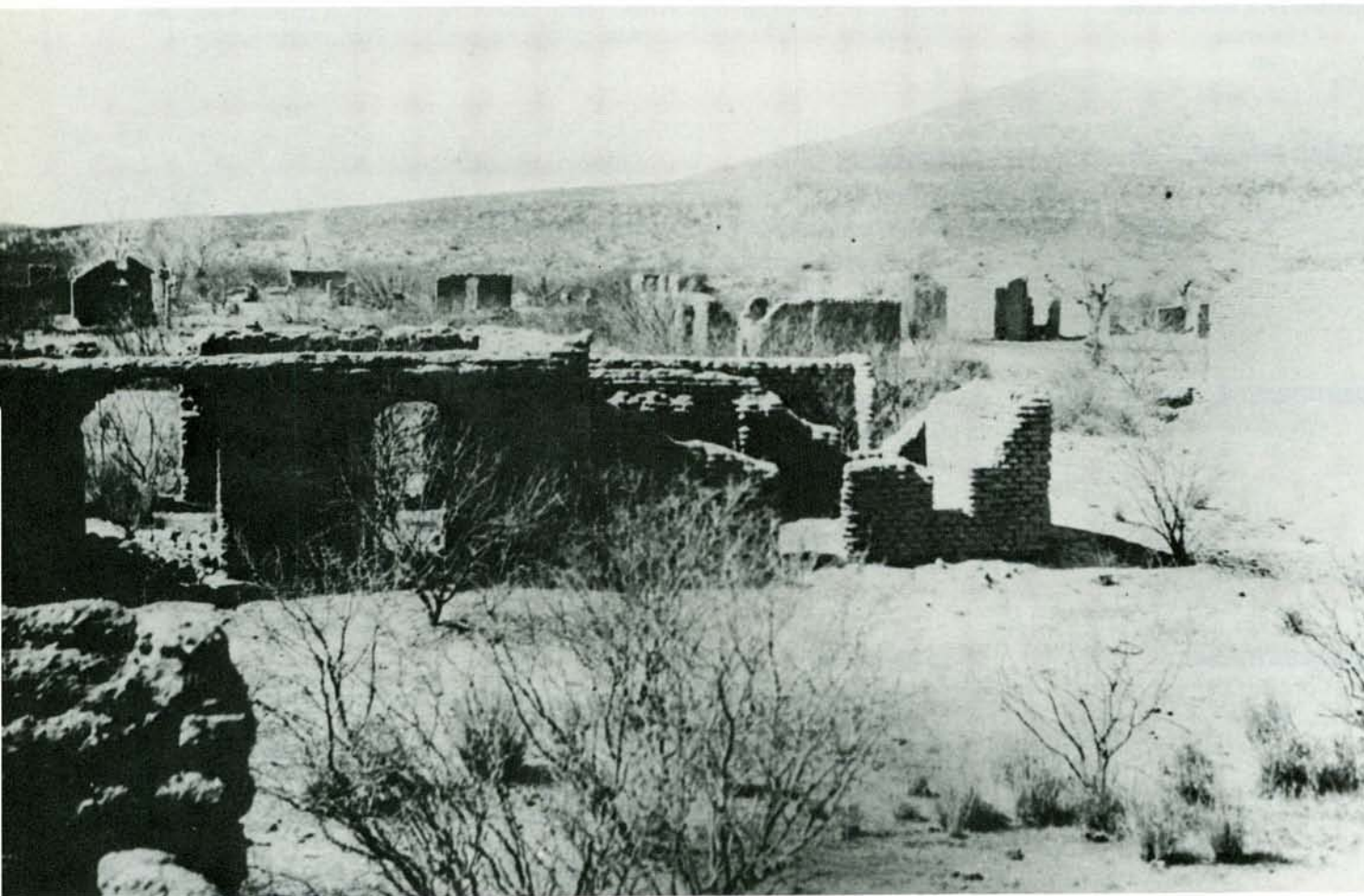


Figure 16B. Charleston, Arizona in the 1880s. Photo courtesy of the Arizona Historical Society.

The crumbling of adobe walls into fine bits created a veritable Kansas dust-storm. (40)

No building was left intact, not one was safe to live in. (31)

Leveled a number of adobe houses. (27)

B. No one was injured. (27, 10)

Everyone within the saloon did a breakneck for the street. (40)

People shrieked in terror. (40)

C. Boulders crashed down the mountain sides striking sparks and setting fire to grass up and down the valley. (10, 31)

Smoke hung over the valley for days. (31)

Ashes sifted to the earth and blanketed the river until the fish floated belly-up. (31)

Water spurted from cracks in the earth. (10, 31)

Spring-fed streams suddenly stopped flowing. (10, 31)

Large vents were left in the ground, some as much as four ft wide and 10 to 30 ft in length and some 15 ft in depth. (27)

Quaked violently (10, 31)

D. Rains which came later washed soil away from fire-weakened grass roots. Thorny brush replaced it, and the land was no longer suitable for cattle ranching, and the cattlemen soon left. (31)

CHIHUAHUA CITY, MX
Chihuahua
V

- a. 3:17 pm (A12c, A13)
- b. 4 sec (A12c, A13)
- c. E-W (A12c, A13)
- A. The towers of the parish church were moving in a manner suggesting their imminent fall. (A12c)
- D. An oscillating earthquake (A13)

Editorial Note: Aguilera gives Chihuahua City an intensity rating of V on his isoseismal map of the event. (7)

CHIRICAHUA MTS, AZ
Cochise Co.
VIII

- C. The shake precipitated torrents of big rocks down off the big Chiricahua Mts. just to the E of us; these rocks set the mountains on fire. (A14)

CHIVATO MTS., MX
Sonora
VII

- C. One minute after the first quivering sensation the highest cliff of the Chivato Mountain fell, causing a cloud of dust to rise like smoke from the explosion of a large amount of powder. (25b, 38b)

CINCO DE MAYO, MX
Sonora
XII?

- C. The fault has been traced 12 mi S of the Bavispe River through Cinco de Mayo mining district and beyond. (4, A4)

CLIFTON, AZ
Greenlee Co.
?

- D. Effects of the earthquake were visible as far north as Clifton. (26)

COCHISE'S STRONGHOLD, AZ
Cochise Co.
VII

- C. Since the earthquake, the water in Cochise's stronghold is said to have entirely disappeared. (37e)

COLORADO RIVER, AZ
Yuma Co.
III

- B. At its junction with the Gila River, it was the western boundary of the felt area. (10)

CORRALITUS MINING CO., MX
Chihuahua
VII-VIII

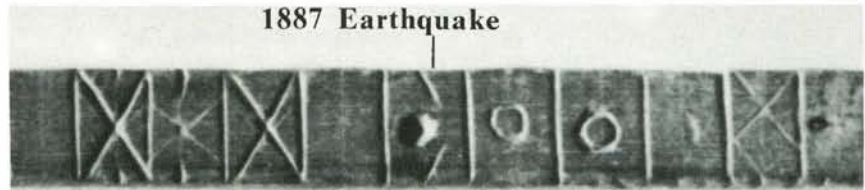
- A. The houses were shaken up a little, and most are cracked at the corners. (14g)
- B. I have heard of no persons injured in this part of the state. (14g)
Most people sleep in the plaza. (14g)
- C. Springs have broken out in several parts of our property, where water poured up several feet. These springs subsided as the violent shocks ceased. (14g)
An abundant spring had opened. Previously a small one of little importance had existed which had dried up some time ago. (A13)
Heavy hot rocks rolled down from the mountains, and set the grass on fire. (14g)
- D. Strong quake. (A13)

COYOTE MTS., AZ
Pima Co.
VII

- B. The earthquake was felt strongly by the Papago Indians living in Pan Tak. (22)
- C. A rockfall was reported in the Coyote Mtns. (22)



17A



17B.

Figure 17A & 17B. Papago calendar stick, representing 1875–1940. Saguaro, and later, wood sticks, were used by the Papago Indians as calendars. Each section represents one year, and contains symbols invented by the owner to record various events. The line above the photo indicates the year 1887 on the calendar stick. As explained by the owner of the stick, the mark signifies the first large earthquake at Coyote Village or Pan Tak, near Kitt Peak. Photos courtesy of the Arizona State Museum, University of Arizona.

Editorial Note: The debris which fell in 1887 was shown to Emil Hauray in 1938 by a Papago eye-witness.

CRITTENDEN, AZ
Santa Cruz Co.
VI

- a. 2:13 pm (38b, 39a)
- A. No serious damage was done. (38b, 39a)
Pictures fell off walls. (27)
Dishes crashed to the floor. (27)
- B. People rushed from their houses. (27)

HACIENDA DE LA CRUZ, MX
Sonora
IX

- C. Many fissures were formed, among which two are of much interest. The largest trends N 38° W with a length of 180 m, a width varying from 2 cm to 1 m, and a maximum depth of 2.25 m. The walls dip 80° to the SW. The other fissure is 20 m N of the former; it is 70 m long with a maximum width 50 cm, and the depth varying between the same limits as the first and it runs N 35° W and dips SW with the same inclination. (7)

There are also other cracks of smaller dimensions from 5 to 10 m, whose direction is not the same as the two larger fissures but which cut them perpendicularly; and there are others that join the big ones at angles of 10° to 15°. The cracks form a large zone of 10 m in width, and are 800 m from the bank of the Oputo River. (7)

CUCHUTA, MX
Sonora
IX

- C. From Badehuachi to Cuchuta are three cracks of which the largest is 80 m long, 0.25 m wide, 0.80 m deep; all of these have a common direction of N 20° E. (7)

CUCHUVERACHI, MX

Sonora

IX–XII

- C. [The surrounding mountains] were covered with fire in their highest parts [probably caused by rockfalls]. (A11c, A13)

Between the end of the great fault and the Guadalupe gorge are found other cracks that are as long as 200 m, with variable width from 0.20 m to 0.60 m and trending N 60° W for the first one encountered on leaving the gorge of Cuchuverachi; the second is situated on the hill and trends N 10° W, and the last one we found following an arroyo of Cuchuverachi towards the S and almost in the bottom of the ravine with a strike of N 20° E. (7)

The northern end of the fault is found in the edge of the ravine of Cuchuverachi. The depression is scarcely 0.2 m, the depth of the crack is 7.5 m. (8)

CUMBERO MESA, NM**AKA: Cubero Mesa**

Valencia Co.

VI–VII

- B. Three sheep herders were reported killed by the earthquake. (26, 38d)

Editorial Note: See Appendix II for discussion of this questionable report.

- C. Rockfall occurred. (26, 38d)

CUMPAS, MX

Sonora

VIII–IX

- A. Four houses were destroyed. (18)

The church fell down and 10 houses. (A11c)

- B. No one was hurt. (18)

- C. There is a stream known as the Eye of Water (Ojo de Agua) with which residents watered their fields. For some time now, it has been dry and apparently because of the earthquake, it sprang forth again. (A11b)

- D. Cumpas was badly racked by the shock. (37e)

DAVIDSON'S CANYON, AZ

Pima Co.

VII

- C. Water flow in Davidson's Canyon has doubled in quantity. (38j)

DELICIAS, MX

Sonora

VIII

- A. Falling rocks were scattered among 150 persons. (14f)

- B. No one was hurt. (14f)

At the mine [Santa Elena], the earthquake caused great panic. (14f)

- C. The whole hill fell down. (14f)

DEMING, NM

Luna Co.

VII–VIII

- A. Several buildings were badly cracked. (32)

One building, which was only partly finished, will have to be taken down. (32)

- B. Felt (30a)

Many townspeople ran out of their homes and seemed very much alarmed. (141)

Persons were thrown to the ground. (32)

DIEZ, MX

Chihuahua

VII

- a. About 3:00 pm (33)

- b. 3 min (33)

- c. Vibrations were E and W. (33)

- A. Many dwellings were badly cracked. (33)

- B. The settlement was thrown into quite an excitement. (33)

- D. The shock was severe. (33)

DRAGOON MTS., AZ

Cochise Co.

VIII (-IX?)

- d. A great noise like the report of numerous cannons was heard near the top of the mountain. The explosions continued. (38e)
- B. Men and burros fled. (38e)
- C. The noise was followed by an immense volume of smoke arising. (38e)
There were forest fires. (27, 43)
Huge boulders were hurled down the mountainside. (38e)
A large crevice was reported to be present in the mountainside. (38e)

DRIPPING SPRING RANCH, AZ

Gila Co.

V?

- D. The earthquake was at the ranch in force. (38d)

DUDLEYVILLE, AZ

Pinal Co.

IV-V?

- D. The earthquake gave them a grand shake-up. (37e)

DURANGO, MX

Durango

IV

- B. Felt as far south as Durango (A2)

Editorial Note: Aguilera gives Durango an intensity rating of IV on his isoseismal map of the event. (7)

EL PASO, TX

El Paso Co.

VII-VIII

- a. Reports varied: 3:08 pm (10, 25a, 37a, 39b), 3:15 pm (14a, 14h), 3:15:32 pm (14k), 2:20 pm (14i), 2:30 (14l)
- b. Reports varied: 2 min (10, 14i, 25a, 37b, 39a), 1 min 12 sec (14k), 1-5 min (14h)
- A. The clock in the County Clerk's Office and the District Court Room both stopped, as did many others about the city. (14a)
Little property damage. (10)
Caused the old Court House dome to "shimmy" (13)
The Court House was not damaged. (14k)
The shock caused the roof of the Court House to rattle like a thousand tin pans. (14i)
Shook books off table in courtroom (10)
Hanging articles oscillated. (25a, 10, 37b, 39a)
Windows, chandeliers, and glassware rattled. (14a)
Chandeliers swayed rapidly to and from (sic). (14h)
Plaster fell in the Freudenthal Store. (14i)
A little plaster fell from the ceiling of the school house. (14a)
The motion of the building swung the massive doors of the Sheriff's safe wide open. They had been closed but not bolted. It faced south. (14a)
The doors to Mr. Rothchild's enormous safe stood open and were swung shut. (14a)
Big pieces of steel in the Sheldon Building could be heard scraping together as the naked structure swayed with the vibrations of the earthquake. (14i)
Rocking motion of the houses, like the motion of a boat in a chopping sea (14a)
The new Bronson block which is said to be one of the best built in the city, shows many cracks. (14a)
The floor rocked up and down. (14h)
A huge crack was left in the Central High School. (14j)
The walls in many buildings cracked and walls of adjoining buildings grated together with an ominous sound. (14a)

The chimneys and flagstaff of the Court House swayed back and forth, some say a few inches each way, while others place the distance at three or four ft. (14a)

The dial on the north side of the cupola was bent out of shape. (14a)

The front wall of the old Mundy Building bent and writhed like the body of a huge snake. (14a)

The rear wall of the Joseph Schultz Building was so badly cracked and racked that it had to be propped up with timbers. The wooden casing of the windows were smashed and bricks fell. (14a)

Central school was examined and reinforced by columns. (14k)

Myer Opera House was condemned. (14k)

B. Eastern boundary of felt area (A7)

Felt 60 mi east of El Paso (4)

Occupants of the crowded court room, being panic stricken, stampeded into the street. (13, 14a)

Women meeting at a church rushed out. (14k)

Everybody rushed out of doors. (10, 14a, 25a, 39a)

Streets filled quickly with frightened people who came out of doors like a swarm of bees. (14a)

One girl fainted at the Central school building, and one boy jumped from an upstairs window. (14k)

One man reported feeling himself swaying. (14i)

One of two scholars were hit by plaster which fell from the ceiling of the schoolhouse. (14a)

The motion made many persons quite sick, the illness resembling sea sickness. (10, 14a, 14k)

C. The ground was rolling under our feet like the rocking of a boat on a choppy sea. (14a)

D. An earthquake was in full swing. (14i)

Many noticed the smell of sulphur 2 min before the shock. (10, 25a, 37b, 39a)

The shock reached its greatest intensity at 3:15:36. [It began at 3:1:32 and ended at 3:16:44.] (14a)

The shock was a gentle upheaval of the earth with a wavelike motion—just like you feel when the old liver isn't perking right, and the ground undulates when you walk. (14k)

It existed 2 min, from the first verticle oscillation perceptible, such as was experienced at the Times Office, which passed several sec before the horizontal oscillatory movement [which] was so discernable. (14a)

The roadbed and track appeared uneven and wavy to people on the Santa Fe passenger train from El Paso to Silver City, NM. (14l)

ELGIN, AZ

Santa Cruz Co.

VI-VII

a. 3 pm (27)

b. 2 min (27)

c. W-E (27)

d. Loud murmur somewhat like the ocean but more awesome (27)

A. Trees and houses began to quiver and shake. (27)

Water splashed out of buckets and pans. (27)

C. A heavy haze appeared in all directions. (27)

It did not at first seem to weave, but looked like the earth was dancing up and down and then in a few moments the trees began to wave back and forward very rapidly. (27)

All the mountains in view had forest fires, including the Patagonia Mtns., the Santa Ritas, the Huachucas, the Dragoons, the Whetstones, the Rincons, and the Santa Catalinas. (27)

In the mountain sections streams were dried up in 24 hrs. (27)

ELIAS CREEK, MX

Sonora
XII

- C. The earth has sunk from 10 to 30 ft all along the way between Elias Creek and Batetto Ranch. All the old trails leading over the mountains have been destroyed. The sink is so broken that no traveler dare go across it. (36a)
The fault begins in Elias Creek, a tributary of San Bernardino River a few mi south of the Arizona line. The fault curves eastward on the south bank of the creek. (4, 10)

ELISU ARROYO, MX

Sonora
XII

- C. The fissure passes some 300 ft to the W of this small canyon, below a stratified mass of shaley rock which rises abruptly at this point. [The canyon is a short distance north of Pitaicachi]. (4)

LOS EMBUDOS CANYON, MX

Sonora
XII

- C. Here the fault begins a North-South trend. (4)
The fault has a direction of 30° NW-SE and the depression is not more than 2.5 m. (8)

SIERRA LOS EMBUDOS, MX

Sonora
VII

- C. Covered with fire in their highest parts [probably caused by rockfalls] (A11c, A13)

EMPIRE RANCH, AZ

Pima Co.
IX

- C. One spring in the vicinity went dry, and three others doubled their volume, but on cessation of the disturbance, the dry spring recommenced flowing. (14f)
The earth's open water (sic) was thrown to a great height. (14f)
A fissure was reported. (14f)
The earthquake made a crack in the earth from which mud and water issued. (38g)

ERIE CATTLE CO. RANCH, AZ

County unknown
VIII-IX

- A. Several buildings were reported shaken down. (37e)

ESPUELOS, MX

Sonora
?

- C. According to Colonel Kosterlitzky, of Sonora, a duplicate fault exists on the Chihuahua side of the Espuelas (sic) and Pitaicachi. (48)

FAIRBANK, AZ

Cochise Co.
IX

- A. H. B. Addington's house swayed. (37b)
Many houses were greatly damaged. (38c)
The railroad track of the Atchison, Topeka and Santa Fe road, at a point where it ran in an E-W direction, was bent 4½ in. out of line, the convexity looking south. The bend was about 300 ft in length. (18)
- C. Embankments along the railroad moved as much as 12 in. (38c)
Kimballs Lake near Fairbank was completely dried up in 20 min after the shock. (37b, 38c)

FT. APACHE, AZ
Navajo Co.
VII-VIII

- a. 3:11 pm (29a)
- b. Reports varied: 1 min 30 sec (29a), 3 min (17a, 37b, 38a, 39a)
- c. S-N (29a)
- A. Clocks stopped. (37b, 38a)
Goods on shelves of the post sutler store were shaken to the floor. (37b, 38a, 39a)
Considerable damage was done to the post buildings. (37b, 38a, 39a)

FT. DAVIS, TX
Jeff Davis Co.
III

- B. Felt at Ft. Davis; eastern limit of felt area (A2)

FT. HUACHUCA, AZ
Cochise Co.
VII

- b. 2 min (37b)
- A. No particular damage was done to the post. (15)
Beyond cracking the hospital walls, none of the other buildings at the post were injured by the earthquake. (37e)
Other than the falling of plaster in some of the government buildings, only the hospital was damaged. (37b)
Cracks in the hospital walls are so large that daylight shows through plainly. (37b, 38c)
Every building has been damaged. (38c)
- B. No one was injured. (37b)
- C. The woods are on fire on the north range. (39a)

FT. MCDOWELL, AZ
Maricopa Co.
VI-VII

- a. 2:55 pm (29b)
- b. Reports varied: 30 sec (29b), 70 sec (37c)
- B. A large majority of the population rushed into the streets. (25a)
- D. The earthquake was felt at El Paso, Deming, Tucson, Yuma, Phoenix, and McDowell. It seemed heaviest at the latter place. (30a)

FT. THOMAS, AZ
Graham Co.
V

- a. 3:12 pm [MST] (29c)
- b. 1½ min (29c)
- c. Apparently S-N dying away with very easy E-W motion (29c)
- d. Slight rumbling (29c)
- A. Rattled crockery (29c)
Swung field glasses and other articles quite strongly (29c)
- D. Moderate earthquake. (29c)
Undulating motion (29c)

FT. VERDE, AZ
Yavapai Co.
O

- B. Not felt (25a, 29d)

FT. YUMA, AZ
Yuma Co.
III

- B. Western boundary of the felt area (7)

ELIAS CREEK, MX

Sonora
XII

- C. The earth has sunk from 10 to 30 ft all along the way between Elias Creek and Batetto Ranch. All the old trails leading over the mountains have been destroyed. The sink is so broken that no traveler dare go across it. (36a)
The fault begins in Elias Creek, a tributary of San Bernardino River a few mi south of the Arizona line. The fault curves eastward on the south bank of the creek. (4, 10)

ELISU ARROYO, MX

Sonora
XII

- C. The fissure passes some 300 ft to the W of this small canyon, below a stratified mass of shaley rock which rises abruptly at this point. [The canyon is a short distance north of Pitaicachi]. (4)

LOS EMBUDOS CANYON, MX

Sonora
XII

- C. Here the fault begins a North-South trend. (4)
The fault has a direction of 30° NW-SE and the depression is not more than 2.5 m. (8)

SIERRA LOS EMBUDOS, MX

Sonora
VII

- C. Covered with fire in their highest parts [probably caused by rockfalls] (A11c, A13)

EMPIRE RANCH, AZ

Pima Co.
IX

- C. One spring in the vicinity went dry, and three others doubled their volume, but on cessation of the disturbance, the dry spring recommenced flowing. (14f)
The earth's open water (sic) was thrown to a great height. (14f)
A fissure was reported. (14f)
The earthquake made a crack in the earth from which mud and water issued. (38g)

ERIE CATTLE CO. RANCH, AZ

County unknown
VIII-IX

- A. Several buildings were reported shaken down. (37e)

ESPUELOS, MX

Sonora
?

- C. According to Colonel Kosterlitzky, of Sonora, a duplicate fault exists on the Chihuahua side of the Espuelas (sic) and Pitaicachi. (A8)

FAIRBANK, AZ

Cochise Co.
IX

- A. H. B. Addington's house swayed. (37b)
Many houses were greatly damaged. (38c)
The railroad track of the Atchison, Topeka and Santa Fe road, at a point where it ran in an E-W direction, was bent 4½ in. out of line, the convexity looking south. The bend was about 300 ft in length. (18)
- C. Embankments along the railroad moved as much as 12 in. (38c)
Kimballs Lake near Fairbank was completely dried up in 20 min after the shock. (37b, 38c)

FT. APACHE, AZ

Navajo Co.
VII-VIII

- a. 3:11 pm (29a)
- b. Reports varied: 1 min 30 sec (29a), 3 min (17a, 37b, 38a, 39a)
- c. S-N (29a)
- A. Clocks stopped. (37b, 38a)
Goods on shelves of the post sutler store were shaken to the floor. (37b, 38a, 39a)
Considerable damage was done to the post buildings. (37b, 38a, 39a)

FT. DAVIS, TX

Jeff Davis Co.
III

- B. Felt at Ft. Davis; eastern limit of felt area (42)

FT. HUACHUCA, AZ

Cochise Co.
VII

- b. 2 min (37b)
- A. No particular damage was done to the post. (15)
Beyond cracking the hospital walls, none of the other buildings at the post were injured by the earthquake. (37e)
Other than the falling of plaster in some of the government buildings, only the hospital was damaged. (37b)
Cracks in the hospital walls are so large that daylight shows through plainly. (37b, 38c)
Every building has been damaged. (38c)
- B. No one was injured. (37b)
- C. The woods are on fire on the north range. (39a)

FT. MCDOWELL, AZ

Maricopa Co.
VI-VII

- a. 2:55 pm (29b)
- b. Reports varied: 30 sec (29b), 70 sec (37c)
- B. A large majority of the population rushed into the streets. (25a)
- D. The earthquake was felt at El Paso, Deming, Tucson, Yuma, Phoenix, and McDowell. It seemed heaviest at the latter place. (30a)

FT. THOMAS, AZ

Graham Co.
V

- a. 3:12 pm [MST] (29c)
- b. 1½ min (29c)
- c. Apparently S-N dying away with very easy E-W motion (29c)
- d. Slight rumbling (29c)
- A. Rattled crockery (29c)
Swung field glasses and other articles quite strongly (29c)
- D. Moderate earthquake. (29c)
Undulating motion (29c)

FT. VERDE, AZ

Yavapai Co.
O

- B. Not felt (25a, 29d)

FT. YUMA, AZ

Yuma Co.
III

- B. Western boundary of the felt area (7)

FRONTERAS, MX

Sonora

X-XII

- b. 3 min (1)
- c. W-E (1)
- A. Ten houses demolished, and not one left standing. (18, 37g)
A number of buildings, some more than 100 yrs. old, collapsed instantly. (1, 10)
In Fronteras some houses were destroyed. Their walls fell toward the W. (7)
Nearly all the houses were destroyed. (17c, 37e)
Seventeen houses were destroyed completely and the rest are in sad shape. (A11c)
- B. Two women badly injured (37g)
Several were injured. (10)
A single death was reported at Fronteras. (A7)
One person killed—a young girl who was buried in the ruins (10, 37g, 38j)
One child was killed, and one woman fatally injured. (1, 18)
- C. Below Fronteras, huge boulders were hurled from the mountain sides. Clouds of dust rose in the air. (37e)
[Within] about 1,000 yards from the edges of town, the ground is covered with crevices. Of these, about 40 of them have water flowing from them, more or less abundantly. (A11c, A13)
- D. Three shocks were felt. (1)
The principal line of disturbance passes through Bavispe, Oputo, east of Fronteras, and through San Bernardino Ranch. (A5)

FRONTERAS RIVER VALLEY, MX

Sonora

IX-XI

- a. Shock felt about 3:00 (18)
- A. Property damage: \$78,115 (A1)
- C. Mountain fires were seen immediately succeeding the shock. The entire valley is believed to have subsided a little. (18)
[The valley] was severely cracked up. (4)
There was a sudden and unexpected increase in the flow of the tributaries of the Yaqui River, including the affluents (sic) of the Batepito, Fronteras, and Bavispe Rivers and the appearance of some new springs and the disappearance of others. (7)
Extending the entire length of the valley, over 100 mi, are fissures varying in width from a few in. to ten ft, having a northerly and southerly direction. (18)
The river dried up for a moment, but then water started flowing again in great quantity; so much that the persons who were on the other side from the town who wanted to come see their families couldn't get across. Ojo de Agua increased its volume of water by more than 200%. (A11c, A13)
Openings of numerous fissures occurred, generally N or NE in direction, from many of which water flowed abundantly. River swelled to volume usual in rainy season of summer. Fields had become green and air moist with prevailing fogs. (23)
The ground shows huge rents in the valley, some of them 10 ft wide, and from six to eight inches in depth. Dozens of smaller cracks, varying from four to eight inches in width. (37e, g)
Water forced up through cracks in many places, with a red sand of a quality not seen before in that vicinity. (37e, g)
The road to Tombstone was fissured by wide, deep cracks in places. There were several new springs and water holes, and at places the road was turned to quagmires (sic). (26)
In the San Pedro and other places, springs have flowed forth that have flooded the San Pedro and Fronteras valleys. (A11b)

RIO FUERTO, MX
AKA: Rio Fuerte

- B. Felt from mouth of Rio Fuerte to mouth of Colorado River (A2)

III

HACIENDA LA FUNDICION, MX

Sonora

IX-X

C. In the Hacienda La Fundicion, to the E of Bavispe, there are numerous cracks that have a width of 1.30 m, 1.15 m deep, and 60 m long with a trend of N 40° W. (7)

GALEANA, MX

Chihuahua

VIII

a. 3:00 pm (A13)

b. 23 sec (A13)

A. The houses and the churches suffered greatly. (A13)

HACIENDA DE LA GALERA, MX

Sonora

IX

C. In the Hacienda de la Galera three great cracks run N 45° W outlining a block of earth 15 m wide which has sunk 60 cm. (7)

GILA BEND, AZ

Maricopa Co.

III

B. Felt (7)

GILA COUNTY, AZ

VII

C. Huge boulders were precipitated from cliffs. (17a)

GILA & COLORADO RIVER JCT., AZ

III

B. Felt (10)

GILA CROSSING, AZ

Maricopa Co.

V

B. It was noticed by many of our people [Pima Indians], if not by all. (6)

GLOBE, AZ

Gila Co.

VI-VII

a. Earthquake shocks were felt here at 3:11 pm. (10, 37b, 39a)

b. Vibrations lasted 20 sec. (14b, 17a, 37b, 39a)

c. Vibrations N-S (17a, 37b, 38a, 39a)

A. The shock did little local damage. (10, 39b)
Stopped pendulum clocks (10)

B. The earthquake emptied our population from their houses into the streets. (10, 17a)
Caused sickness to the stomach (39b)

GRAHAM MTS., AZ

Graham Co.

VII

C. At the moment of the shake, great clouds of dust were seen to rise from three to four places on Graham Mountains. (38d)

GRANADOS, MX

AKA: Granadas

Sonora

IX-X

A. [Town] greatly damaged (17c, 38j)

Demolished the majority of the houses. (A13)

Most of the houses fell down and the ones that didn't end up in ruins are in such bad

condition that no one dares live in them. (A11c)

Total damage was valued at 31,390.00 pesos. [See Table 2]

- B. No loss of life is reported. (17c, 38j)
- C. Beginning near the San Bernardino Ranch, at the Arizona boundary, river-bed cracks and downthrows exist as far S as Granadas, which was as far S as Good-fellow traveled. (4)
In the area of Oputo, Granados, Bacadéhuachi, Nácori and Guásabas, generally various sources of water remained salty. Upon digging holes in some parts, the soil is loose, and in other areas, water has been found spilling out after digging only 9 or 10 in. (A11g)

GUADALUPE, MX

Sonora

XII

- C. The fault changes its direction to 40° NW–SE and begins to form a large curve whose mean tangent has a direction of 55° NW–SE. (8)

GUADALUPE GORGE, MX

Sonora

XI

- C. Between the end of the great fault and the Guadalupe Gorge, are found other cracks that are as long as 200 m, with variable width from 0.20 m to 0.60 m and trending N 60° W for the first one encountered on leaving the gorge of Cuchuverachi; the second is situated on the hill and trends N 10° W, and the last one we found following the arroyo of Cuchuverachi towards the south and almost in the bottom of the ravine with a strike of N 20° E. (7)

GUANAJUATO, MX

Guanajuato

II

- D. *Editorial Note:* Aguilera gives Guanajuato an intensity rating of II on his isoseismal map of the event. (7)

GUASABAS, MX

AKA: Huasabas

Sonora

IX

- A. [Town] greatly damaged (17c, 38j)
Most of the houses were demolished and no one dares live in the others. (A11b, c, A13)
Total damage was valued at 18,000.00 pesos. [see Table 2]
- B. No loss of life is reported. (17c, 38j)
Many people were crippled in the ruins. (A11b)
- C. Rockfalls were common on the watershed of Guasabas. Wherever the water ran out of the openings in the earth, a white layer of salt or saltpeter, has been left. N of *Guasabas* in the highest part of the Cerros del Urudemo and Cerro de Carrizales, from a rock that was opened up, a fairly large stream of water is flowing. In the Cerro de la Puente, the whole thing is spilling water. All the openings in the earth that run from S–N and also in the river, where they are considerable, were made by currents of water. (A11g)

GUAYMAS, MX

Sonora

IV

- a. 2:45 pm (25b, 38b, 39a)
- b. Lasting a few seconds (25b, 38b, 39a)
- c. Direction was E and W (25b, 38b, 39a) N–S (A13)
- A. No damage reported (25b, 38b, 39a)
All clocks stopped. (25b, 38b, 39a)
The lighthouse was uninjured. (25b)
- B. Felt (4, 14b, A6, A13)
- D. Two earthquakes were felt, with short intervals. (25b, 38b, 39a)

GUERRERO, MX

AKA: Concepcion

Chihuahua

VII

- a. 3:18 pm (*A13*)
- A. Caused cracks in churches and other buildings (*A13*)
- B. Some 7 min in advance, an oscillating and vibrating earthquake was felt. (*A13*)

HARSHAW, AZ

Santa Cruz Co.

VI-VII

- A. Pictures fell off walls. (*27*)
Dishes crashed to the floor. (*27*)
- B. People rushed from their houses. (*27*)

HERMOSILLO, MX

Sonora

VII

- a. 3:50 pm (*A11a, A13*)
- b. Lasting maybe 2 min, not more (*39b*), 25–30 sec (*A11a, A13*)
- d. Accompanied by subterranean noises (*A11a, A13*)
- A. Plastering fell. (*39b*)
Buildings rocked and swayed as if about to fall. (*37b*)
Some cracks occurred in houses which were not very solid. (*A11a*)
Many houses were thrown down. (*37b*)
No other damage done (*39b*)
- B. Ladies jumped and ran from house to house. (*39b*)
- D. Vibrating earthquake—light at first and later stronger (*A13*)

HUACHINERA, MX

AKA: Guachinera

Sonora

VII(-IX?)

- A. Slightly damaged the buildings (*A13*)
Some of the houses fell down. (*A11b*)
The commissions of Guachinera, Estancia, and Galera estimated that 206 rooms were damaged and calculated the value at 4,006.00 pesos. (*A11g*)
- B. No deaths (*A11b*)

HUACHINERA VALLEY, MX

Sonora

VII

- C. Rockfalls were common on the watershed of Huachinera Valley. (*7*)

HUACHUCA MTS., AZ.

Cochise Co.

IX-XI

- a. 3:10 pm (*14c, 15*)
- b. Lasted 3 min (*37a*)
- c. Seemed to be SE-NW (*15*)
- B. Deer, coyotes, rabbits and cattle were running in different directions. (*43*)
- C. Had forest fires (*27*)
The rocky ledges along the sides of the mountains rose up and fell outward, breaking into all sizes of boulders. The friction of the rocks set fire to the grass. (*43*)
The ground began to ripple and wave. It rose in billows to a height of two or three feet and would then drop almost in its old place, but leaving pronounced cracks. (*43*)
On way to Charleston, he saw sheets of water spurting into the air near the river. (*43*)
Canyons which had small streams dried up, some had water return in 12–15 yrs, but some never did return. (*27*)
- D. The shock passed through the range twice. (*14c, 15*)

HUACHUCA RESERVOIR, AZ

Cochise Co.

IX

- A. Reservoirs were not damaged. (37a)
- C. A severe shock cracked the hillside for a mile or more on the Huachuca Reservoir Hill, overlooking Tombstone, the crevasse from four in. to a ft wide [still visible in 1911—the crevasse widened in 1911 and caused Huachuca Water Co. pipes to break]. (37j)

HUDSON SPRINGS, AZ

County Unknown

III

- B. Felt (14b)

JANOS, MX

Chihuahua

IX-X

- A. Demolished all the houses (A13)

JIMINEZ, MX

Chihuahua

III

- a. 4:45 pm (A13)
- b. 5 sec (A13)
- B. Felt (14a)
- D. Light oscillating earthquake (A13)

KINGSTON, NM

Sierra Co.

V

- a. 3:05 pm (14a)
- b. 30 sec (14a)
- c. E-W (14a)
- B. Two distinct shocks were felt here. (14a)

LAKE VALLEY, NM

County Unknown

V

- a. Two shocks felt at 3:12 pm (25a, 38b, 39a)
- b. 8 sec (25a, 38b, 39a)
- c. E-W (25a, 38b, 39a)

LAREDO, TX

Webb Co.

VI-VII?

- C. Fires [5/9] on the summit of mountains on many places on both sides of the road from Monterey (14f)

Editorial Note: Not certain whether they are connected with earthquake

LAS CRUCES, NM

Dona Ana Co.

VI-VII

- a. Began at 3:10 (32)
- b. 20 sec (32)
- c. Direction of the waves was from W-E (32)
- A. No damage was done. (32)
Court House and Catholic Church, both large brick structures were uninjured (32)
The front of the Republican Office creaked and seemed as if it was about to fall. (32)
Many clocks were stopped; the post office clock, which hadn't run for six months started and is still ticking. (32)
Some crockery was broken in Regmond & Co.'s store. (32)

- B. Everyone in the Republican Office rushed to the street. (32)
Everyone fled from their houses. (32)
Many complained of a sickening sensation. (32)
- C. The water in the acequia was washed up on the bank on each side about ten inches; a boat in the water was tossed from side to side by waves. (32)
- D. The first sensation was a gentle tremor, which increased in violence. (32)

LAS VEGAS, NM
San Miguel Co.
II?

- B. The earthquake was felt as far NE as Las Vegas. (A2)

LOS ANGELES, CA
Los Angeles Co.
I

- a. 2:14.7 pm (A10)
- D. Tremor recorded on magnetic instruments of the U.S. Coast Survey Observatory. [Dr. Schott's report of June 20, 1887; copy furnished by USGS]. (A10)

MACORITA, MX
Sinaloa
III

- B. Felt (25b)

SIERRA MADRES, MX
AKA: Madera
Sonora
VIII-XII

- C. Fire and smoke belched from the towering Sierra Madre Mountains. (10)
The fault opened in the layers of alluvium and detritus of the andesite rocks which make up the bulk of the Sierra Madre. (7)
- D. The central seismic region lies within the Sierra Madres, which generally run north and south. (4)

SIERRA MAGALLANES, MX
Sonora
VII

- C. Covered with fire in their highest parts [probably due to rockfalls] (A11c, A13)

MAGDELENA, MX
Sonora
VII

- C. Large volumes of smoke were seen above a point in the mountains 40 mi SE of Magdalena. (14e)

MAMMOTH, AZ
Pinal Co.
VII

- A. Walls of buildings generally were pretty well shaken up. (38i)
Roof of the saloon fell in some days after the shock (38i)
- C. Surrounding mountains shook off a large amount of surplus hanging rocks, which were thrown to the base of the mountains. (38i)
- D. The first greeting was an electric shock, then came the rocking motion of the earth. (38i)

MARICOPA, AZ
Pinal Co.
III

- D. Shock was experienced in Maricopa (7, 37c)

MAZATLAN, MX
Sinaloa
III

B. Felt (A13)

LA MESA, TX
Dawson Co.
VI-VII

A. There was no great damage to the adobe houses. (14k)
C. The earthquake rocked trees back and forth across the roads, and shook things up considerably. (14k)

MESILLA, NM
Dona Ana Co.
VI

C. The temblor sloshed water out of a fish pond two ft deep, the fish swam away in the ground waves. (14k)

MEXICAN CENTRAL RAILROAD
III

B. Felt east of the Mexican Central (A5)

MEXICO CITY, MX
Federal District
III-V

a. 4:45 pm (A13)
b. 2 sec (A13)
c. NE-SW (A13)
B. Seismic movements were felt. (4)
The earthquake was felt as far south as the City of Mexico (A5)
D. Light earthquake (A13)

MEXICO VALLEY, MX
Mexico
III

B. Southern limit of the felt area. (7)

MILLER CANYON, AZ
Cochise Co.
VII

A. The Tombstone waterline from Miller Canyon into the town was broken [by a falling boulder]. (28)

MONTEZUMA, MX
AKA: Moctezuma
Sonora
IX-X

A. The houses were wrecked—the walls of many had fallen out and the roofs fallen in—and the prefect of the district prohibited anyone from living in the houses for six mos. (26)



18A



18B.

Figure 18A & 18B. Church at Moctezuma, Mexico, before the 1887 earthquake (A) and in 1964 (B). "The earliest photographs show a square, three-tiered bell tower, capped by a dome, attached to the southeast corner," wrote George Eckhardt. (A3) Original photos by J. Arvisa (A) and George Eckhardt (B). Photos courtesy of the Arizona State Museum

MONTEZUMA DISTRICT , MX

AKA: Moctezuma District

Sonora

VIII-XI

- A. Destroyed several villages (37g, 39b)
Those in NE part suffered most terribly (39b)
Oputo and all its houses destroyed (39a)
Houses were leveled to the ground. (39b)
- B. Nine persons killed in Oputo. (39b)
- C. Fields burning in the east (A11b)
Confirmed report that the waters have increased considerably in the District of Moctezuma as well as in Arizpe. The rivers have enriched their volume of water and the springs are much more abundant. (A11b, e)

Editorial Note: See Appendix II for discussion of volcano reports.

MULE PASS, AZ

Cochise Co.

VI?

- c. Lasted 90 sec (5)
- D. It was a violent tremor of the earth, including two sharp shocks. (5)

MUSTANG HILLS, AZ

Cochise Co.

VII-VIII

- C. Biscuit Mountain in the Mustang Hills is a monument to what an earthquake can do to a forested peak. (28)

NACORI, MX

Sonora

VI-VII

- A. Slightly damaged the buildings (A13)
Total damage was valued at 7,935.00 pesos. [see Table 2]

NACOZARI, MX

Sonora

VII-XI

- B. No damage done beyond giving people a big scare (37g)
- C. On the trail from Oputo to Fronteras, between Nacosart (sic) and the Yaqui, a little more than halfway from Fronteras to Batepito, the rocks have been terribly broken-up. (4)

The road to Tombstone was fissured by wide, deep cracks in some places. There were several new springs and water holes, and at places the road was turned to quagmires (26)

NACOZARI RANGE, MX

Sonora

VIII-IX

- C. After the Teras Range, the Nacozari Range has the greatest number of rock avalanches. (7)

NOGALES, AZ

Santa Cruz Co.

VI-VII

- a. Big shock was at 3:00 (38b)
b. Reports varied: 12 sec (38b), 1 min (25b)
A. Damage is slight. (38b)
Buildings trembled. (25b)
Pictures fell from walls, dishes crashed to the floor. (27)
Walls of several houses were cracked. (38b)
B. Nobody was hurt. (38b)
People rushed into the streets. (25b, 27)

LOS NOGALES ARROYO, MX

Sonora

XII

- C. Here the fault forms a bend which changes its course from 5° NW-SE to 10° NW-SE. The depression of the western wall of the fault to the extent of 1.8 or 2.5 m continues, and its walls have an inclination of about 80°. (8)

OLIVE CAMP, AZ

Pima Co.

VI

- a. 2:30 pm (39a)
b. 3 min (39a)
d. It was preceded by a rumbling sound, as if a train or cart was passing over a bridge. (39a)
B. No one was hurt, with exception of the few who were very badly frightened. (39a)
The few ladies in camp ran from their homes to the nearest dump for safety. (39a)
D. Severe earthquake shock (39a)

OPOSURA, MX

Sonora

VII-IX?

- a. 3 pm (A13)
A. Slightly damaged the buildings (A13)
A few houses were thrown down. (37g)
Completely destroyed (17, 38j)
B. No one injured (37g)
Thirty-five to 40 people were buried in the ruins and several injured in the towns of Bavispe and Oposura. (17c, 38j)
D. *Editorial Note:* Oposura may be a misspelling of Oputo, or it may be the name of a village in the Oposura Mountains.

OPUTO, MX

Sonora

X

- A. A few old crumbling adobes were thrown down. (37g)
The walls of the church shattered and the roof fell in. (26)
The characteristic damage received by all houses not prostrated was in the corners. (4)
An irrigation canal that was used to water fields was destroyed. (A11c)
In the town of Oputo, which, after Babispe suffered the most, the walls fell towards the west; the truncation of the corners occurred in greater number in the southwestern than in the northwestern corners. The walls that suffered least were those running E-W, and whose cracked corners were on the western side. (7)

A large number of houses fell down; the ones that remained standing were in bad shape and on the point of falling down. (A13)

Total damage was valued at 28,835.00 pesos. [see Table 2]

B. One person was injured. (37g)

Editorial Note: The names of eight people killed by the earthquake are listed in this article. (39d)

Nine persons were killed. (10, 39b, A6)

Nine people were killed outright, and several others injured. (4)

9 killed, 6 wounded (23, A11g)

At the first shocks, women and children ran into the church which was destroyed by the earthquake. Forty persons were killed. (26) *Note:* In the preceding report, the location was likely confused with Bavispe.

Editorial Note: See Appendix II for a complete discussion of casualty figures.

C. Fires on nearby mountains burned for several days. (10)

Seven [volcanoes] were noted that burned for 2 days [probably fires due to rockfalls]. One on the Cerros de Las Casitas had its mouth on the highest part of the hill on the N side. Two more towards the E in the Sierra Guepari, the opening towards the W. Two were also E in the Sierra Bacapiri, their mouths toward the W. Another, in the NE in the Sierra Las Joyas, its mouth facing S and another on the Cerros de Saucito to the NW of this village, its mouth could be seen to the S. None spewed lava. (A11g)

Rock falls were also common on the watershed of Oputo. (7)

There are landslides and cracks in the hills, damages being worst in Oputo. (A11g)

American prospectors reported a fissure 2½ ft wide. (26)

In the ravines and the valleys, springs of water broke forth. (A13, A11c)

Infinite and immense openings in the earth, especially in *Oputo* where there is one a yard wide and close to a hundred in length. Water flowed from some of these crevices and [a crevice that] formed in a house under construction, spewed fire and caused the fresh adobe to run. (A11g)

D. The principal line of disturbance passes through Bavispe, Oputo, east of Fronteras and through San Bernardino Ranch. (A5)

ORACLE, AZ

Pinal Co.

VII-VIII

C. There were numerous slides and large quantities of rock and earth hurled to the base of the Santa Catalina Mountains. (38e)

ORGAN, NM

Dona Ana Co.

IV-V

D. Shock was lighter than it was in Las Cruces. (32)

ORO BLANCO, AZ

Santa Cruz Co.

VI

a. 2:15 pm (38d)

b. 1 min (38d)

c. Apparently from the W or SW (38d)

d. Accompanied by a subdued roaring sound as of approaching wind or rumbling wagons (38d)

A. School-house clock stopped (38d)

B. Children ran out of schoolhouse (38d)

People generally ran out of their houses. (38d)

D. The earthquake was very distinct. (38d)

PANTANO, AZ

Pima Co.

VII-VIII

- a. Main shock around 11:00 (15)
- d. A rumble was heard. (15)
- A. Looking glasses were knocked about. (10, 38b, 39a)
Dishes were upset in all of the houses. (38b, 39a)
A cupboard was turned over. (10, 38b, 39a)
Several of the depot chimneys were shaken down. (10a, 38b, 39a)
The roof of an adobe house was removed from its fastenings. (10, 38b, 39a)
The engine of a freight train leaving Pantano was almost thrown from the bridge just above the town. (10, 38b, 39a)
- C. Dense smoke was seen near 'the window in the rock,' then came a crash. It was heard that the top of the mountain broke off. (15)

Editorial Note: The mountain referred to is probably in the Rincons.

PATAGONIA MTS., AZ

Santa Cruz Co.

VII

- C. Had forest fires (27)

PEDREGOSO CROSSING, MX

Sonora

VIII-IX

- C. On the trail to Bavispe, south of Pedregoso, in a deep narrow canyon, the shattering of rocks has been extensive. Tons have fallen into the canyons from the cliffs above. (4)

PENASQUITO, MX

Sonora

XII

- C. The fault runs N and S with a width of four and a depth 4.5 m. (8)

PENUELAS SPRINGS, MX

Chihuahua

VII

- C. Several important springs on the eastern side of the mountains, opposite Babispe (sic) in Chihuahua, were increased in size, notably Penuelas on the Carretas Ranch. (4)

PHOENIX, AZ

Maricopa Co.

VI

- a. Reports varied: 3:40 pm (14b), 2:47 pm (37c), 2:55 pm (10, 25a)
- b. Reports varied: several sec (14b), 1 min (37a, 37c), 1½ min (37c)
- c. Reports varied: Vibrations were N and S (14b), distinctly E and W (25a, 37c)
- d. Reports varied: no noise (10, 25a), a deep rumbling sound was heard to the SE (10)
- A. Glass did not shiver. (37c)
Not a bottle or a dish was broken. (37c)
No property damage occurred in the Phoenix area. (10)
Several large pendulum clocks stopped. (14b)
Buildings swayed. (10)
- B. No injuries occurred in the Phoenix area. (10)
People living in the upper stories rushed downstairs. (14b)
The population dashed into the streets. (10)
A few cases of nausea were reported, but nothing serious. (37c)
- C. A massive dust cloud was seen rising over the mountains. (10)
- D. Slight shock. (30a)
Only a wavelike motion (10)
Was slowly tremulous (25a, 37c)
The earth rocked like a cradle. (37c)

PICKET POST MT., AZ

Pinal Co.

VII

C. Huge rocks rumbled down the N side of Picket Post Mtn. (41)

PINAL, AZ

Pinal Co.

VI

- A. Cans and bottles fell off shelves. (41)
A store swayed back and forth. (41)
- B. [He] thought that the store he was in would collapse, but nothing serious happened. (41)

SIERRA PINITO, MX

Sonora

VII

C. Continued to spew forth smoke on May 5th (A11c, A13)

PITAICACHI, MX

AKA: Pitaycachi

Sonora

XII

C. A dike may be seen in the breast of the fault slip. The difference of level between the two sides is much greater than seven ft. (4)
Fault strike is 22° NW-SE, its western edge is still depressed to a depth of four m. (8)

PORVENIR, MX

Sonora

IX

C. The valley from *Porvenir* to *Agua Prieta* had crevices in many places, spilling water forth in abundance, to the degree that it was like a flood which had left the land swampy and impassable. (A11c, A13)

PRESCOTT, AZ

Yavapai Co.

II?

B. Not felt. (25a)
Felt. (10)
A few of our people claim to have felt the Phenix (sic) earthquake on Tuesday. They did not seem to realize, however, until notified by telegraph from Phenix (sic), that we had an earthquake. (30a)

PUSCH'S RANCH, AZ

Pima Co.

VI

B. A mare stood for several hours trembling with fear and refused to move. (10, 38c)

RIGGS' RANCH, AZ

Cochise Co.

VI

- d. We heard the most terrible rumble. (A14)
- A. The old adobe house began to lurch and pitch like a bronc. (A14)
- B. We rushed out and got on top of the platform that covered the well in front of the house and there we rode until it was over. (A14)

RIO GRANDE VALLEY, NM

III-IV

B. The earthquake also jolted some areas in western Texas and several towns along the Rio Grande Valley in New Mexico. (10)

ROSALES, MX

Chihuahua

V

- a. 3:50 pm (A13)
- b. 8 sec (A13)
- c. E-W (A13)

RUCKER CANYON, AZ

Cochise Co.

VII

- A. No damage was done to the buildings at Mike Gray's place. (37e)
- C. A fire was started in the mountains. The entire force of the ranch fought it for three days after the earthquake. (37e)

SABINAL, NM

Socorro Co.

VIII-IX

- c. Two tremors felt both in NE and SW directions *(14b)*
- A. A number of the ancient adobe dwellings were leveled to the ground. *(14b)*
Buildings tottered. *(14b)*
Houses were shaken down. *(14b)*
- B. Men, women, and children rushed to the streets, in numerous cases only in time to escape with their lives from the tottering buildings. *(14b)*

SAHUARIPA, MX

Sonora

VIII-IX

- A. The church fell down and almost all of the houses suffered considerably. *(A11b)*

ST. DAVID, AZ

Cochise Co.

VIII-XI

- b. 3 min *(1, 10)*
- A. A house rocked. *(11)*
One end of the school house was thrown out badly. *(38c)*
The school is considered unsafe to hold school in. *(10, 24)*
The schoolhouse is completely wrecked; one wall fell out and the front tottered. *(1)*
One side of the stone school house fell, then the rest of the building collapsed. *(42)*
Peter A. Lofgreen's house was very much damaged, and in July, 1888, the east end fell in during a storm. *(24)*
Many houses cracked, and some were damaged to such an extent that they were unsafe to live in. *(24)*
The fort was completely destroyed. *(42)*
The most serious damage was the effected (sic) in the Mormon village of St. David's in the valley of the San Pedro, near the Sonora Railroad, in southern Arizona, where all the houses, which are of adobe, or unburnt brick, suffered more or less, and the west front of the combined church and schoolhouse fell at the first shock, the chimneys also being violently thrown down; as, however, the building was then untenanted there was no person injured. *(A7)*
- B. No lives were lost. *(42)*
Cows bellowed and horses neighed. *(11)*
It produced seasickness. *(1)*
- C. Water was thrown out of irrigating canals. *(10)*
The ground seemed to rise up and all about (sic). *(11)*
The motion of the earth was distinctly visible beneath the feet. *(1)*
At St. David's, the motion was described as a rocking or heaving of the soil, unattended by violent shocks. *(A7)*
In some places the ground caved in. *(42)*
The ground in the valley nearby is cracked and sunk by two steps of about one foot each. *(1)*
Artesian water was found some time later when two men heard something that sounded like water running underground. *(42)*
The water level changed abruptly the day of the quake, and artesian ponds suddenly appeared in the valley adjacent to the village. *(10)*
Swamps seemed to be swallowed up. Clay colored and sandy washes had taken the place of some scum covered areas. *(42)*
The San Pedro changed from a creek narrow enough to jump across to a wide river bed. When the rains came, the water in the stream took the stagnant waters with it. The malaria epidemic subsided. *(10, 42)*
- D. St. David, built on alluvial soil, suffered more than Tombstone. *(1)*

SALT RIVER, AZ

Maricopa Co.

VI-VII

- C. People in Phoenix saw a dust cloud caused by a rockslide near the Salt River. *(10)*

SAN ANDRES, MX

Chihuahua

VII

- a. 3:30 pm (A13)
- A. Caused cracks in building (A13)
- C. A spring called "Pineda", situated in the live rock on a hill close by, exhibited an increase in the amount of water flowing from it for two hrs but the water was cloudy with red mud [reddish-brown]; after two hrs the spring returned to its normal flow and color. (A13)
- D. Was fairly strong (A13)

SAN BERNARDINO MTS., MX

Sonora

VII

- C. After the earthquake they were covered with fire in their highest parts [probably due to rockfalls]. (A11c, A13)

SAN BERNARDINO RANCH, AZ

AKA: Slaughter Ranch

Cochise Co.

X

- d. There was an angry rumbling and at the same time, there was occasional booming of distant earthquake artillery. (36a)
- A. Demolished the dwellings of Stonewall Howell's father and of Sheriff Slaughter, and their stable, smoke-house and milk house; the buildings were all of adobe. (1, 36a, 37e, 39b)
All the buildings on the place were thrown down. They were built of adobe, and were substantial. (1, 18)
Of the other towns and ranches where walls were thrown down, the San Bernardino Ranch is the most interesting because it furnishes confirmation of the epicenter's location. On this ranch, which is almost due N of the epicenter, the walls of the two houses were totally destroyed—those running E to W fell to the N, and the N to S walls fell to the W. (7)
Two adobe buildings were instantly prostrated at the time of the first shock. (4)
Out of 7,000 adobes that were used to build the houses of the ranch, there were but 120 whole ones recovered from the ruins. (36a)
- B. It was difficult to stand. (36a)
- C. The ground moved with an undulating motion. (36a)
A stream flowed with increased volume and new springs came into being. (10)
A lake covering a number of acres between the San Bernardino and Batetto ranches disappeared entirely almost immediately after the shock. The lake was known to contain many fish, but none were left on the bottom. (36a)
Riverbed cracks, ruptures, downthrows, and lesions begin at the San Bernardino Ranch and continue south to Granadas. (4)

SAN BERNARDINO RIVER VALLEY, AZ & MX

Cochise Co. & Sonora

IX-XII

- C. Opening of numerous fissures, generally N or NE in direction, from many of which water flowed abundantly. River swelled to volume usual in rainy season of summer. Fields had become green and air moist with prevailing fogs. (23)
The bed of every watercourse in San Bernardino Valley has changed level relative to the mesa from six in. to two ft, in addition to offset caused by the great fault. (4)
Many and extensive simple cracks were formed on the mesas with a general direction towards the main fault. Their width varies from an inch to a foot or two, usually under a foot. (4)
Between the head of San Bernardino Valley and Bavispe, great rifts seen in the ground. He had to dodge boulders that were thrown across the path. (14i)
The entire valley is (sic) apparently sunk from two to four ft. The relative level has changed that much. (14i, 20)
The entire valley is apparently sunk from two to four ft. The relative level has changed that much (14i, 20)

SAN CARLOS, AZ

Gila Co.

VI

- a. 3:12½ pm (29g)
- b. Reports varied: 1½ min (29g), 2½ min (37b, 38a, 39a)
- c. N-S (29g)

- d. A rumbling noise as if a heavily laden wagon was being drawn over a pavement accompanied the shock. (29g)
- B. Caused a band of cattle en route to San Carlos to stampede (38i)
The Indians were badly scared. (37b, 38a, 39a)

SAN CARLOS RESERVATION, AZ

Gila Co.
VII

- b. 2½ min (14b)
- B. The Apaches abandoned their homes and rushed to the mountains. (10, 14b)

SAN ELIZARIO, TX

El Paso Co.

- B. Felt (14b)

SAN FRANCISCO, MX

Sonora
III

- B. Felt (A13)

SAN JOSE MTS., MX

Sonora
VII-VIII

- C. Clouds of dust were seen to rise above the mossy head of the San Jose Mtns. (14c, 15, 37b, 39a)
There were large forest fires caused by falling rocks. (1, 23, 43)
Other effects of the earthquake that terrified the inhabitants of these places were the fires on all the mountains near the epicenter and even some far distant ones situated in the Territory of Arizona, citing, among others, the San Jose Mountain. Some continued to burn for many days; and from their reflected light and smokiness, it seems, came the idea that a volcano had erupted. The agitated imagination of those who had just gone through the terrible effects of the earthquake located volcanoes at different places in the state, and naturally, in that direction where they saw the most constant fire and smoke. (7)

SAN MARCIAL, NM

AKA: San Marcel
Socorro Co.
VI-VII

- B. Reports varied: Two distinct shocks were felt and the alarm was general. (25a)
Two distinct shocks were felt and the alarm was great. (38b, 39a)

SAN MIGUEL, MX

AKA: San Miguelito
Sonora
VII-IX?

- A. Town was uninjured (20)
Slightly damaged the buildings (A13)
Some of the houses fell down. (A11b)
It was estimated that 151 rooms were damaged. The value of damaged urban property was 4,018.00 pesos, and of damaged suburban property, 5,255.00 pesos. (A11g)
The value of damage done to crops was 3,020.00 pesos. (A11g)
- C. Fissures also run from Baceras to below San Miguelito on the upper portion of the Yaqui, but are lost sight of at that point. (4)

SAN PEDRO RIVER VALLEY, AZ

Cochise Co.
VIII-XI

- c. Position of fallen objects shows motion from SE (1)
- A. At the Grand Central Silver Mill, on the San Pedro, the chimney of a house was dislocated, and the upper portion, without falling, swung around from N-E about 90°. (A7)
Buildings thrown down (A1)
- B. The motion was sufficiently violent to produce a distinct sense of nausea. The earthquake was felt distinctly down the San Pedro Valley to its junction with the Gila. (A1)

- C. Falling rocks caused sparks which started fires which burned out the entire valley; 50,000 head of cattle died in the fire or from starvation after it. Torrential rains washed ashes and topsoil into the San Pedro several months later. Brush replaced the grass and the loss of topsoil was followed by erosion. The range never came back and will not carry a quarter as many cattle as it did before 1887. (28)

Throughout the San Pedro Valley for a distance of 130 mi north of the Mexican border the motion was described as a rocking or heaving of the soil, unattended by violent shocks. (47)

Parties in from San Pedro report a rent made in the earth several miles long and from three to eight inches in width. (38f)

The stream is reported to have a slight increase of water. This is diminishing rapidly. (18)

An earthquake fissure not less than 20 mi long extends from below Benson 15 mi north. The earth has sunk and at one place a long crack appeared out of which water burst forth, but afterwards ceased flowing. The crack in many places is still open, the depth being several feet. From above Empire Ranch [to] 70 mi from here the fissure is also reported. When the earth opened, water was thrown to a great height. One spring in that vicinity went dry and three others doubled their volume of water, but on cessation of the disturbance, the dry spring recommenced flowing. (14f)

In addition to cracks and dislocations in the valleys named, were lesions of another kind; outbursts of sand and water through fissures and small crater-like holes, a few inches to a foot or more in diameter. This phenomenon was experienced in the Sulphur Spring and San Pedro Valleys in the United States to a considerable extent, but not with the severity found farther S. (4)

The ground near San Pedro River cracked open six in. wide and water is rising in places heretofore dry. (25b)

There was a raise of nearly four ft in [San Pedro River]. (38b)

The River suddenly ceased to flow and for a short time was entirely dry, only to resume its course again with a volume at least two ft higher than before. (39a)

A small lake in the valley has been closed up. (38c)

Sheets of water spurted into the air in hundreds of places along both sides of the River. A few flowed for a month and a few longer. (43)

SAN RAFAEL, MX

Sonora
XII

- C. The fault crosses the Yaqui River at this location. Within less than one mi north of the fault junction with the river to a point about 300 ft from the stream, dip slip decreases from approximately eight ft to zero. The fault becomes simply a crack in the bluff which leads to the river bank. (4)

SAN SIMON, AZ

Cochise Co.
VII

- A. A small crack occurred in one wall of a house. (21)
The chimney on the section house fell. (37b)

SANTA ANA MINE, MX

Sonora
VII-VIII

- d. The rumbling and grinding noise was frightful. (26)
A. Material began to "rock & reel" over the yard. (26)
B. The miners all ran out. (26)
C. The ground at the surface swayed and sunk. (26)
A tunnel at about 400 ft swayed back and forth. (26)

SANTA CATALINA MTS., AZ

Pima Co.
VIII

- C. There were forest fires. (27)
The quake broke large boulders from their moorings. Rocks crashed down the mountainsides, and large clouds of dust rose several thousand ft above the peaks. (10)
Great slices of the Santa Catalina mountain were torn from its side and thrown to its base. Vast clouds of dust rose above its crest several thousand ft above sea level. (14b, 25b, 38a)

At three points in the Santa Catalina Mountains, separated by three to five mi, clouds of dust were seen to rise above the crest. (38a, 39e)

One towering peak known as "Old Castle," a prominent landmark from Tucson has entirely disappeared. (14b, 25b, 30b, 44a)

The shock evidently loosened a quantity of rocks from the towering peaks of the old "castle." A huge volume of dust was soon afterwards seen to rise above the peaks. (39a)

Parties who were near the Rillito and saw the old "castle" take a tumble, describe it as an awful scene of confusion in which the mountain peaks seemed to be dancing the racquet. (39a)

Over the summit of Mount Lemmon, the highest peak of the Catalinas, for quite a while after the shock hovered a huge dark canopy of smoke and dust, until it gradually faded away. (38a)

A part of the familiar appearing land was found to have disappeared. (10, 39a)

A good effect of the earthquake was the opening of two large gold veins which were discovered in the Santa Catalina Mountains where the whole side of the mountain slid down. (3, 14e, 39b)

The canyon is full of water brought to the surface by the earthquake. (14e, 39b)

SANTA CRUZ RIVER, AZ

Santa Cruz Co.

VII

- C. An increase of water in the Santa Cruz is reported. (38j)

SANTA ELENA MINE, MX

AKA: Santa Elona

VII-VIII

- B. Falling rocks were scattered among 150 persons; none were injured. (14f)
Earthquakes caused a great panic. (14f)
C. The whole hill fell down. (14f)

SANTA FE, NM

Santa Fe Co.

III

- B. This earthquake was felt as far north as Santa Fé. (A5)
Seismic movements were felt. (4, 10)

SANTA RITA MTS., AZ

Santa Cruz & Pima Cos.

VII

- b. The rocks fell for 5 min. (9)
c. Seemed to move SW-NE (9)
B. Cattle held their heads in the air, a horse had its ears laid back. (9)
C. Ground moved under [him] as he sat in a four ft deep canyon (9)
Rocks fell down the sides of the hills. (9)
Had forest fires (27)

SANTA ROSALIA, MX

Chihuahua

IV-V?

- a. 3:50 pm (A13)
D. Fairly strong earthquake. (A13)

SIERRA BLANCA, TX

Hudspeth Co.

III

- B. Felt (14a)

SILVER CITY, NM

Grant Co.

VII-VIII

- A. Several buildings were badly cracked. (26)
B. Persons were thrown to the ground. (26)

SINALOA STATE, MX

III

B. Felt (23)

SOLDIER'S HOLES, AZ

Cochise Co.

VIII

A. From the Sonora line to Soldier's Holes there is not an adobe house considered safe to live in. (37e)

SOLOMONVILLE, AZ

Graham Co.

VII

a. Felt the impact at 3:10 pm (10)

b. Continued 4–5 min (38d)

d. About 3:00 a strange creaking noise was heard in the court room; it grew louder and louder. (10, 38d)

A. No serious damage done (38d)

Walls seemed to tremble and move, chimneys of courthouse were shaking. Tall flag pole on the court house swung back and fro like the mast of a ship (38d)

Some plastering fell in courtroom and in some other houses. (38d)

Walls of several houses were cracked. (38d)

Some chimneys fell. (38d)

B. Everyone sprang up and out of the windows of the courthouse. (10, 37d, 38c, 38d)

Outside, all staggered on their feet. (38d)

C. At the moment of the shake, great clouds of dust were seen to rise from three to four places on Graham Mountains. (38d)

SONORA RAILROAD, AZ & MX

Cochise Co. & Sonora

VIII

A. In one place near the frontier, running E & W near the station of Fairbank, the track was displaced 3 in. to the North, while a chimney-shaft, without being overturned was turned violently around upon its base. (23, 47)

B. Shocks were felt along the Sonora Railroad. (25b, 39a)

SONORA RIVER, MX

Sonora

IX

C. A road that runs along the easterly headwater branch of the Sonora River [35 mi W. of the Nacosari Road] was badly fissured. (26)

SULPHUR SPRINGS VALLEY, AZ

Cochise Co.

IX–XI

d. Rumbling noise warned of the approach of the earthquake. (1)

A. Nearly all of the adobe buildings of the ranches suffered. (1)

Residence of Mr. Duval, an adobe, was almost completely demolished—outside walls thrown into the rooms, all beds and furniture in two rooms destroyed (37f)

B. Cattle were violently thrown to the ground. (38e)

Persons were in some places thrown down by the heaving of the soil. (23, 47)

C. Surface of this plain was visibly agitated by first shock (23)

Water was rocked out of the cattle troughs. (1, 47)

Some fissures occurred in the bed of an old stream, and water spurted out to a small but varying height and in considerable quantity. These streams continued flowing for two or three days, but at present [5/7/87] all save two are dry. These seem to be permanent, and are running a small amount of water at ordinary temperature. (18)

Several of the streams which appeared at the time of the earthquake have ceased to flow [May 22]. (38l, 37e)

Just after the shock, on the plain about 1½ mi. from C. S. Abbott's house, water shot up into the air to a considerable height, about 4 or 5 ft in width, and extended for fully 100 ft in distance. (38e)

At the Abbott's Ranch, to 35 mi N of the Mexican line, water gushed out of wells to a height of several ft and the ground near by was seen to swell, then burst, and from

cracks abundant water flowed for about 20 min. (1)

The rush of water in the Sulphur Spring Valley that was caused by the earthquake was immense. (38c)

Today [5/8] flow decreasing very fast, but for miles the plains were covered with water. (38e)

None of the old springs have diminished (5/9) but rather the reverse. (37e)

A large number of new springs have burst forth, and some from the mountain-sides. (38c)

In the great Sulphur Spring Valley parallel to this and a little to the E, the motion was described as a rocking or heaving of the soil unattended by violent shocks. (A7)

A party of surveyors could distinctly see the wave approach, and were cognizant of the moment when the earth would rock, and did rock beneath their feet. (1)

The effects were most marked in the Sulphur Spring Valley, which extends N-S a length of about 100 mi, the lower portion extending into Sonora. No stream flows through this great plain, but water can generally be reached at depths of from five to 40 ft from the surface, and many wells are sunk for the vast herds of cattle there pastured. The soil of this valley was violently affected throughout by a succession of undulations. (A7)

The soil burst open, with discharges of water, while the wells overflowed and were partially filled with sand. (23)

Water in all the wells throughout the valley rose up to, or above surface, carrying coarse sand and gravel out of wells which had been sunk in fine sand. In about two hours, the water had everywhere resumed its normal level, and we do not hear that any of the innumerable shocks which have occurred since have redistributed its equilibrium. (1)

In addition to cracks and dislocations in the valleys named, were lesions of another kind—outbursts of sand and water through fissures and small crater-like holes, a few in. to a ft or more in diameter. This phenomenon was experienced in the Sulphur Spring and San Pedro valleys in the United States to a considerable extent, but not with the severity found farther S. (4)

In southern part of valley, for about 7 mi S from Mexican frontier, are a great number of cracks and dislocations. For distances of several hundred feet, along some lines with a generally N-S course, vertical downthrows on one side, of from 1-2 ft and more, the depressed portion rising either gradually or by a vertical step to the original level. Branching, and in some cases intersecting, cracks were observed. These depressions were evidently connected with outbursts of sand and water, which along cracks—marked by depressions on both sides—sometime covered areas of many hundred sq ft with layers a ft or more in depth, marked here and there by craters 2 ft or more in diameter, through which water had risen during the outburst of these mud volcanoes. (23)

The water in the wells rose at once to the surface, in some cases leaping several feet into the air, but soon regained its former level. In one case the soil, after rising into a dome, burst with a great discharge of water. Such ruptures of the soil were, however, rare in those parts of the valley where the earth is tenacious, but in the southern and more narrow part, for a distance of about seven mi, beginning at the Mexican frontier and going northward, the more sandy soil was broken at frequent intervals by cracks with vertical displacements of from one to two ft or more. One of these was traced for 750 ft, with occasional branches and subdivisions, and for 100 ft the two sides of the fissure had a difference of level of from 24 to 26 in, but in a distance of 10 or 12 ft at right angles rose gradually to the original level. Elsewhere the rise was sudden, by a second vertical crack, areas of an acre or two having broken away and dropped down from one to two ft. The cause of these depressions was made evident by the large amounts of mud and sand which were thrown up in many places along these cracks, often covering several acres, sometimes with a layer of from six to 12 in. In one example a belt of this kind of about an acre, along the line of a crack where the soil had sunk on both sides, showed two rounded holes or craters, through which, after the first eruption of mud, water had evidently flowed. About four ft down one of these holes the water channels were seen to extend sidewise, affording a footing for a man. (A7)

Almost on U.S. line, a long crack six in. wide crosses the road, and for a distance southward of seven mi the valley is fissured in every direction by mere cracks or

wide crevasses, out of which water flowed in streams. In places over an area of an acre or so the level of ground is disturbed, sinking sharply to a depth of two ft, and returning without marked breach of continuity to its natural level. Had the valley been thickly peopled, not a building would have stood. (1)

TEPIC, MX

AKA: Tepachi

Sonora

IX-XI

- a. 3:20 (10, 26)
- b. About 5 min (26)
- c. After the sounds were subdued, he could see the earthquake moving W in the mountains. (26)
- d. Accompanied by reverberating reports like immense blasts or explosions (26)
Accompanied by crushing, grinding, and rumbling noise (26)
The dancing was interrupted by "bump, bump, bump," three distinct tremendously loud subterranean knocks coming about one second apart. (10, 26)
- A. The walls and roofs of every house were shattered, the walls of many had fallen out and the roofs fallen in. (26)
The irrigation ditches around town were all broken. (26)
- B. The crowd ran hither and thither, falling and sprawling as they went. (26)
- C. The ground swayed, vibrated, creaked, oscillated, sunk, rose, and trembled. (26)
Immense puffs of acrid, blinding dust were sent up. (26)
Columns of dust were rising from the hills. (26)
In one half hour the sky turned a brownish color and the sun appeared red as blood. ... the sunset was gorgeous that night ... the air was laden with dust almost to suffocation. (26)
The plaza and streets were ripped up by fissures, some as wide as six in. or more. (26)
Roads to the Santa Ana Mine were crossed by fissured zones—cracks went for considerable distances. (26)
He observed three waves rolling toward him which seemed to be about 20 ft apart and two ft high, moving as rapidly as the incoming waves along the seashore. As he ran, he tripped over one of these waves. (26)
Pre-existing water holes had changed to flowing springs; some water holes had dried up. (26)
A new spring had started in the middle of the road where no water had previously existed for three mi on either side. (26)

TERAS MTS., MX

Sonora

IX-XII

- C. Rock falls were most abundant in the Teras Range. (7)
The fault ascends into the Teras Mountains. (4)
The epicenter of the earthquake, or place from which the vibrations felt on May 3rd radiated, has the form of a curved line that trends in the same direction as the great fault already described, reaching a length of nearly 2 km. The cracks there are cut in every imaginable angle so that it is not possible to determine the point from which they radiated in order to accept it as the central point of the surface propagation of the earthquake.
All the cracks have almost completely vertical walls, and it is not without some doubt that I dare to say that they deviate from the vertical some 2° to 3° in such a way as to converge at depth. The sinking, not exceeding 5 m, has the same irregularity as the fissuring. At times the block of land between two cracks will sink, forming thereby a kind of gulch whose borders are practically vertical; at other times the sinking forms steps with each step decreasing in size as it recedes from the epicentral region; this phenomena is repeated on the opposite side and together they have the appearance of a series of steps that are separated by the central line. All this can be seen in that part of the zone in which is found the greatest regularity of the fissuring and sinking; but a few meters forward there are cracks that cut across these small steps, and between these are similar sinkings, and finally, there are other cracks that cut through everything. All this has the result of giving the earth an appearance of being, literally, broken to pieces. Observations show that the pieces

enclosed by the cracks, of definite importance and direction, are frequently rhomboid in form. This occurs in such a way as leave the earth reduced to vast quantities of rhomb shaped polyhedrons arranged at different heights. In the middle of all these numerous cracks of varying directions and lengths are lines of fracture oriented N 30° W, N 35° W, N 25° W, N 60° W, and N 45° E. Without these it is not possible to see the point of convergence on the ground which is nevertheless clearly indicated by the direction of the cracks. (7)

D. Continuous rumbling and groaning of the peak [summer 1887]. The vibrations seemed to come from the northern end of the mountains. (10)

TOLUCA, MX

Mexico

III

B. Seismic movements were felt. (4)

TOMBSTONE, AZ

Cochise Co.

VII-VIII

a. Reports varied: 2:11 pm (10, 38a, 39a), 3:06 pm (37a), 2:48 pm local time, 2:13 pm standard time (19), 3:06 pm local, 2:48 standard (18)

b. Reports varied: 40 sec (10, 25b, 38a, 39a), 35 sec (37a), 1 min (1), 1.75 min or possibly 1.65 min., severe shaking—10 sec, moderately severe—20 sec (18)

c. Directed from the W (1)
SW-NE (18)

d. It commenced with a low rumbling noise, followed by two violent shocks. (1)
Heard rumble such as made by heavy ore teams in passing; noise increased until it was like a continuous roll of heavy firing with occasional short peals like a sharp clap of thunder. (18)

Sounds resembling the explosion of dynamite echoed through the area. (10)

Small rumblings followed for several hours. (10)

A. Several bottles shaken from shelves in drug store (10, 37a)

Glasses and statuettes moved on desk (18)

A hook was shaken from a wall. (37a)

As an indication of the electrical influence of the terrestrial disturbance of yesterday, the magnetic needle of the surveying instrument in the office of County Treasurer Ritter, has left its normal position of lying horizontal and now stands upright against the glass of its case. (37b)

Little damage was done in the mines, where there were miles of workings, and large cavernous open stopes in the limestone, with little timbering. (34)

Every clock was stopped. (28, 37a)

Glassware crashed to the floor. (10)

Globes crashed from the chandeliers in the famed Crystal Palace Saloon. (10, 38n)

Windows were broken. (25b, 39a)

Plaster on the outside of a house cracked and some peeled off. (37a)

Two-story adobe building began to shake gently, then more violently (18)

No building of any stability has been damaged at all. (18)

The shocks, though they cracked the walls of buildings, and dislodged large stones which rolled down the hillsides, were not sufficient to destroy houses, dislodge timbers, or otherwise injure any of the large mines in the district. (A7)

North wall of Schieffelin Hall is badly cracked (37a)

Much damage was done to buildings. (25b, 26, 35, 38a, 39a)

Walls of the hotel swayed. (37a)

Foundations were disarranged so as to require the resetting of engines. (34)

Chimneys were thrown down. (35)

B. Persons riding or driving were unaware that anything happened. (18)

No person was hurt. (18, 25b, 39a)

Citizens were very badly scared. (37a)

Crowds formed in streets. (18)

A hook was shaken from a wall and hit a resident on the head. (37a)
A lady fainted. (37a)
Several school girls fainted. (37a)

- C. Forest fires were started by sparks from boulders dislodged from the mountains. (35)
Streets were cracked and fissured. (26)
The road from Nacosari, Fronteras, and Tepic was fissured by wide, deep cracks in some places. There were several new springs and water holes along the road, and at places the road turned to quagmires (sic). (26)
Embankments along the New Mexico & Arizona Railroad were moved from their former positions as much as 12 inches in some instances. (25b, 39a)
Ten mi from the city a lake covering an acre of ground was completely dried up in 20 min. (25b, 39a)
- D. In Tombstone, a violent trembling of the earth was felt, accompanied with at least two distinct shocks in the interval or less than two min. (A7)
Continued furiously for 40 sec. (25b)

TORRES STATION, MX

Sonora
VII

- c. The fall [of rocks] caused deafening noise. (25b)
C. One minute after first quivering sensation the highest cliff of the Chivato Mountain fell, causing a big cloud of dust to rise. (25b, 38b, 39a)

TOTAL WRECK, AZ

Pima Co.
VII

- A. An adobe house was cracked in several places. (10, 38b, 39a)

TOUGHNUT MINE, AZ

Cochise Co.
VII

- d. In a large inclined open stope 150 ft below the surface, he heard a heavy roaring noise, followed by the beginning of vibration which seemed to culminate in a very pronounced jolt. (10, 34, 35)
A. No damage was done to any of the mines. The deepest workings are 700 ft. (18)
B. Men working at 150 ft did not notice it so much. One crew of men at that depth did not know of it at all until they came out of the mine. (18)
Men working at a depth of 600 ft felt the vibrations severely. Some said they became sick, and all said that the bottom of the drifts or shaft seemed to rise. (18)
C. Loosened rocks from the hanging wall crashed down with much noise, striking sparks as they came into contact with the hard footwall. (10, 34, 35)

TRES ALAMOS, AZ

Cochise Co.
IX-XII

- B. Great excitement prevails. (37b)
C. Earth opened in several places, from five to ten rods from the river, flowing a stream of water of 50 in (37b)
An earthquake fissure of not less than 25 mi in length is reported. It extends from below Benson to 15 mi below Tres Alamos. The crack varies in width from 6-18 in. The earth has sunk several inches on one side. In some places water burst forth from the crack but has now ceased. The crack is open to the depth of several ft in many places. (37f, 39b)
Tres Alamos road crosses the fissure. (37f)

TUCSON, AZ

Pima Co.
VII-VIII

- a. Reports varied: 2:12 pm (10, 14b, 25b), 2:14 pm (30b), 2:12½ pm (38a), 2:15 pm (39a), 8:12 pm (37a); At the cessation of the vibrations, the telegraph operator at Tucson noted 2:14 o'clock. (A7)
b. Reports varied: 4 min (14b, 25b, 30b, 39a), 1 min 45 sec (38a), 2 min. (17a)
c. Reports varied: NW (14b, 25b, 38a), N-S. (39a)

- d. Accompanied by a rumbling sound (*14b, 25b*), rumbling followed by a grating sound (*38a*), preceded by an explosion and rumbling noise (*37a*)
- A. Considerable damage was done to buildings. (*14b, 25b, 44a*)
 Many houses were cracked. (*14b, 38a, 39a*)
 The courthouse cupola swayed like the mast of a ship in a turbulent sea. (*10, 14b, 25b, 38a*)
 Many clocks were stopped. (*10, 14b, 25b, 38a, 39a*)
 The office of the Weekly Arizona Citizen, a large two-story building, shook so violently that no one could stay in it. (*10*)
 Hanging lamps swayed to and fro like pendulums. (*39a, 10*)
 Windows and doors rattled loudly. (*10, 39a*)
 Charles Etchell's blacksmith shop, an adobe structure, is badly cracked. (*10, 39a*)
 Buildings seemed as though they were toppling over. (*14b, 25b*)
 The walls of the Citizen Office, a large two-story brick, seemed to sway 3 or 4 ft from their proper position. (*30b, 39a*)
 Goods were thrown from shelves of stores. (*10, 14b, 25b, 38a*)
 Crockery thrown from shelves, crashed to floor (*10, 27, 39a*)
 Plaster fell on the floor. (*38a, 39a*)
 The public school building rocked to and fro like a cradle, and some of the plastering fell. (*10, 14b, 25b, 39a*)
 Furniture moved about as though animated. (*10, 38a*)
 Two story residence of merchant B. M. Jacobs was bandied about and severely damaged (*10, 38a*)
 Capping fell from several houses. (*38a*)
 The brick coping of a house in Barrio Libre was thrown in every direction. (*10, 39a*)
 No damages have been sustained by the courthouse except by the tall brick chimneys, some of which are out of plumb. (*38g*)
 At San Xavier, the earthquake demolished the Spanish cemetery walls, the atrium walls and cracked the arches in the Suffering Savior Chapel. (*A 16, A17*).
 Many houses were cracked. (*14b, 38a, 39a*)
 Pearson block has suffered many cracks in the brick work and the plastering. (*39a*)
 There is no part of the city but what shows its effects. (*38p*)
 The city marshal's office, in the rear of the City Hall, had a hole knocked in it. (*10, 39a*)
- B. No one injured (*14b, 25b*)
 Entire population fled to streets terror stricken (*10, 18b, 25b, 27, 38a*)
 No less than six persons have been reported as laboring under fits of insanity, all of whom have been affected since the disturbance of this section of mother earth. (*38g*)
 Many on streets became sick. (*10, 38a*)
 Many people were moved in their chairs two or three ft. (*10, 38a*)
 Dogs did not bark the night following the earthquake. (*38c*)
 Horses looked terror stricken. (*37a*)
 Generally, people left their houses. (*39a*)
 A woman fainted. (*10, 39a*)
 People kept to the centre of the street. (*38a*)
 Shortly before the earthquake, roosters had been crowing, dogs whining. (*38n*)
- C. Soon after the shock, wind came from W, 84°, sky cloudless but somewhat murky [probably due to dust raised by rockfalls] (*38a*)
 In some parts of Tucson, the earthquake modified the water level. Some springs and wells on the surface ceased flowing. The deep well in the back of the McKay home dried up soon after the quake. Previously the well had ample water. (*10*)
- D. The trembling was a series of very rapid vibrations, commencing with a barely perceptible movement, and gradually increasing in intensity until one could hardly keep on one's feet. (*10, 30b, 39a*)



19A



19B

Figure 19A & 19B. San Xavier Mission, south of Tucson, after 1873, but before 1887 (A) and San Xavier after the 1887 earthquake, probably between 1891 and 1893 (B). Photos courtesy of the Arizona Historical Society, George B. Eckhardt Collection (see also Figure 26).

SIERRA TURICACHI, MX

Sonora
VII

- C. In the mountains of Turicachi, Magallanes and Cabullona, three craters have opened. (A11b)

URES, MX

AKA: Eures

Sonora
VII-VIII

- a. 3:50 pm (A13)
- A. Many buildings have been cracked and rendered unsafe. (14f)
The House of Correction, property of the state, experienced grave effects to the extent that it was necessary to move to other parts of the public office that were installed there because the building threatened to collapse. (A11b)
A church and several buildings cracked. (25b)
- B. None have been hurt, but inhabitants are leaving as fast as possible. (14f)
- C. A large slice of the mountain near town fell down with a terrible crash, the friction of rocks ignited the woods, causing the belief that a volcano had broken out at Delicias. (14f, 39b)

WASHINGTON CAMP, AZ

Santa Cruz Co.
VI-VII

- A. Pictures fell from walls. (27)
Dishes crashed to the floor. (27)
- B. People rushed from their houses. (27)

WEST SIDE MINE, AZ

Cochise Co.
VI-VII

- B. One man who was working alone above the 500-ft level in a very soft raise did not feel the shock. (10, 34)
At the 500 ft level [reported also as 600 ft] a group of men dropped their tools and rushed for the shaft. (34, 35)
- C. The miners thought that the mine was caving in, as everything seemed to be moving. One man who was leaning against a wall of hard white limestone felt a wave or deflection in the rock approach and pass him. (10, 34)

WHETSTONE MTS., AZ

Cochise Co.
VIII-IX

- C. Smoke was noticed about 5:00 pm after the earthquake. (14b, 15)
Fire was seen coming forth from the mountain. (1, 15, 38b, e)
The volcano in the Whetstones, so far as heard from, proves to be a timber fire. (1, 14f, 15, 37b)
At night the horizon was brilliantly illuminated by fires. The phenomena continued during the days following the earthquake. (14f)
A heavy column of smoke began to ascend from the highest peak of the Whetstone Range. (14c, 14f)
There were signs of upheaval and mountain slides. (14f)

WHITE WATER CANYON, AZ

Cochise Co.
VIII

- d. A noise like the fluttering noise of a flock of birds was heard, then it became deafening. (21)
- B. Horses ran away. (21)
The ground rocked so that we couldn't stand up. (21)
- C. A great cloud of dust and smoke made it as dark as pitch. (21)
Rocks falling had set fires. (21)
Three days later a good stream of water was found where before it was dry, which continued to run almost all year. (21)

WILLCOX, AZ

Cochise Co.
VII-VIII

- a. Severe shock felt at 2:10 (14b)
- b. 1 min 45 sec (14b)
- c. N-S (14b)
- A. Much damage done to buildings (14b)
The two-story residence of N. J. Wilson is ruined. (14b, 37a)

B. No one was injured. (14b, 37a)

YAQUI RIVER VALLEY, MX

Sonora

IX-XII

C. The stream flow increased in volume, and new springs came into being. (10)

There was a sudden and unexpected increase in the flow of the tributaries of the Yaqui River, and the appearance of some new springs and the disappearance of others. (7)

A grand fault extends along the eastern side of the valley. This fault has a general northerly and southerly strike, with a dip of from 45° to vertical; and the difference in level of the two sides is for 50 mi an average of eight ft. It lies close to the foot of the mountain ranges, where the *mesa* drift joins the steeper part of the chain, until it crosses the Yaqui, where it goes directly into the mountains. There are numerous minor faults and fissures; and the entire valley of the San Bernardino is apparently sunk from two to four ft. The relative level is changed that much. This condition exists also on the Bavispe River above and for some distance below Bavispe, and on the Yaqui at and below its junction with the San Bernardino. Almost every water-course in the disturbed area has changed in the same way. (20)

There are other fissurings for nearly 100 mi further but I am unable to say whether they are a direct continuation of the principal fault or not, because I could not reach them owing to the rain and condition of the Yaqui River which was too dangerous to ford at that place. (45)

YUMA, AZ

Yuma Co.

IV-V

a. At about 2:20 (2:30) a slight shock was felt. (44a)

b. Reports varied: It lasted some three to four sec (44b), Gentle tremor lasting 2 min (44a)

d. No noise of any kind was heard. (44b)

A. Earthquake shock was distinctly felt at Tacna and Adonde Stations (44b)
Caused houses to creak, suspended articles to swing to and fro (44b)
Rocked cradles (44b)

B. Felt (4, 30a)

Only a few persons noticed it. (44a)

No damage was done to any one, only the momentary scare. (44b)

C. Caused small ripples upon the surface of the water (44b)

Water sloshed over the sides of a ditch. (44b)

ZACATECAS, MX

Zacatecas

III

D. *Editorial Note:* Aguilera gives Zacatecas an intensity rating of III on his isoseismal map of the event. (7)

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Figure 20. Religious procession at Baceras, Mexico (close-up of Figure 11). Photo courtesy of the Arizona Historical Society.

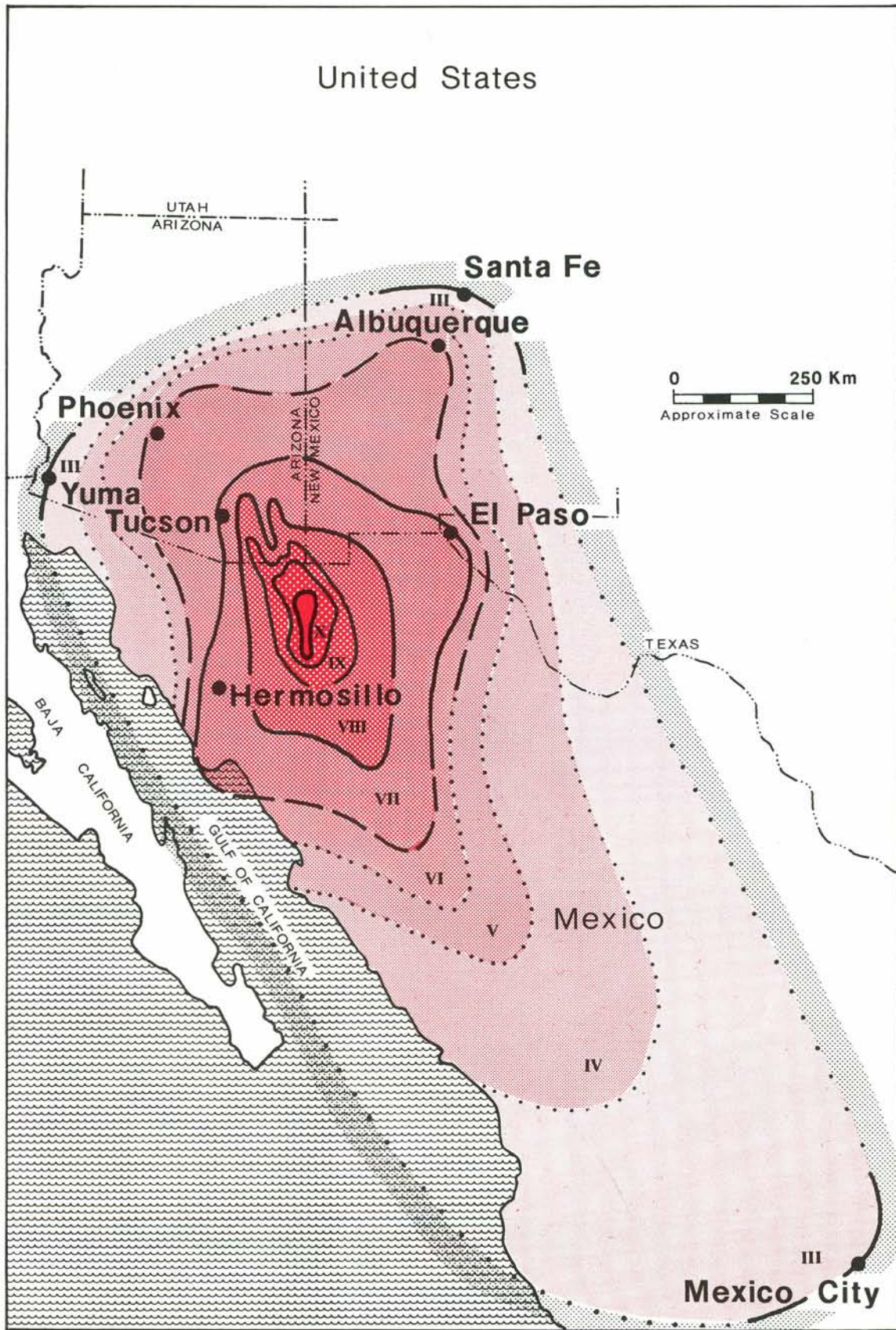


Figure 21. Isoseismal map of the 1887 felt area. Roman numerals depict Modified Mercalli intensity values.

ANALYSIS OF INTENSITY PATTERNS

Intensities assigned to localities listed in the previous section have been contoured to produce the isoseismal map shown in Figure 21. Moderate intensities (IV, V, VI) attenuate in a northwest direction over a shorter distance than to the southeast; perhaps the structural transition across the Colorado Plateau boundary serves as a barrier to wave propagation. East-west attenuation appears greater than southerly attenuation, possibly because wave propagation is more effective *along*, rather than *across* structural trends, which are oriented north-northwest in southern Arizona and northern Sonora.

Maximum intensities (X and XI) were felt in the Fronteras and San Bernardino Valleys of Sonora—including the towns of Bavispe, Oputo, Fronteras and Tepic. Loss of life, major destruction of property and great upheaval of valley soils, rocky slopes and drainage occurred (Figure 22).

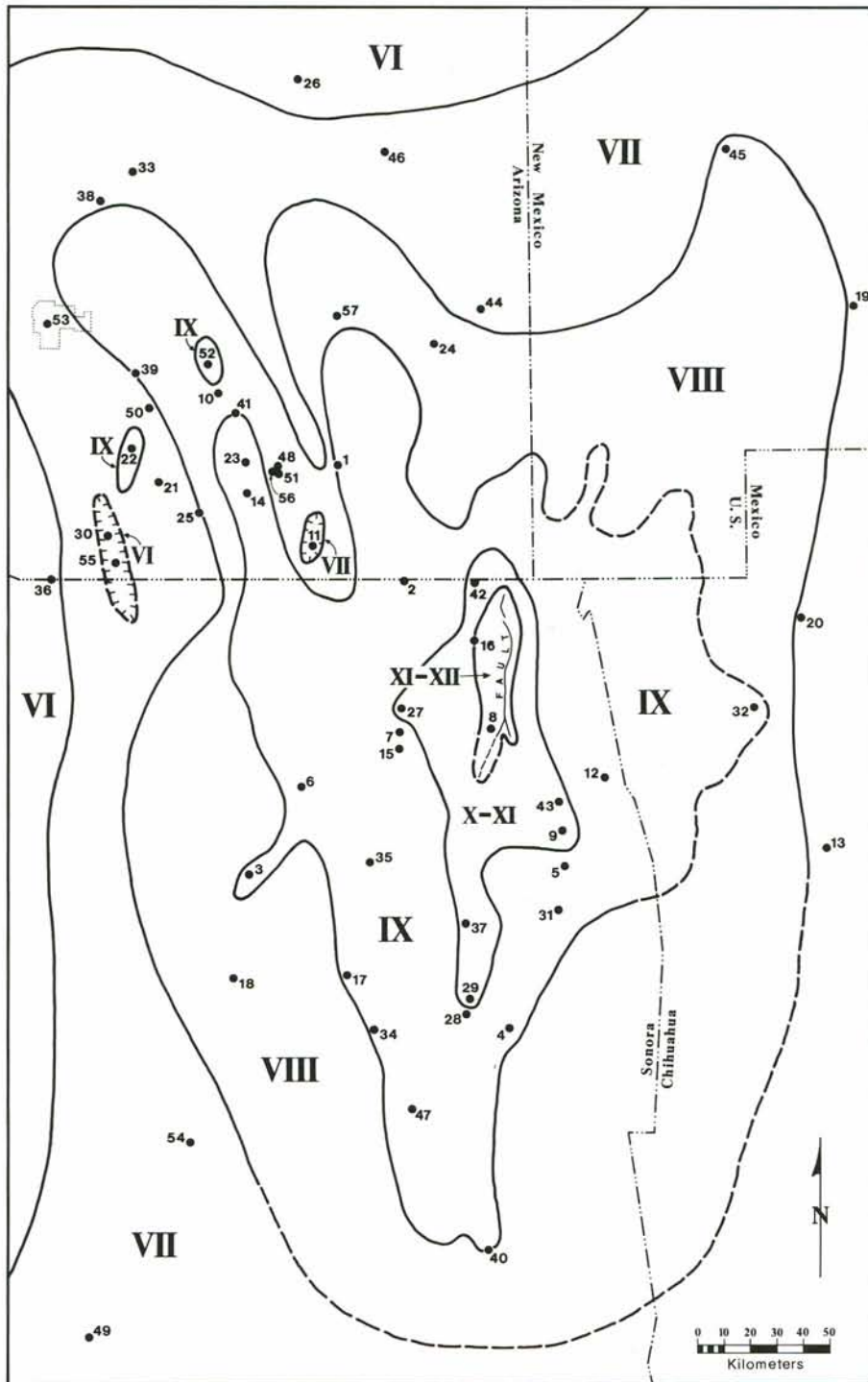
TABLE 2.

Value, in pesos, of damage done by the May 3, 1887 earthquake in Oputo, Guasabas, Granados, Bacadehuachi and Nacori.
Source: *La Constitucion*, 6/17/1887, p. 2, Hermosillo.

TOWNS	Number of ruined properties	Number of damaged properties	Value of damaged property	Value of ruined property	Value of contents	Total losses
Oputo	130	11	\$ 180.00*	\$22260.00	\$1395.00	\$23835.00
Guasabas	98	75	\$14040.00	\$ 7335.00	.....	\$21390.00
Granados	17	64	\$15400.00	\$ 600.00	.....	\$16000.00
Bacadehuachi	7	16	\$10725.00	\$ 1230.00	.....	\$11955.00
Nacori	33	12	\$ 460.00	\$ 4475.00	.....	\$ 4935.00
TOTALS	285	188	\$45805.00	\$35915.00	\$1395.00	\$78115.00
An earlier summary included the value of damage done to the following churches:						
Oputo	1	...	.....	\$ 5000.00	\$	\$ 5000.00
Guasabas	...	1	.....	\$10000.00	.....	\$10000.00
Granados	...	1	.....	\$ 2000.00	.....	\$ 2000.00
Bacadehuachi	...	1	.....	\$10000.00	.....	\$10000.00
Nacori	1	...	.....	\$ 3000.00	.....	\$ 3000.00
TOTALS	2	3	.....	\$30000.00	\$	\$30000.00

Granados, May 28, 1887-V. Provenio.

* One 1887 peso would be the equivalent of \$10.60 in 1980 U.S. dollars



INTENSITIES NEAR EPICENTER

1. Abbott's Ranch IX-XI
2. Agua Prieta Ranch IX
3. Arizpe IX-XI
4. Bacadehuachi VIII-IX
5. Baceras VIII-IX
6. Bacoachi IX
7. Badehuachi IX
8. Batepito IX-XI
9. Bavispe XI-XII
10. Benson VIII
11. Bisbee VII-VIII
12. Carretas Ranch VII
13. Casas Grandes VII
14. Charleston IX-XI
15. Cuchuta IX
16. Cuchuverachi IX-XII
17. Cumpas VIII-IX
18. Delicias VIII
19. Deming VII-VIII
20. Diez VII
21. Elgin VI-VII
22. Empire Ranch IX
23. Fairbank IX
24. Fort Bowie VIII
25. Fort Huachuca VII
26. Fort Thomas V
27. Fronteras X-XII
28. Granadas IX
29. Guasabas IX-X
30. Harshaw VI-VII
31. Huachinera VII-IX
32. Janos IX-X
33. Mammoth VII
34. Moctezuma IX
35. Nacozari VIII-IX
36. Nogales VI-VII
37. Oputo X-XI
38. Oracle VI-VIII
39. Pantano VII-VIII
40. Sahuaripa VIII-IX
41. Saint David VIII-IX
42. San Bernardino Ranch X
43. San Miguel VII-IX
44. San Simon VII
45. Silver City VIII
46. Solomonville VII
47. Tepic IX-XI
48. Tombstone VIII
49. Torres Station VII
50. Total Wreck VII
51. Toughnut Mine VII
52. Tres Alamos IX
53. Tucson VII-VIII
54. Ures VII-VIII
55. Washington Camp VI-VII
56. Westside Mine VI-VII
57. Willcox VII-VIII

Figure 22. Isoseismal map of epicentral area, May 3, 1887. Influence of the topography was considered during interpretation.

In several valleys in Arizona, extensive ground failure resulted in property damage, disruption of transportation routes and alteration of ground and surface water systems. All dwellings were leveled at the Slaughter (San Bernardino) Ranch on the Mexican border in San Bernardino Valley. People and cattle were thrown to the ground in Sulphur Springs Valley. Spurting water fountains and mud volcanoes were also reported there, along with temporary widespread flooding. Cracks, gaping fissures, subsidence and damage to buildings were observed in southern portions of San Pedro and San Simon Valleys as well. Intensity (MM) IX was assigned to such locations.

Further north and west in Arizona (Figure 23), population centers experienced the following intensities:

- VIII Benson, St. David, Tombstone
- VII Tucson, Nogales
- VI Phoenix, Globe
- III Yuma
- II Prescott

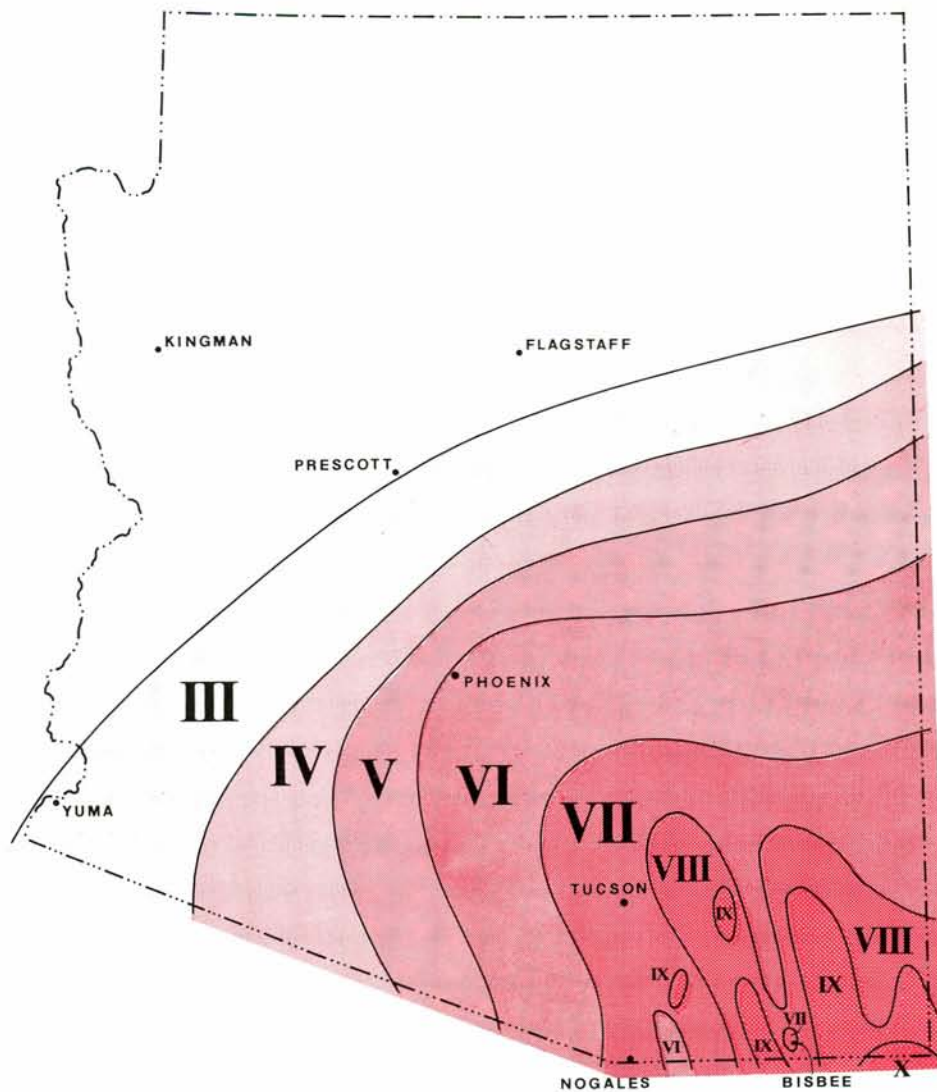


Figure 23. Isoseismal map of 1887 earthquake, Arizona portion.

INDUCED ROCKFALLS

An interesting aspect of the earthquake is the large area in which rockfalls, slides and avalanches were observed, surely a direct result of the Basin and Range topography. Rockfalls and dust clouds were seen in mountains surrounding Phoenix and all other ranges closer to the epicenter (Figure 24). According to Aguilera (1888), blocks up to 200 cubic meters crashed to the valley floors near the epicenter, and in some narrow valleys they rebounded up the opposite slopes. Dust clouds a few hundred meters high were raised as far north as the Santa Catalinas near Tucson. Sparks from falling boulders ignited dry brush and grasses, causing fire to spread rapidly across entire mountainsides. At first, these fires were mistaken for volcanic eruptions (Appendix II).

Close to the epicenter, assigned intensities were higher in the valleys than in the mountains. This relative difference in intensities resulted from the greater impact of liquefaction and ground rupture (minimum MM VIII and IX) on populated areas, which were heavily concentrated in the alluvial valleys. Aguilera (1888) attributed the rockfall distribution to combined factors of weathered state of lithology and gravitational stability:

The rock avalanches in the mountains are no measure of the actual intensity of the seismic phenomena in those places where they occurred; they are a better measure of the state of disintegration of rock as well as its state of equilibrium. There are places where the shaking was very weak, not having sufficient energy to crack the poorest constructed walls in the dwellings, and where, nonetheless, great rockfalls originated.

Given equal intensity, where the constituent rock of the hills had suffered most by the incessant devastating action of weathering processes, the avalanches acquired greatest proportions; the same for those peaks where large masses of rock were in unstable equilibrium and where the lightest oscillation was sufficient to detach them from their narrow supporting bases and topple them, with a thunderous roar, as they made their descent into the valley. On the other hand, we found not one rockfall in any of the granitic mountains. This is due, in some measure, because such mountains have no needles, sharp peaks, or overhanging crests, and a result of the structure of the granite is that it affords no place for the capricious rock groups that form literal miracles of balancing, such as are seen on basaltic, trachytic, and andesitic mountains.

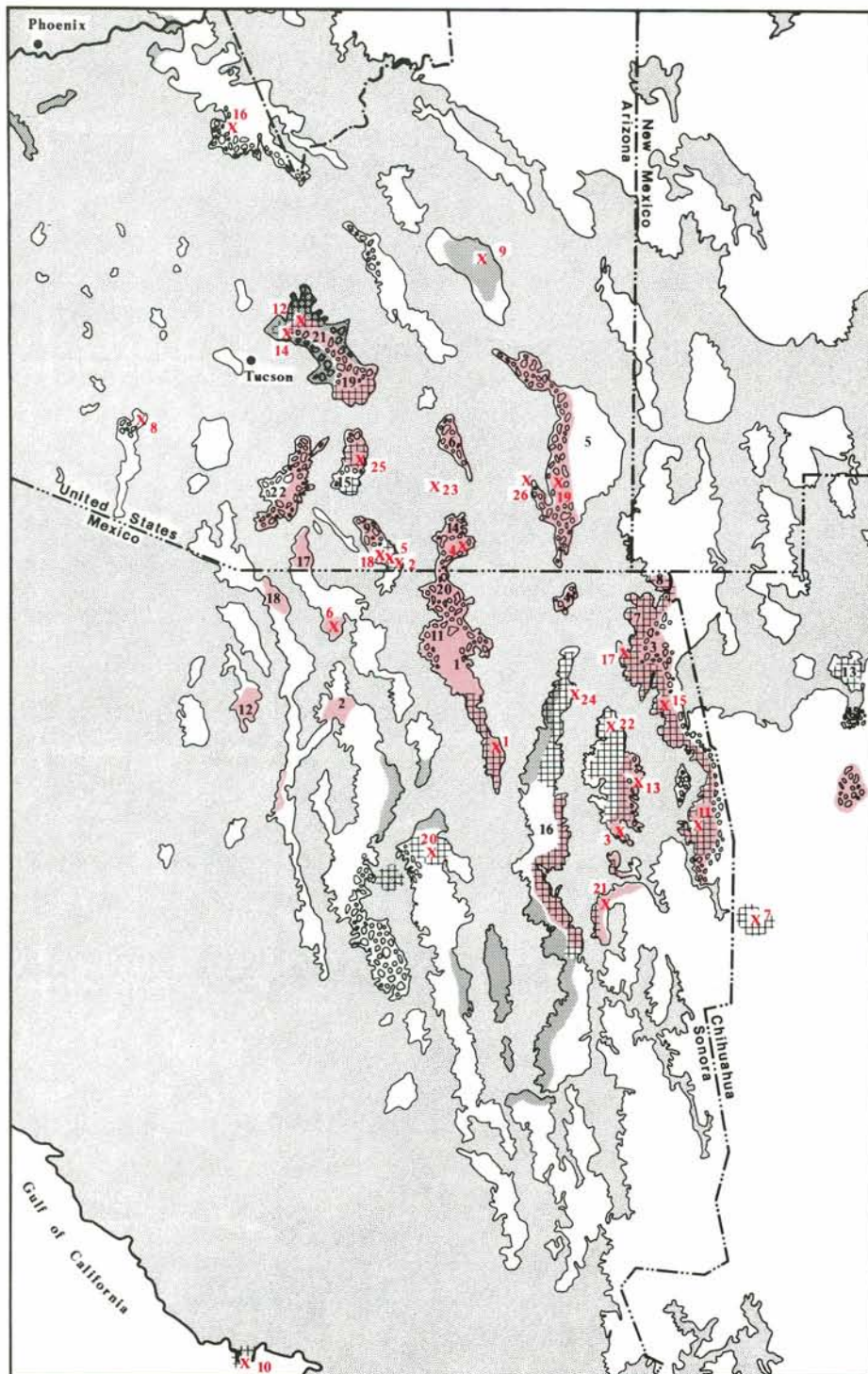
Apparently, Aguilera believed that the energy of the seismic waves in the earth is not as significant as the presence of a horizontal component of motion in triggering the fall of precariously-situated rocks and boulders.

Aguilera continued:

The relation I found between these landslides and the intensity of the earthquake is this: that between certain limits of intensity, they are directly proportional to the horizontal component of the movement, that is, they are more abundant and of greater size where the movement is oscillatory, even when it lacks intensity at another place where the movement is vertical. In the region where the earthquake acquired an oscillatory character is where the landslides begin inasmuch as the deviation of the vibration from the vertical displaces the unstable rocks and the action of gravity uniting with the force of the shock facilitates the rock avalanches. This, in my opinion, is what happened in the explored areas in which the earthquakes had their greatest intensity and caused the most damage: but in the hills and mountains closest to the epicenter there are absolutely no rockfalls, although they are formed of the same class of rock and are in the same general state of alteration as other mountains that had numerous avalanches. It is at some 20 kilometers where rockfalls begin to show, due to the fact that in the epicentral region the movement was vertical.

HYDROLOGIC EFFECTS

Widespread effects of the vibrations on groundwater and surface flow were evident. In the Yaqui, Fronteras, San Bernardino, Sulphur Springs, and San Pedro Valleys, Goodfellow (1888) found field evidence that sand and water had burst through fissures and small crater-like holes,



SPECIFIC LOCALITIES

1. El Alamo
2. Ash Canyon
3. Sierra Bacapiri
4. Bisbee
5. Carr Canyon
6. Chivato Mt.
7. El Colorado
8. Coyote Mts.
9. Mt. Graham
10. Cape Haro
11. Cerro Jaquiverachi
12. Mt. Lemmon
13. El Llano
14. Old Castle (Cathedral Rock?)
15. Pedregoso Canyon
16. Picket Post Mt.
17. Cerro Pitayachi
18. Ramsey Peak
19. Rucker Canyon
20. Santa Elena Mine
21. Cerros De Saucito
22. Teras Mts.
23. Toughnut Mine
24. Cerro La Ventana
25. Whetstone
26. Whitewater Draw

GENERAL LOCALITIES

1. Sierra Los Ajos
2. Sierra Azul
3. Sierra Cabellera
4. Sierra Cabullona
5. Chiricahua Mts.
6. Dragoon Mts.
7. Sierra Los Embudos
8. Sierra Guadalupe
9. Huachuca Mts.
10. Sierra Madres
11. Sierra Magallanes
12. Sierra Magdalena
13. Cerros Del Mezcal
14. Mule Mts.
15. Mustang Hills
16. Sierra Nacozari
17. Patagonia Mts.
18. Sierra Pinito
19. Rincon Mts.
20. Sierra San José
21. Santa Catalina Mts.
22. Santa Rita Mts.

EXPLANATION







-  Dust clouds or smoke observed
-  Fires reported
-  Rockfalls
-  Landslides
-  Lowlands (no reports)
-  Mountains (no reports)

Figure 24. Besides the numerous cracks formed in all the valleys near the epicentral region, there were important rock avalanches in the mountains. Blocks up to 200 cubic meters crashed to the valley floors and, in some very narrow valleys, they rebounded up the opposite slopes. (7) The Xs on the map indicate observed rockfalls during or directly after the shock wave.

a few inches to a foot or more in diameter. These craters were found wherever the "river cracks" existed, and sometimes elsewhere.

In all of these valleys, the water table was within a few meters of the surface and the unconsolidated deposits, mainly sand and gravel, were several kilometers thick. The combined factors of saturated unconsolidated sand and moderate or intense ground motion cause the suspension of grain particles in their own pore water—in other words, liquefaction. Phenomena resulting from this process include compaction and settling at the surface, earthquake fountains (spurting mud and water), soil lurching and fissures. The towns most heavily damaged by the earthquake rest upon alluvial terraces close to the main stream banks.

Goodfellow (1888) states:

Of the effects of the *temblor*, none have been of greater interest or more importance than the modification of the water-supply of the shaken district. During the first shock, all over the area of severe and even moderate vibration, the phenomena of water-craters were exhibited. This, however, was merely a temporary affair, the flow ceasing as soon as the violent shaking was over. It is the permanent re-arrangement of the water-distribution which we have to consider. Many apocryphal stories have been told of the wonderful increase of water in the Yaqui and other streams immediately succeeding the earthquake. In addition to the outpouring of the crater water, many springs were made. This latter effect was not, however, an instantaneous one. In most of the rivers and springs where there has been increase, at first they were almost dry; then in a few days or weeks was a gradual augmentation of water, this antedating the rainy season. At the present time there is an alteration in the water-supply, with others, of the following streams and springs; the rivers of Fronteras, Yaqui, and San Bernardino, the springs of Penuelas and several others with uncertain names; the arroyos of the passes, Elias, Elisu, and Cabellera. Most important is the Yaqui River. This gradually gained in volume after the first diminution, until the flow equaled its midwinter amount. The San Bernardino is now flowing from head to mouth, a thing never before known at this season of the year, and is said to be gaining. Several important springs on the eastern side of the mountains, opposite Babispe in Chihuahua, were increased in size, notable Penuelas on the Carretas Ranch. A number of entirely new springs were started. In fact, over the entire central seismic region, the water-supply has visibly augmented.

Reports of liquefaction, new springs, disappearance of former lakes and springs, and changes in well levels have been assessed in order to map the impact of the earthquake on the hydrologic system in southern Arizona (Figure 25).

The possible relationship of basin subsidence and drainage disturbances caused by the 1887 seismic event to the arroyo cutting, supposedly initiated around 1890 throughout southeast Arizona (Bryan, 1925; Cooke and Reeves, 1976; Hastings and Turner, 1965) is a subject of further investigation.

IGNITED GASES

The mountain fires attributed to the earthquake were believed to be caused primarily by falling boulders. However, Goodfellow (1888) also discussed possible emission of ignited gases, based on his field investigations after the earthquake:

The evidence of gaseous irruption (sic) were few but striking. Primarily were the statements of many who claim to have seen streaks of flame at different points, in the course of the first night in particular, and several times thereafter during succeeding days and nights while the heavy shocks continued... The evidence [for outbursts of ignited gas] was found in several places, both in the riverbeds and in the hills along the line of faulting. This consisted of cinders about the margin and on the walls of the river-fissures, and the discovery of burnt branches overhanging the edges of such places, as well as the same testimony on some of the hills and mountains near the main fault.

Reports of such phenomenon still baffle seismologists (Derr, 1973). Presently, the above observation cannot be further substantiated or disclaimed.

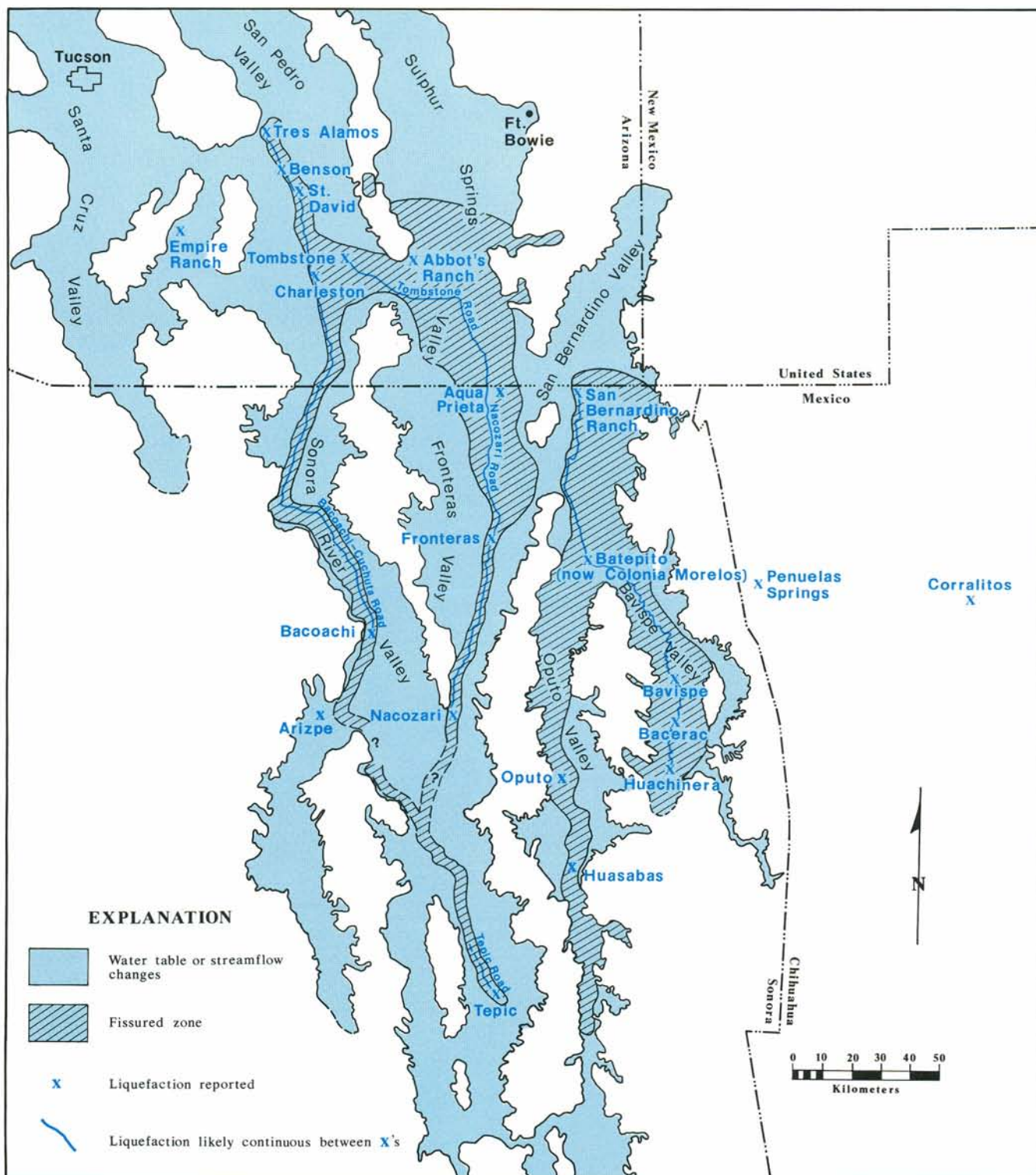
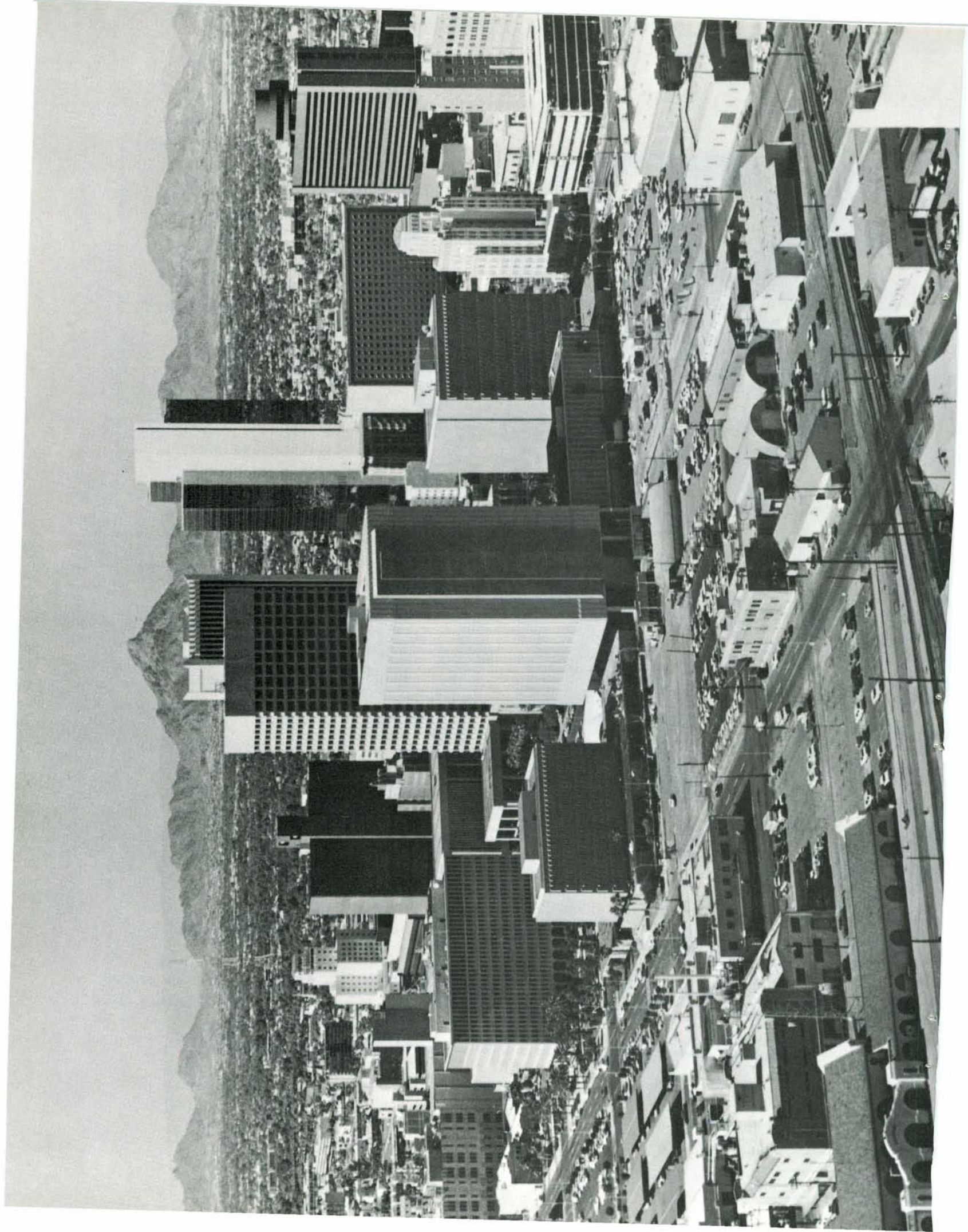


Figure 25. Ground failure and hydrologic effects associated with the May 3, 1887 earthquake.



IMPLICATIONS

For Seismic Hazard in Arizona

The significance of the 1887 earthquake in terms of current seismic hazard in Arizona is twofold: First, as the largest historical event, it provides an estimate of the maximum size earthquake to be expected in Arizona; secondly, analysis of intensities generated by the 1887 shock forms a basis for predicting damage from a magnitude 7 earthquake in or near Arizona.

Seismic hazard is defined by several combined factors: magnitude, geographic location and frequency of earthquakes, as well as susceptible human population and property. Whereas the 1887 earthquake represents a maximum credible earthquake for Arizona, the recurrence interval and future location(s) of damaging earthquakes in Arizona cannot yet be estimated. Monitoring of current earthquakes and geomorphic studies of fault scarps are needed to provide data for evaluating where and how often damaging earthquakes might occur in Arizona.

Estimates of possible damage, however, can be made assuming a repeat of the 1887 event in the same location. In 1887, less than 90,000 people inhabited the entire Arizona Territory, 90% of which was rural. Now, nearly two million people occupy the metropolitan corridor between Phoenix and Tucson alone. Heavy population influx has resulted in urban expansion into flood plains and onto steep bedrock slopes—the two most vulnerable locations in terms of seismic risk because of potential liquefaction and rockfalls, respectively. Many homes in Arizona are composed of unreinforced masonry; some are low-fired adobe brick. In fact, the buildings occupied by many Arizona citizens today are quite similar to those damaged or destroyed in the 1887 earthquake, in terms of materials and design (DuBois, 1979). Masonry, in general, is much more susceptible to earthquake damage than wood-frame construction because of its inability to yield with horizontal earthquake stresses. Undoubtedly, damage in Arizona from a similar event would be far greater today than it was in 1887.

If a magnitude 7 earthquake were to occur further north, along the postulated northwest-trending belt of seismicity through Arizona (Sumner, 1976; Fugro, 1975), disastrous consequences to the populace would result. This region includes the three largest cities in Arizona—Phoenix, Tucson and Flagstaff—and approximately 90% of the State's population. Secondary effects resulting from rockfalls, possible dam failure, liquefaction, fires and disruption of vital communication, transportation and utility systems (Appendix III) would be greater threats than the actual shaking or faulting associated with a large earthquake.

There has been little evaluation of potential hazards from seismic activity in Arizona. A study of the 1887 earthquake has indicated that immunity to earthquake damage in this state is a false assumption.



Figure 26. Statue of St. Francis of Assisi at San Xavier Mission. Note crack in the wall behind the statue, caused by the 1887 earthquake (A16). Photo courtesy of John P. Schaefer.

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APPENDIX I

AFTERSHOCK REPORTS*

LOCATION

FORESHOCK AND AFTERSHOCK REPORTS

ARIZPE, MX
Sonora

The earthquakes repeated in the days following the 3rd. (A13)

BACERAC, MX
Sonora

(6/17) Aftershocks have been experienced which are 9–12 sec in duration, preceded by certain subterranean noises and detonations. (A11g)

The earthquakes have continued being felt in this municipality, without stopping for a single day. For your information, I include below a list of the earthquakes that have happened daily since the 20th of August:

Dates	Light	Strong
August 29	2	1
August 30	6	2
August 31	3	2
September 1	2	1
September 2	2	
September 3	1	
September 4	2	
September 5	1	
September 6	3	
September 7	2	1
September 8	4	
September 9	1	
September 10	3	
September 11	2	3
	34	10

Of these 44 quakes, several have had a length of as much as 40 sec, and in particular the second one which occurred today alarmed the population greatly and until right now (it being 8 pm) there have been 5, 2 light and 3 strong, all of them have been oscillating, and some notably strong, accompanied by an imposing subterranean noise. (A13) (Sept. 11, 1887—Ignacio Davila)

BATEPITO RANCH, MX
Sonora

(6/1) The earth has been in almost constant tremor since May 3; they have had a tremendous shock there three nights since and a very live one day before yesterday. (36a)

BAVISPE, MX
Sonora

According to the reports from the State Government, the tremors continued; from the aforementioned hour until 10:00 the next day; 18 tremors, three of them very strong, with subterranean noises, were counted. Letters from the same place add that by the 7th, 71 quakes/tremors had been felt. (A11c, A13)

Smaller shocks followed. (10)

There are frequent repetitions of the shakings, 9–12 sec in duration. They are preceded by certain subterranean noises and detonations from the mountains of La Madera, which are to the west of Bavispe (4 leagues away). (A11g)

*Dates preceding the reports in this section indicate either the actual date of the news clipping or the date of the report as given by the newspaper.

BENSON, AZ
Cochise Co. Another slight shock at 2:51 pm [the initial shock reported at 2:10 pm] (37a)
Minor shocks felt afterwards at intervals (14b, 14e, 25b)
(5/7) Another shock occurred at about 11:00 am. (39a)
(5/7) Light shocks occur every now and then, but create no damage and little alarm. (14e)
(5/7) Have experienced several shocks today, the heaviest one occurring at 4:30 pm and lasted about 10 sec (14e)
(5/9) Another shock occurred this afternoon at 1:14. No damage was done. (14f)

BISBEE, AZ
Cochise Co. Rumbling was followed by three light shocks at different intervals [description of initial and aftershocks]. (37b)
Several lighter shocks have been since felt. (37b)
The initial shock was succeeded at frequent intervals by many lesser movements in the next three days, and less frequently at least up to May 29. (5)

CABULLONA, MX
Sonora There were several others afterward. (A11c, A13)

CASAS GRANDES, MX
Chihuahua The quakes were repeated about six times, according to a letter from Col. Artalego. (A13)
(5/9) Until last night it has been repeating, although moderated, three times in the day and a couple more at night. (A12c)

CHARLESTON, AZ
Cochise Co. (5/3) A second shock caused another breakneck race for the wide open spaces. (40)
He said they had a temblor every day he was there. (37e)
Tremors continued intermittently for nearly three weeks. (31)
Every day and at the same hour for about a month, the earth's tremblings recurred, but with gradually lessened force and for a shorter duration each time, until finally they faded away to nothing. (43)
The mules, cows and horses indicated the coming shock by their behavior. They would stop and brace their legs, and their eyes would become round and glassy in appearance. (43)

CHIHUAHUA CITY, MX
Chihuahua (5/4) The table upon which we are writing these lines is imprinting an oscillatory movement. The office roof is creaking. (A12c)

CORRALITUS MINING CO., MX
Chihuahua Shaking occurs here at intervals, from day to day, but not as severe as the first shock. (14g)

DIAZ, MX
Chihuahua (5/8) Slight shocks have been felt since then at an interval of a few hours. (33)

EL PASO, TX
El Paso Co. (5/4) A shock was felt at 11:00 am on Tuesday. (14a)
(5/4) A light shock followed at about five o'clock [5/3]. (14a)
(5/4) At least four other shocks have been felt. One at 6:30 last evening was felt distinctly by persons on the second floors of buildings, and gas fixtures and other movables were seen to sway. It was four to five sec in duration. (14a)

	(5/4) Some felt a shock between 8:00 and 9:00 pm Tuesday. (14a) A shock was felt at 11:00 pm Tuesday. (14a) (5/10) A shock occurred at 10:11 pm Saturday, and was plainly marked in portions of the city. (14f)
ELGIN, AZ Santa Cruz Co.	The ground would seem to rise about a foot and drop—this happened in intervals of a half hour and continued until 7:00 the following day. (27)
ESTANCIA, MX Sonora	(6/17) Aftershocks have been experienced which are 9–12 sec in duration, preceded by subterranean noises and detonations. (A11g)
FT. THOMAS, AZ Graham Co.	(5/3) There was a second shock at 3:51½ pm (MST). It was very light and had an apparent duration of five sec. (29c) (5/3) There was a slight shock at 6:27 pm, with a duration of 15 sec. (29c)
FRONTERAS, MX Sonora	Aftershocks were felt for several days. (10) They announced having felt the earthquake of the 3rd and other repetitions until the 5th, destroying several houses and leaving weakened the rest. (A13)
GALEANA, MX Chihuahua	The earthquake was repeated two times: at 8:00 pm on the 3rd and at 4:00 pm on the following day. (A13)
GALERA, MX Sonora	(6/17) Aftershocks have been felt, 9–12 sec in duration, preceded by subterranean noises and detonation. (A11g)
GUACHINERA, MX Sonora	(6/17) Aftershocks have been felt, 9–12 sec in duration, preceded by subterranean noises and detonations. (A11g)
HERMOSILLO, MX Sonora	After an interval of about 15 min there were three more successive tremors occurring at intervals of 10–15 min, but so mild that they were scarcely felt by some people. (A11a, A13) (5/14) In about two hours [on 5/3], another shock of less violence occurred. (39b) (5/6) That night, from 10:00 to 12:00, three more tremors were felt and yesterday at 6:00 pm, two more, and two more at night from 10:00 until 11:00; but each time they were very light. (A11a, A13) (5/7) Last night at about 11:00 a very distinct short shock was heard by all, buildings cracked and women screamed. (39b) (5/7) This morning about 9:30, another similar to the one last night was experienced. (39b)
HUACHUCA MOUNTAINS, AZ Cochise Co.	The initial shock [5/3] was followed by two much slighter shocks, at intervals of about 40 min each. (14c, 15)
LAS CRUCES, NM Dona Ana Co.	Slight shocks were reported by several persons during the 12 hrs after the first [shock]. (32)

- NOGALES, AZ
Santa Cruz Co. (5/4) Another sharp shock was experienced at 6:00 this evening. (25b)
(5/24) At 9:30 last [night?] 13 slight shocks of earthquake were felt here. (38m)
(5/24) Three other shocks were felt later; no damage was done. (38m)
- OPUTO, MX
Sonora The shakings have continued, destroying buildings. (A13)
Many of the walls that remained standing in the first earthquake have fallen down in the later smaller quakes. (A11c)
- SAN CARLOS, AZ
Gila Co. (5/3) At 3:52 pm a slight shock of about five sec duration was felt [second shock]. (29g)
- SAN JOSE MOUNTAINS, MX
Sonora (5/7) Another violent earthquake is reported to have occurred in the San Jose Mountains. (14e, 39b)
- SAN MIGUELITO, MX
Sonora (6/7) Aftershocks have been felt, 9–12 sec in duration, preceded by certain subterranean noises and detonations. (A11g)
- TEPIC, MX
Sonora Another shock followed the main shock in five min, and others for about two hrs in five or six min intervals. (26)
Shocks continued throughout the night with a duration of 10 to 30 sec, with decreasing frequency. (26)
It seemed that a fairly strong shock occurred every one half hour during the night. (26)
A shock every two or three hrs occurred during the next day. (26)
Two or three shocks a mo. occurred for the following six mos. (26)
- TERAS MOUNTAINS, MX
Sonora Goodfellow reported continuous rumbling and groaning of the peak, on his trip later in 1887. The vibrations seemed to come from the northern end of the mountains. (i0)
During June, July and September when the severity of the shocks was decreasing one could easily hear them, when not feeling them. The low roar and rumble in the mountains could easily be distinguished and always preceded a severe vibration or was significant of some disturbance too slight to be felt where we were. (A5)
- TOMBSTONE, AZ
Cochise Co. A second shock occurred at 3:14. It was very slight, lasting about two sec. (37a)
A third shock was hardly felt, at 3:45 pm. (37a)
Small rumblings followed for several hrs. (10)
(5/4) Several shocks occurred yesterday at about 5:40 and continued to shake for 40 sec. (25b)
(5/4) Four distinct shocks were felt in this city today. (37b)
(5/5) Several slight shocks were felt during last night. (37c)
(5/7) Succeeding the severe shock (5/3) during the following 48 hrs, marked and noticeable tremors occurred about every half hour. These were of greater or less severity, but none approached the first. Had instruments been here to record the motion, no doubt they would have demonstrated a continual vibration. (18)
(5/7) The heaviest shock, since the first, occurred last night about 9:30. (18)
(5/9) A slight shock of earthquake was felt at 1:40 today. (37e)
(5/22) They had another young (sic) earthquake in Tombstone. (38l)
(9/3) During the past week, Tombstone has been visited with not less than one half dozen light shocks. (36b)

TUCSON, AZ
Pima Co.

The first trembling after the great shock was at 2:45. Four others occurred at about 30 min intervals. (38a, 38b)

(5/4) at 6:30 o'clock yesterday morning, a slight tremor was felt by a number of citizens. (38a)

The earthquake repeated itself, although much less strongly, 45 min later [after the main shock] and at 10:30 pm, and the next day between 7:00 and 8:00 in the morning and at 10:30 am and at 11:45. (A 11d)

(5/5) One or two vibrations have been felt since. (14b, 39a)

(5/7) Several baby tremblors (sic) were experienced last night. (39a)

(5/7) Two very slight shocks were felt in this city today. (39a)

(5/9) From one to two slight shocks have occurred here for several days; too slight to cause alarm. (14f)

(5/14) Two distinct shocks occurred yesterday, the first at 1:45, the other at 2:32 pm. The second cleared the court house almost instantly. (38j)

GENERAL VICINITY OF
NORTHERN SONORA AND
SOUTHERN ARIZONA

In succeeding days and nights after the main shock occurred, the heavy shocks continued. (4)

APPENDIX II

DOUBTFUL ACCOUNTS

SECTION A:

A number of exaggerated or questionable reports were encountered in the process of searching for original documentation. Certain conditions existing in 1887 were conducive to such reports. Modes of communication and travel were much slower in 1887, and, in many areas, communication systems were newly-established or non-existent. Never having experienced an earthquake, many residents of Arizona and Mexico had no comparative context in which to place this event. In 1887, scientific knowledge of earthquake causes and effects was very limited. Few people were educated in the information that was available. Thus great fear and wild speculation were easily generated, which may have motivated the eccentric reports contained in this section. For instance, several people immediately concluded that the Day of Judgement had come. Although some of the quotations included in the Historical Accounts Section (p. 17) may seem questionable, the quotes which follow are highly doubtful according to more reliable evidence.

Reports from 1887 are arranged chronologically by the date they were published; Arabic numerals following the reports refer to the source listing on p. 71.

CONTEMPORARY REPORTS

- a1.* (5/4) Notwithstanding the great earthquake yesterday, Petos' corn cure is all the rage. (*37b*)
- a2.* (5/4) The cause we leave for scientists to determine, although it may prove the precursor of the appearance of the Star of Bethlehem, which we are told will be resplendent in a southeasterly direction this week or next week (*14a*)
- a3.* (5/5) Shortly after the earthquake a volcano broke out 22 mi. south of this place, in the Total Wreck Mountains. The sky is brilliantly illuminated. (*25b*)
- a4.* (5/5) It is believed that a volcano is in active operation in the San Jose Mountains, or on the border of Sonora, about 75 mi. W of here. (*25b*)
- a5.* (5/5) The volcanic eruption is pronounced genuine in the Whetstone Mountains. Lava and smoke can be seen from the streets of Benson, nearly 20 mi. from the disturbance. (*25b, 39b, 14c*)
- a6.* (5/5) There is evidence of an active volcano in the Whetstone Mountains, resulting from the earthquake. Tuesday night a bright fire was visible, betimes the flames shooting upward from 50 to a hundred ft or more. If it should prove to be an active volcano, Arizona would become much more famous as the home of the only active volcano in the United States. (*38b*)
- a7.* (5/5) At first [the volcano near Benson] was thought to be the woods on fire, but the constancy of the burning and the appearance at night indicate that it is a volcano caused by the earthquake yesterday. (*14b*)
- a8.* (5/5) Another volcano is said to be in existence in the Catalina Mountains. (*25b*)
- a9.* (5/5) Authentic news, this moment, comes from Wilcox (sic) that another volcano has made its appearance in Winchester Mountain, about 45 mi. from here. (*25b*)
- a10.* (5/6) Cumbero mesa, 70 mi. W of Albuquerque on the Atlantic & Pacific, is a rugged upland occupied by countless flocks of sheep which are cared for by herders who follow their flocks day and night. On Tuesday Cuberto Gonzales, a large sheep raiser, rode over the range to inspect the flocks. Reaching the mesa at 3:10 pm, he climbed to the top of a high rock to scan the country in search of his herders. At that moment the sky became overcast, a low rumbling sound seemed to approach from the SW and then a slight tremble shook the rock upon which he was perched, followed immediately by a loud report and several shocks which made the rock sway to and fro like the mast of a ship at sea. He was overcome by a deathly sickness which almost caused him to fall from the rock. Recovering himself he started down by the path he had climbed, but found the rock had been rent in twain, leaving a fissure 10 ft wide which counted for the report he had heard. He managed to regain the ground and remounting his horse rode rapidly in the search of his herders. He found some of the sheep scattered and bleating with fright, but no herders in sight. A short distance further on he was horrified by finding one of the men stretched upon the ground dead. He instituted a search for the other two and found them a mile away, both dead. Their bodies bore no marks of violence or injury of any kind, and they were scarcely cold, the flexibility of their bodies indicating that death had overtaken them all within the time Gonzales had been on the mesa. The only plausible theory that could be formed as to the cause of their death was that of extreme fright caused by the terrible convulsion of the elements which he himself had witnessed had killed the men at the same moment. The expression of their features which bore an impression of fright and terror sustained this theory, and it is believed that the three herders were perhaps the only human victims of the great southwestern earthquake. (*39b*)

- a11. (5/7) The earthquake in California [Centerville, May 3 at 8:12 am] on Tuesday morning also suggests its intimate connection with that of Tuesday afternoon in this city, which would give it a general direction from the NW to the SE. (39a)
- a12. (5/7) Word comes from Fort Huachuca that a dense column of smoke rose above the San Jose Mountains, on the Sonora line near Fort Huachuca, after the earthquake in Tucson Tuesday afternoon, and at night the top of the cone was aflame. As there is no timber on that mountain and the hills in the vicinity are covered with lava, there can be no doubt that it is an active volcano. (39a)
- a13. (5/7) Every vantage (sic) of evidence of the volcano has disappeared, but the Benson correspondent continues to describe the glare in the sky, the molten lava pouring down the mountain side, the convulsions of the atmosphere in the neighborhood of the supposed active crater; that correspondent is a lightning (sic) striker, he is an Arizona editor of Ocheltree, in fact he is genuine Arizona daisy. (38d)
- a14. (5/7) It was a gentle affair and as far as its effects are concerned, they are more beneficial than disastrous. (39a)
- a15. (5/10) A. O. Nelson, a young man about 20 years of age, is contained in the county jail awaiting an examination as to his mental condition. He appears to be well educated and is evidently crazy on the subject of earthquakes. (38f)
- a16. (5/10) One hundred and 50 persons were killed. Simultaneously with the shock, volcanic eruptions recurred, in the mountains illuminating the country, for long distances in every distance. (14f)
- a17. (5/10) The earthquake seems to have disturbed the mental equilibrium of several people. No less than six persons in Tucson have been reported as laboring under fits of insanity, all of whom have been effected since the disturbance of this section of mother earth. (38g)
- a18. (5/11) Recent discoveries in the vicinity of Tempe, it is said, discloses the fact that the ancient races of that section were driven away by the frequency of earthquakes. It is said that among the records of the old archives recently unearthed of the Aztec or other ancient people, it is recorded that the people were driven out of Salt River Valley by the frequency of earthquakes which resulted in great destruction of property and lives. The date of the record is fixed about 700 yrs ago. (38g)
- a19. (5/12) A good many people have not yet get (sic) fully over the earthquake. (38h)
- a20. (5/14) In the former of these [Oputo] all the houses were thrown down and nine persons killed; in the latter [Bavispe] the entire population is said to have been destroyed. Thus the center of the convulsion turns out not to have been Tucson, as seismologists first declared, but some 50 or 60 mi S of the border. (39b)
- a21. (5/14) Professor Falb of Vienna connects the Tucson catastrophe with the earthquakes in Italy, and likewise with the explosion of gas in the coal mine in Vancouver. (39b)
- a22. (5/14) A lake between the San Bernardino and Batepito ranches was seen to shoot in the air like a great fountain to the height of at least 100 ft. Accompanying this vast body of water in its flight was a boulder that weighed a ton. This great missile was landed on an elevation some 30 ft above the surface of the lake. (36a)
- a23. (5/14) A gentleman who arrived from Sonora says that there is strong evidence of a volcanic eruption at about 40mi SE of Magdalena, and it is confidently stated that one peak is throwing out large volumes of smoke, accompanied by streams of lava. Smoke and fire can be distinctly seen from several points of the Sonora railroad. As near as can be ascertained the volcano is in the Sierra Azul range. From the appearance of the country and the heavy earthquakes that have occurred it is believed that other volcanoes will break forth in a few days. (39b, 14e)
- a24. (5/14) The earthquake of the 3rd inst. (sic) started a terrible volcanic eruption at Bavispe destroying Montezuma, killing 150 persons and igniting the woods, also 20 persons were killed at Opoto, by falling of buildings. Many persons were injured at Granada and Guasabas which towns were almost completely destroyed. (39b)
- a25. (5/14) (Hermosillo) A new volcano appeared, and its eruption destroyed all the timber and pastures of the adjoining valleys and mountains. (39b)
- a26. (6/1) At Bavispe, the earthquake destroyed the town, killed 100 people and closed the horrors of the day by swallowing up three houses, in one of which there was a girl. (36a)

CURRENT NARRATIVES

Unsubstantiated interpretations and questionable reports continue to appear in current literature. Errors perpetuated in reporting, such as those found below, should be eliminated from future articles on this subject.

- a27. The first known tremor caused by an earthquake elsewhere occurred May 3, 1887, Tucson history enthusiast Stephen Troy Ochoa said. That quake was centered in Magdalena, Sonora, where 275 persons perished, many of them crushed to death when the roof of a cathedral collapsed. (38n)
- a28. A freighter trudged into the little town of Total Wreck, saying his freight wagon and team of oxen had been swallowed up when a crevasse opened and then closed in a stifling cloud of dust. (28)
- a29. Six hundred persons perished near Fronteras south of the border, and the earthquake was called the Sonoran Quake. (28)
- a30. In Bisbee, giant boulders cascaded down the mountain sides, crushing homes and stables. (38o)

- a31. Goodfellow and the residents of northern Mexico, Southern Arizona and New Mexico would be terrorized again four days [May 7] later when vibrations from a second Mexican earthquake would crack buildings, topple chimneys and twist railroad tracks. (38o)
- a32. Had there been a Richter scale in 1887, the earthquake might have registered 8.7. (38o)
- a33. Bavispe, Sonora: 14:13, May 7,* intensity VIII–IX. Epicenter not accurately known. Seismic movements were felt from Toluca, near Mexico City, to Albuquerque and Santa Fe on the N, from Guaymas and Yuma on the west to a point 60 mi. east of El Paso on the E.
 "From Guaymas to Nogales, Benson, Tucson, El Paso, and at places as far away as Albuquerque, water in tanks slopped over, cars were set in motion on the tracks, chimneys were thrown down, and buildings cracked. Mr. Goodfellow was at Tombstone and felt the tremors and heard sounds like prolonged artillery fire coming from the south and dying away to the north. (p. 56, E. Q. History of U.S.). (A9) †

Editorial Note: Sturgul and Irwin (1971) cite two major earthquakes in May 1887, one on the 3rd and another on the 7th.

*The reference given for the second event (May 7) is Coffman and Von Hake (1973), p. 56.

†The quote which appears in Sturgul and Irwin's report is indeed in *Coffman and Von Hake*, but it occurs on page 69 (not p. 56), as part of a description of the May 3rd earthquake. Probably, the reference to two events in the *Daily Citizen* (38o) was prompted by the journalist's observation of Sturgul and Irwin's (1971) error.

SECTION B:

EXPLANATION

The reports presented in this section are included to give perspective to the "questionable" reports presented in Section A.

b1. Verification of the Number of Casualties

[Pertinent reports: a16, a20, a 24, a26, a27, a29]

The lack of efficient communication systems between the epicentral area and the towns in Arizona Territory contributed to the inaccuracy of the first reports of the number of people killed or injured by the earthquake. Directly after the event, many Arizonans believed that Southern Arizona Territory was the epicentral area, and thus assumed that there had been no deaths. After information of the great destruction in Northern Sonora reached Arizona, the casualty reports tended to be exaggerated. In an attempt to verify the number of casualties and injuries, actual obituary lists and the reports of James Douglas and George Goodfellow, who both visited the epicentral area, were judged to be most accurate. These reports indicate that the number of deaths resulting from the earthquake is 51 or 52, and the number of injuries is considerably higher than the estimated 29.

Don Carlos Velasco is in receipt of the following names of the persons killed by the earthquake in the towns of Bavispe and Oputo. In Bavispe the names of the dead are, Miguel Samaniego, José M. Ortega, Reynoldo Samaniego, Eufemio Samaniego, Rita Samaniego, Josefa Martines, Mariano Madrid, Concepción Madrid, Reyes Machiche, Mariano Jamaniego, Rosa Samaniego, Martin Parra (h.), Maria Gomez, Isabel Baltierrez, Felipa Bacaene, Jesus Bacaene, Simona Colocio, Genoveva Morales, Trinidad Serrano, Francisca Henriquez, Romula Henriquez, Jose Henriquez (h.), Pilar Bizearra, Jose Galaz, Maria Jesus Lugo, Miguel Cortéz, Antonio Vasquez, Miguel Galáz, Josefa Viescuan, Juan Henriquez, Procopio Jaquez, Soledad Quideza, Ines Quizada, Rosa Martinez [Bavispe, Mx]. (39d)

Hermosillo's *La Constitucion* adds the following names to the list of those killed: Serapio Vargas, Juan Samaniego, Eulalio Serrano, Francisco Gafaz, Petra Babuche, Isabel Torrero, Francesca S. de Samaniego, Trinidad Zorrillo and Edwiges Saminiego.

Editorial Note: One name which appears in the *Weekly Citizen* list of casualties does not appear in the *La Constitucion* list. This may indicate that the number of casualties was 43, or it may indicate that one person was misidentified. However, the list appearing in *La Constitucion*, Goodfellow's report and Douglas's notes all state that the number of casualties was 42.

Forty-two lives lost out of a population of 700. (20)

Deaths—Bavispe
 Boys—16
 Girls—9
 Women—7
 Men—10
 29 injured (A1)

One child was killed and one woman was fatally injured [Fronteras, Mx]. (18)

In Oputo—Jésus Maria Duran, his wife and young daughter, also a sister of Duran's; the wife of Jesus Timbres; the wife of Cirilo Ramierez, a child of Andrez Romo, and a sick man name unknown, in the house of Durazo [Oputo, Mx.]. (39d)

Nine people were killed in Oputo: Juana Timbres, Maria Jesus Trujillo Felicitas Durazio, Beatriz Guerrero, Guadalupe Garcia, Francisco Ramierez, Jose Granillo, and Maria Moreno. Six people suffered injuries. (A 11g)

Editorial Note: (Pertaining to report a10.) The three deaths reported on Cumbero Mesa, New Mexico, have not been included as a part of the total number given in this section, due to the highly questionable nature of this report.

b2. Reports Addressing the Subject of Volcanoes

[Pertinent reports:

a3, a4, a5, a6, a7, a8, a9, a12, a13, a16, a23, a25]

Succeeding the shocks, mountain fires were noticed on many of the ranges. This gave rise to the reports of volcanic action, which may safely be set down as pure imagination. No phenomenon resembling eruptive disturbance, so far as I can now ascertain, has taken place in any part of the section disturbed. At the time of the first and severe shock, owing to the vibration and the rolling boulders down the mountainsides, large clouds of dust arose; this, with the noise, caused many who saw the phenomenon to think that the cause was eruptive. The fires, with only two exceptions that I know of, were burning before the shock. Of these it is possible that they were not noticed prior to this, or, what is in my opinion not improbable, falling boulders ignited the timber. (18)

There is not now, nor has there been, lava eruption or crater volcano. I visited every locality in the Sierra Madres where such phenomena had been reported—fruitlessly. (20)

The explanation, in our opinion, for these mountain fires is that the impact of the rocks, from many of the peaks which were thrown down, developed enough heat to ignite the grass which is very dry at this time of year. The fires, starting in this way at separate points, rapidly spread and became general. It is possible, too, that in some places it was only a coincidence between the day of the earthquake and the day on which the pastures were burned. Such fires are not rare occurrences in this part of the country, and generally occur during the months of May and June. (7)

b3. Addressing Report Concerning the Salt River Excavations

[Pertinent report: a18]

While in the Salt River Valley two weeks ago, I was informed by Mr. Frank Cushing, the ethnologist, who is making extensive excavations in the old ruins abounding there, that one of the principal if not main cause of the abandonment of so populous and fertile a valley was earthquakes. As there are no records of any occurring since that time, Mr. Cushing may take the blame for suggesting this.

The reports claiming that abandonment of Indian settlements in the Salt River Valley was due to earthquake activity, were based on the findings of the Hemenway Archaeological Expedition of 1887–1888 (Haury, personal communication). The above claim was made after one skeleton was found under a collapsed wall (See Fig. 27). No further evidence was presented for this conclusion.

b4. Relationship to Centerville, Italian, Charleston Earthquakes and Other Disastrous Events

[Pertinent reports: a11, A21]

While it is unknown whether the Centerville earthquake may be remotely related tectonically to the Sonoran earthquake, they were not the same event. These two events occurred at least six hours apart. Also, supposing a single event occurred, it would have been unlikely that the shock originating in Mexico would have been felt in Centerville without being felt strongly in Yuma.

Other speculations on relationships of the May 3, 1887 earthquake to distant events on different days have been discounted for obvious reasons.

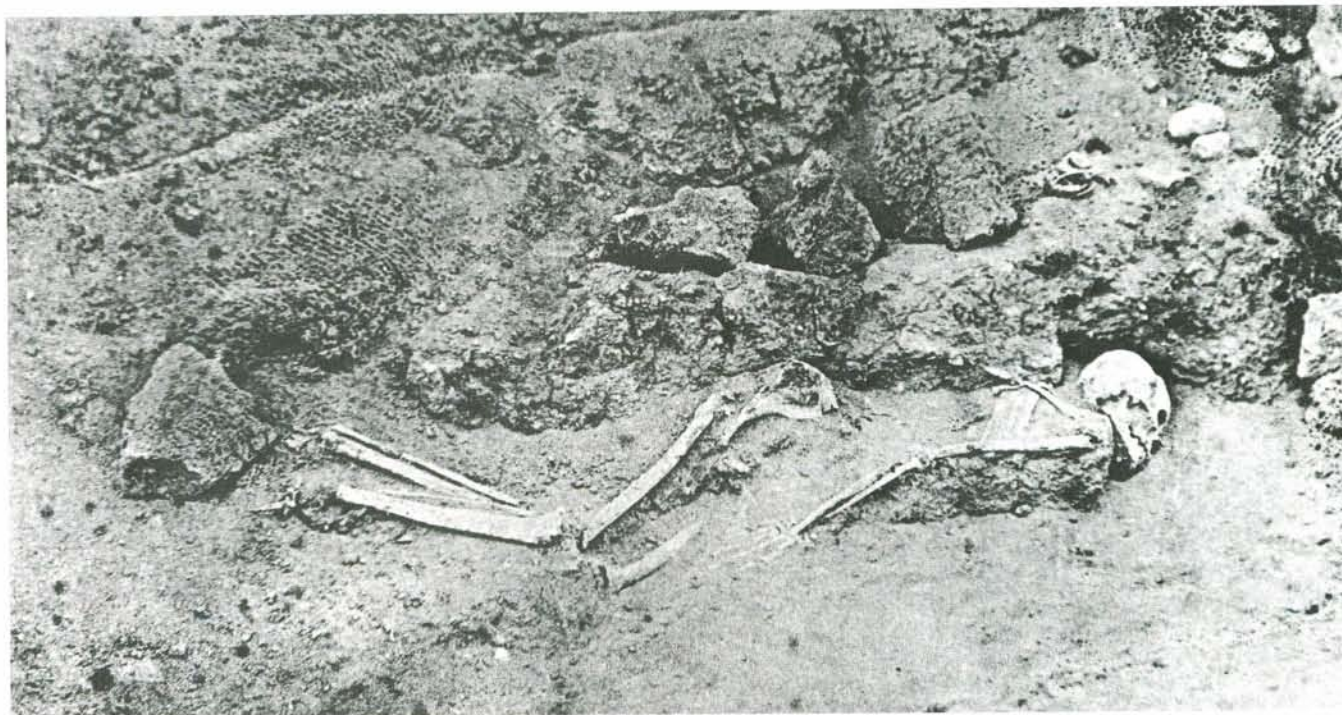


Figure 27. Remains from Los Muertos, an Indian village in the Salt River Valley. "In room K, along the north wall the point marked 35, there was uncovered a skeleton of a man caught beneath a collapsed wall...cited on several occasions as evidence of the destruction of the entire valley by an earthquake." (A6) Photo courtesy of Peabody Museum, Boston, Massachusetts.

APPENDIX III

Ways to Minimize Earthquake Losses

It is possible that a major earthquake could recur in or near Arizona. Based upon historical seismicity patterns, it appears likely that the greatest earthquake hazard exists in the Yuma vicinity and along the northwest-trending seismic belt postulated by Sumner (1976) and Fugro (1975). The frequency of such events is not yet known. Because of the increase in population, urban construction and agricultural development, and the existence of water, gas, electric and sewer lines, a present day magnitude 7 earthquake in Sonora would be more devastating than the 1887 event. The danger increases with expansion and development of an area.

Should a similar seismic incident happen, the water supply would probably be disrupted and contaminated within 150–200 kilometers of the epicentral region. Power failures would likely occur in many areas. Phone lines would be disconnected or tied-up, and roads would become obstructed with fallen wires or rock debris. Firemen and other emergency personnel might not only be understaffed for the task of disaster relief, but also unable to reach certain areas. The safest place during such an event would probably be a treeless meadow, where hazard from falling objects, broken glass and collapsing structures does not exist.

Numerous potential hazards, however, can be minimized or eliminated through planning and common sense. Although earthquake losses can be substantially reduced by adequate and enforced building codes, zoning provisions and vigorous community programs designed to strengthen disaster preparedness, an individual can lessen the dangers to himself and his family by learning what to do in the event of an earthquake.

BEFORE AN EARTHQUAKE

AT HOME

1. Remove Possible Hazards

- Fasten heavy appliances and furniture securely to either the wall or the floor. Bolts or other strong supports should be provided for waterheaters and other gas appliances, since fire damage can result from broken gas lines and appliance connections.
- Remove heavy objects from high shelves. Secure heavy, hanging objects.
- Get rid of piles of newspaper and other flammable materials which could ignite should there be gas leaks in the quake aftermath.
- Install effective latches in cupboards. Positive catches, tiny bolts, toggles and touch latches deter the opening and spilling of contents.
- Keep beds away from windows which do not contain tempered or reinforced glass.

2. Obtain Provisions for an Emergency

- Store water supply. Allow one half gallon of water per person for each of five days. Stored water should be changed occasionally to insure freshness. Chlorine bleach should be kept to purify water, if needed.
- Stock up an adequate supply of canned or non-perishable food which would not require cooking.
- Keep a first aid kit and be familiar with first aid procedures. Include extra medication for those family members who require regular medication.
- Have a battery-powered radio and flashlight in a convenient place. Keep additional batteries on hand.
- Maintain stock of miscellaneous items required for family members (for example, plastic garbage bags, toilet paper, etc.).

3. Educate the Family

- Know the location of your gas and water shut-off valves, as well as the electric fuse box. Make sure all responsible members of your family learn how to turn them off.
- Discuss the possibility of a major earthquake with family members. After several California earthquakes, many children and adults required therapy to overcome fears and feelings brought about by the event. Each member should be mentally prepared for possible effects of an earthquake, so that he or she knows what to do should a disastrous event occur.
- Establish a checkpoint outside the area of seismic risk for family members in the event of an emergency. Remember that telephones should not be used except for genuine emergencies.

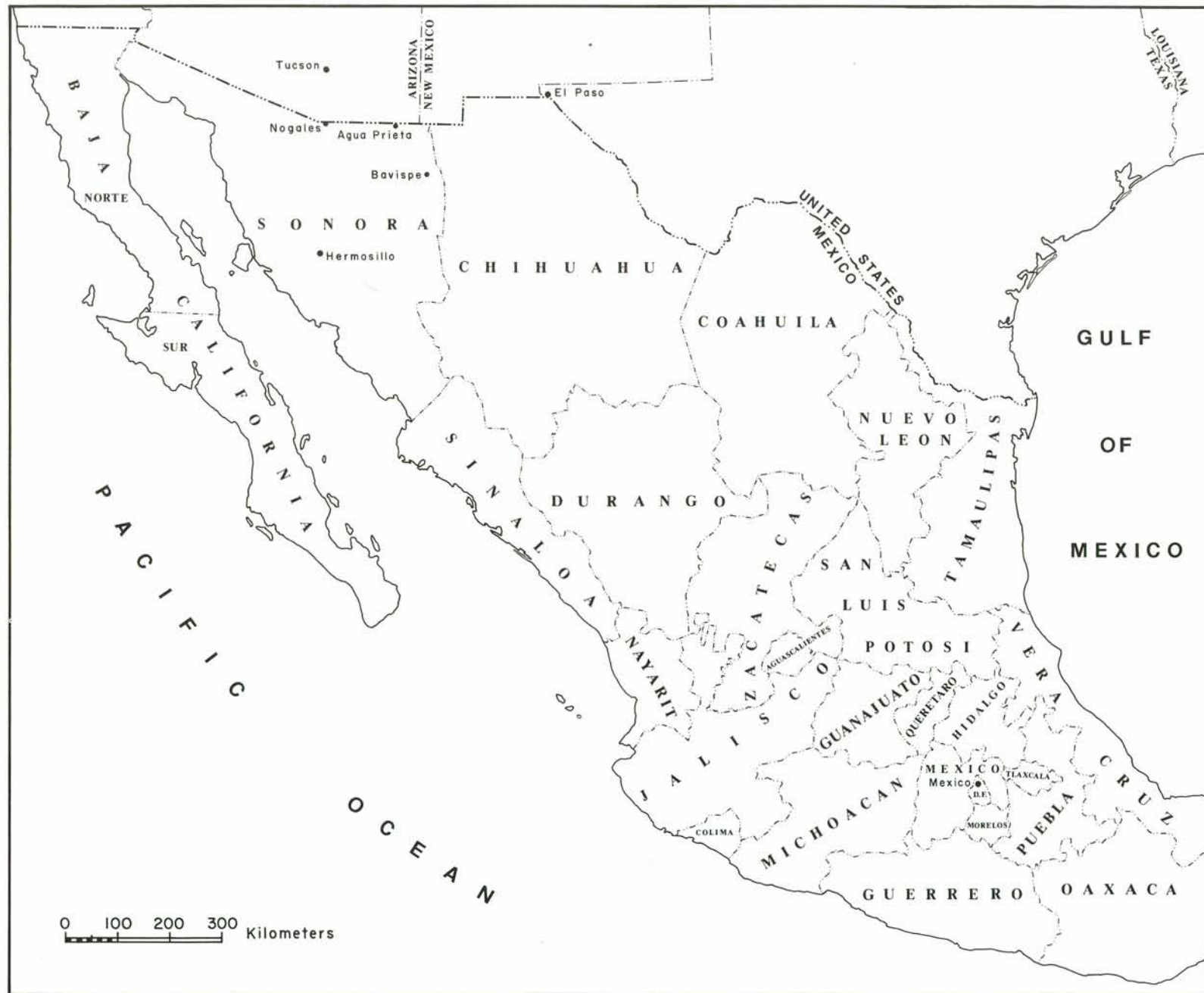


Figure 28. Index map of Mexican states.

INDICES TO HISTORICAL ACCOUNTS

I. Cross-Referenced Place Names

All place names referenced in the felt reports (p. 21-69) are listed below. Both Mexican and United States locations are arranged by state. Names listed in upper case letters (e.g., **ARIVACA, AZ**) appear as alphabetically-arranged entries in the felt reports section. If "see also" appears, additional reports can be found under other entries listed. For example, **ABBOTT'S RANCH, AZ** reports can also be found under **SULPHUR SPRINGS VALLEY** in the felt reports. Finally, those names for which the first letter only is upper case, followed by "see," do not appear as separate entries in the felt reports; they are mentioned only in reports under upper case place names. For instance, Adonde Station, Az reports are listed only under **YUMA, AZ**.

MEXICO

CHIHUAHUA

BOLSON DE MAPIMI
CARRETAS RANCH
CASAS GRANDES
CHIHUAHUA CITY
Concepcion, see: GUERRERO
CORRALITUS MINING CO.
DIEZ
GALEANA
GUERRERO
JANOS
JIMINEZ
SIERRA MADRES
Penuelas Springs, see: CARRETAS RANCH
ROSALES
SAN ANDRES
SANTA ROSALIA

DURANGO

DURANGO

FEDERAL

MEXICO CITY

GUANAJUATO

GUANAJUATO

MEXICO

MEXICO VALLEY
TOLUCA

SINALOA

MACORITA
MAZATLAN

SONORA

AGUA PRIETA VALLEY
SIERRA LOS AJOS
CAJON DEL ALAMO
ALAMOS
ALTAR
ARIZPE
see also: MONTEZUMA DISTRICT
SIERRA AZUL

Babispe, see: BAVISPE

BACADEHUACHI

see also: GRANADOS

Sierra Bacapiri, see: OPUTO

Bacerac, see: BACERAS

BACERAS

see also: BURRO HILL, CALLEJON, SAN MIGUEL

Bacoache, see: BACOACHI

BACOACHI

BADEHUACHI

BAROYECA

BATEPITO RANCH

see also: BAVISPE, ELIAS CREEK, SAN BERNARDINO RANCH

BATEPITO RIVER VALLEY

see also: CAJON DEL ALAMO, NACOZARI

Batteto Ranch, see: BATEPITO RANCH

BAVISPE

see also: BATEPITO RANCH, CALLEJON, CARRETAS RANCH, FRONTERAS, HACIENDA LA FUNDICION, OPUTO, PEDREGOSO CROSSING, SAN BERNARDINO RIVER VALLEY

BAVISPE RIVER VALLEY

see also: CAJON DEL ALAMO, BATEPITO RIVER VALLEY, BURRO HILL, CINCO DE MAYO, FRONTERAS RIVER VALLEY

BUENAVISTA

BURRO HILL

LA CABELLERA

CABULLONA

CABULLONA MTS.

see also: SIERRA TURICACHI

CALLEJON

CAPE HARO

Cerros de los Carrizales, see: GUASABAS

Cerros de las Casitas, see: OPUTO

Chivato Mts., see: TORRES STATION

CINCO DE MAYO

HACIENDA DE LA CRUZ

CUCHUTA

see also: BADEHUACHI

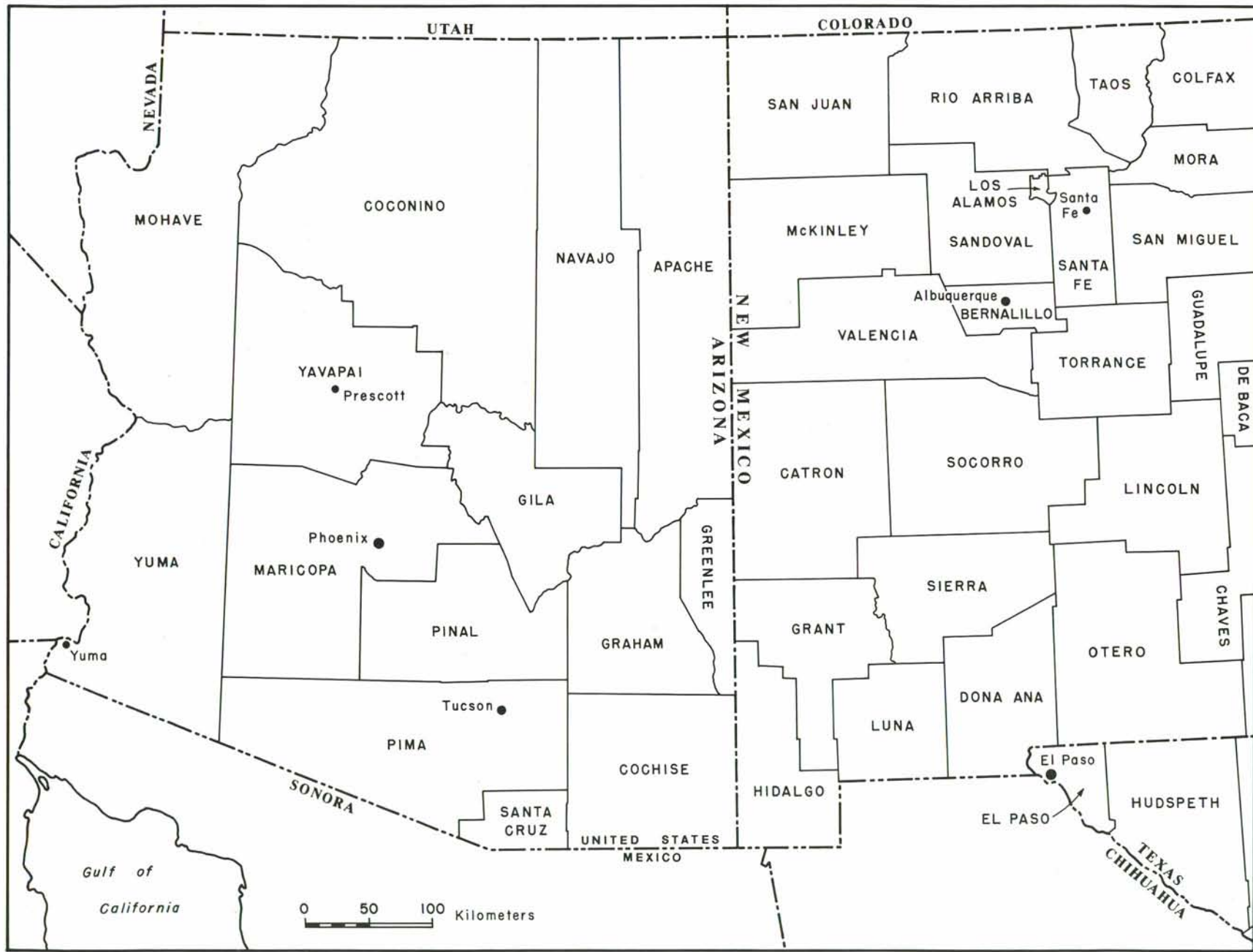


Figure 29. Index map of Arizona and New Mexico counties.

SAN CARLOS
SAN CARLOS RESERVATION
GRAHAM COUNTY
FT. THOMAS
Graham Mts., see: SOLOMONVILLE
SOLOMONVILLE

GREENLEE COUNTY
CLIFTON

MARICOPA COUNTY
FT. McDOWELL
GILA BEND
GILA CROSSING
PHOENIX
SALT RIVER

NAVAJO COUNTY
FT. APACHE

PIMA COUNTY
ARIVACA
COYOTE MTS.
DAVIDSON'S CANYON
EMPIRE RANCH
Mt. Lemmon, see: SANTA CATALINA MTS., TUCSON
Old Castle, see: SANTA CATALINA MTS., TUCSON
OLIVE CAMP
Pan Tak, see: COYOTE MTS.
PANTANO
PUSCH'S RANCH
Rillito River, see: SANTA CATALINA MTS.
Rincon Mts., see: ELGIN, PANTANO
SANTA CATALINA MTS.
SANTA RITA MTS.
TOTAL WRECK
TUCSON

PINAL COUNTY
DUDLEYVILLE
Gila River, see: SAN PEDRO RIVER VALLEY
MAMMOTH
MARICOPA
ORACLE
PICKET POST MT.
PINAL

SANTA CRUZ COUNTY
ASH CANYON
BLOXTON'S RANCH
CALABASAS
CRITTENDEN
ELGIN
HARSHAW
NOGALES
ORO BLANCO
PATAGONIA MTS.
SANTA CRUZ RIVER
SANTA RITA MTS.
WASHINGTON CAMP

YAVAPAI COUNTY
FT. VERDE
PRESCOTT

YUMA COUNTY
Adonde Station, see: YUMA
COLORADO RIVER
FT. YUMA
Gila & Colorado River Jct., see: COLORADO RIVER
Tacna Station, see: YUMA
YUMA

VALLEYS

ALTAR VALLEY
ARIVACA
BABOCOMARI RIVER VALLEY
BABOCOMARI
ELGIN

COLORADO RIVER VALLEY
COLORADO RIVER
FT. YUMA
YUMA

GILA RIVER VALLEY
DUDLEYVILLE
FT. THOMAS
GILA BEND
GILA CROSSING
MARICOPA
PINAL
SOLOMONVILLE

SALT RIVER VALLEY
PHOENIX
SALT RIVER

SAN BERNARDINO RIVER VALLEY
SAN BERNARDINO RANCH
SAN BERNARDINO RIVER VALLEY

SAN CARLOS RIVER VALLEY
SAN CARLOS

SAN FRANCISCO RIVER VALLEY
CLIFTON

SAN PEDRO RIVER VALLEY
ASH CANYON
BENSON
BLOXTON'S RANCH
CHARLESTON
FAIRBANK
MAMMOTH
OLIVE CAMP
ST. DAVID
SAN PEDRO RIVER VALLEY
TOMBSTONE
TRES ALAMOS

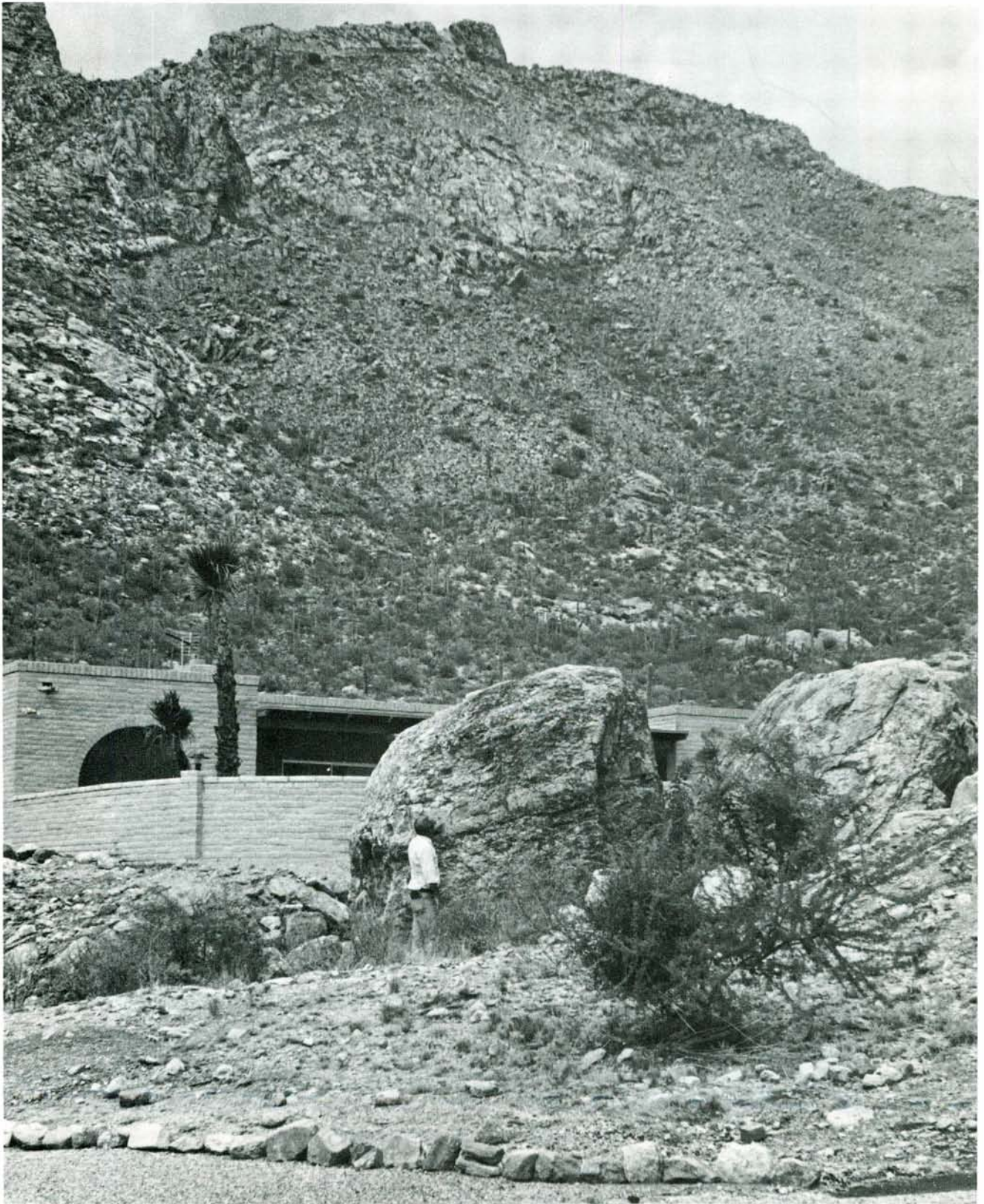
SAN SIMON RIVER VALLEY
BOWIE
SAN SIMON

SANTA CRUZ RIVER VALLEY
CALABASAS
NOGALES
PANTANO
PUSCH'S RANCH
SANTA CRUZ RIVER
TUCSON

SULPHUR SPRINGS RIVER VALLEY
ABBOTT'S RANCH
RIGGS' RANCH
SOLDIER'S HOLES
SULPHUR SPRINGS VALLEY
WHITE WATER CANYON
WILLCOX

VERDE VALLEY
FT. McDOWELL
FT. VERDE

WHITE RIVER VALLEY
FT. APACHE



**Fallen boulders in residential foothill area, Santa Catalina Mountains, Tucson.
It is unknown when this rockfall took place. Photo courtesy of H. Wesley Peirce**

**STATE OF ARIZONA
BUREAU OF GEOLOGY AND MINERAL TECHNOLOGY**

The Arizona Bureau of Geology and Mineral Technology was established in 1977 by an act of the State legislature. This act represents a reorganization of the Arizona Bureau of Mines which first was created in 1915 and placed under the authority of the Arizona Board of Regents. This authority has not changed. The Bureau continues its service in the fields of geology, metallurgy and mining in response to public inquiries, state agency requirements, and various research grants. In order to carry out these functions, two basic branches now are recognized:

The Geological Survey Branch is charged with the responsibility of acquiring, disseminating and applying basic geologic data that are designed to (a) enhance our understanding of Arizona's general geologic and mineralogic history and to assist in determining the short and long range influences these have on human activity, and (b) assist in developing an understanding of the controls influencing the locations of metallic, nonmetallic and mineral fuel resources in Arizona.

The Mineral Technology Branch conducts research and investigations into, and provides information about, the development of Arizona's mineral resources, including the mining metallurgical processing and utilization of metallic and nonmetallic mineral deposits. These activities are directed toward the efficient and safe recovery of Arizona's mineral resources as well as insuring that recovery and treatment methods will be compatible with the basic environmental needs of the state.

