

NEWS RELEASE

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Southern California, Arizona, Nevada, and Oregon Rattled by Distant Aftershocks after the 1906 San Francisco Earthquake

- The largest aftershocks occurred off the Humboldt County coast; very few significant aftershocks hit the San Francisco Bay Area

SAN FRANCISCO, April 18.—Following the great 1906 San Francisco earthquake on the San Andreas fault, a large number of distant aftershocks—or triggered earthquakes—took place farther away from the fault than previously realized. These distant aftershocks, which took place within the first two days after the San Francisco mainshock, rattled areas of southern California, western Arizona, western Nevada, and southern central Oregon. The largest of these events were a magnitude 6.1 earthquake near the Salton Sea (in the Imperial Valley) and a magnitude 5.0 earthquake under or near Santa Monica Bay (Los Angeles County). These findings were announced today at the annual meeting of the Seismological Society of America in San Francisco. They follow from research conducted by Aron Meltzner and David Wald at the California Institute of Technology (Caltech) and the U. S. Geological Survey in Pasadena.

Traditionally, scientists have thought that earthquakes do not trigger other earthquakes more than one rupture length away from the fault rupture—that is, if the part of the fault that slipped in the 1906 earthquake was 250 miles long, the earthquake would not trigger other earthquakes more than 250 miles away from that part of the fault. However, after the 1992 Landers earthquake triggered earthquakes near Mammoth Lakes, California, near Yucca Mountain, Nevada, and in Yellowstone National Park, the scientific community became more aware of these “distant aftershocks.” Looking back in time, Meltzner and Wald wanted to see if the same phenomenon took place after 1906.

“What we found,” said Meltzner, “is that earthquakes started popping up all over southern California and in Arizona and Oregon that were well beyond 250 miles from the fault.” That doesn’t include two earthquakes east of Reno, Nevada that were barely within the 250-mile radius, and countless others that may have taken place in remote locations where no one was around to report them. These distant aftershocks started within an hour of the San Francisco earthquake and continued for about a day and a half.

Meltzner and Wald rule out that the earthquakes in southern California, Arizona, and Oregon—which were all more than 250 miles from the fault—occurred at about the same time by coincidence. “Not only is it highly unusual for so many earthquakes in different places to cluster together like that in time,” explained Meltzner, “some of them apparently occurred in places that rarely experience earthquakes at all.” Meltzner and Wald calculated the odds that all the so-called distant aftershocks were unrelated and happened within the same two-day period by chance alone: about 4 billion to 1. “If it all happened by chance, we could expect something like that to occur once every 20 million years,” added Meltzner. “Obviously, since it happened in the 48-hour period immediately following the 1906 earthquake, it wasn’t just chance.”

Prior to the current work of Meltzner and Wald, no one had looked systematically at the aftershocks of the 1906 earthquake, and very basic questions—such as when or where the largest aftershocks occurred, or how large they were—could not be answered. But for an earthquake as large as the San Francisco event, which had a magnitude of 7.8, aftershocks as large as the 1994 Northridge earthquake or even the 1989 Loma Prieta earthquake are possible, and they can be extremely damaging in their own right, so such questions cannot be ignored.

Part of the reason that the 1906 aftershocks remained unstudied up to this point is that seismic instruments at the time were very primitive, and they were few and far between. The recordings from those instruments are only helpful in the largest earthquakes, and even then they are not without shortcomings. Meltzner and Wald solved this problem by turning instead to descriptive historic accounts—newspaper articles, personal diaries, and letters written by people who felt and described each aftershock—to determine how strong the shaking was at different locations during each aftershock. By knowing the intensity of shaking at a variety of locations, Meltzner and Wald were able to estimate the magnitude and location of each aftershock.

Other findings show that the largest aftershocks overall took place off the Humboldt County coast. For their study, Meltzner and Wald looked at aftershocks which took place from April 18, 1906—the date of the San Francisco earthquake—to the end of December 1907. Within that time period, the largest aftershocks were a magnitude 6.7 earthquake 60 miles west of Eureka, California, five days after the San Francisco earthquake, and a magnitude 6.5 earthquake 40 miles west of Cape Mendocino, California, 16 months later, in August 1907. Other than the magnitude 6.1 earthquake near the Salton Sea on April 18, 1906, the next largest aftershock—and the largest aftershock near the San Francisco Bay Area—was a magnitude 5.6 earthquake in May 1906, near San Juan Bautista. Only one other Bay Area aftershock—a magnitude 5.1 earthquake near Redwood City in June 1907—exceeded magnitude 5.0.

Altogether, this study shows that although the 1906 San Francisco earthquake took place on the San Andreas fault, the largest aftershocks occurred a significant distance—several tens of miles to several hundred miles—away from the fault. This finding has important ramifications for our understanding of earthquake triggering and the behavior of aftershocks following a large earthquake. “Having a good statistical basis from what has happened in the past,” noted Wald, “is the best means for forecasting aftershocks following large San Andreas type earthquakes in the future.”

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Attached:

Figure 1: Map of the largest aftershocks of the 1906 earthquake, April 18, 1906 through December 31, 1907. Red lines show faults in California; the thick red line is the part of the San Andreas fault which ruptured in the 1906 San Francisco earthquake.

Figure 2: Map of the largest aftershocks and triggered events to occur during the first 48 hours after the April 18, 1906 San Francisco earthquake. Red lines show faults in California; the thick red line is the part of the San Andreas fault which ruptured in the 1906 San Francisco earthquake. Dotted line shows 250-mile radius around the part of the San Andreas fault involved in the 1906 earthquake. Note that the largest triggered event had a magnitude of 6.1, and the next two largest events were in the range of magnitude 4.9 to 5.0; *this is not a typo*.