

## Facing the Great Disaster:

# USGS Responds to the Earthquake

By Liz Colvard and James Rogers

In 1906, the only permanent U.S. Geological Survey (USGS) office in California was the Pacific Region Topographic Mapping Office in Sacramento, some 70 miles up the Sacramento River from San Francisco Bay. The office had been established just three years earlier and was the only USGS office ever created for the sole function of topographic mapping. On April 18, 1906, many of the USGS topographers were in Sacramento preparing for summer fieldwork. It was that day that the great earthquake struck.

Although a small amount of shaking was felt in Sacramento, detailed information about the earthquake was slow to reach the residents there. Before the full extent of the damage was known,

USGS topographic engineer George R. Davis, fearful that his 62-year-old father, Edward Davis, was caught up in the earthquake devastation, left Sacramento on the first train bound for San Francisco. "He was very worried. The phones were down and he wasn't sure whether or not the hotel his father was living in was damaged," says George Davis' daughter Anna Davis Rogers, now 88 years old, recalling stories she heard of these events while growing up. "Fortunately [the hotel] hadn't fallen down."

Davis, a tall man with a quiet demeanor and a dry wit, was accompanied to San Francisco by fellow USGS topographer Clarence L. Nelson. Both were 29 years old and in excellent physical condition after a year spent mapping the Mt. Whitney quadrangle, which features some of the most rugged terrain in the conterminous United States.

Upon their arrival in San Francisco, the pair was fortunate to find the elder Davis unharmed at the hotel where he had been living. Nelson had brought his camera to get photographs while things were still "hot" and began taking what would become a memorable set of images. The three men wandered through San Francisco all night and the following morning, moving from one dramatic scene



Left to right: Robert B. Marshall (back to camera), A.I. Oliver, Albert H. Sylvester, Sidney N. Stoner, George R. Davis and A.B. Searle in the USGS Pacific Region Topographic Mapping office, circa 1904-1905. Marshall, Sylvester, Stoner, Davis, and Searle were all part of the USGS group that took the first boatload of relief supplies down the Sacramento River to San Francisco following the 1906 earthquake. Photo: George R. Davis family.

to the next. Nelson captured the horse-mounted dynamite squad, soldiers marching out from the Presidio and a rare scene of two horse-drawn fire engines with one engine drawing water from a cistern on Union Street. One ironic photograph shows refugees wending their way through rubble-filled streets in the direction of a wrecked City Hall. Flames of the burning district shone brightly against the darkness, and Nelson captured the surreal glow in several of his photographs, including one of Union Square with the Breuners building burning in the background.

### USGS Topographers Swing into Action

Because of its proximity to the Bay Area, Sacramento — a growing capital city of 31,000 — figured prominently in early relief efforts. At a mass meeting on the Sacramento courthouse steps the morning of April 19, citizens cheered when Sacramento's ad hoc General Relief Committee declared that they would not wait to be asked to help and that a riverboat had already been secured to transport supplies to San Francisco at the earliest opportunity.

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## A Letter Home

### Earthquake Survivor Percy J. Holmes Recalls the Historic Day's Events

(This letter was published in a Connecticut newspaper, May 1906. Percy J. Holmes was the grandfather of the wife of John Filson, USGS emeritus.)

Merchant E. F. Hawley hands us the following letter from Percy J. Holmes, son of Joshua Holmes of Shelton: 2550 Pacific Avenue, San Francisco, Cal., April 26, 1906.

Dear Mother:

Your letter arrived this morning and I will answer it immediately. It is noon now and the first chance to have had to write to you since the earthquake. I tried everywhere in 'Frisco to send you a telegram, but could not get one off until Saturday, when Mrs. Magee went to Oakland. I gave her a telegram to send to you saying that Uncle William's family and I were all well.

The quake was a great one. It happened at 5:13 a.m. and I was fast asleep, but was awakened by an awful roar and shaking. The whole house was shaking and I thought it was going to fall to pieces. I jumped out of bed and ran into the yard, but the bricks were falling so fast there that I "ducked" back into my room and slipped into my clothes. By that time the shake was over and I had to climb over about two feet of fallen bricks to gain the street.

The house next to ours was a brick one, in the course of construction. It was three stories, and the top story was shaken down, depositing about two tons of bricks into our driveway. All the streets were full of bricks, as the chimneys of the houses were all shaken down. About five minutes later we had another shock, not as heavy as the first and we have had slight shocks at long intervals, ever since. Yesterday we had another severe shock, and most everyone ran into the streets again, expecting a repetition of the first.

Magee's house stood the shock finely, and with the exception of two of the chimneys, that were shaken down, it received very little damage.

The first shock was a "peach" all right. I was not badly frightened until after it was all over. The first thing I thought of was "I'm sorry for the people near Vesuvius," but about five minutes after the shock I found myself trembling like a leaf, and felt as though I was freezing. You cannot imagine how terrible everything shook. I always thought that an earthquake was a rolling motion of the ground, but that one felt as though you rode a bicycle down a long flight of stairs. The sensation is terrible, a person feels so helpless; in fact you are nearly helpless, as the only thing you can do is to run to the nearest open place.

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## America's Shaky Past - The Top 18 Earthquake Events in the United States Since 1700



This Japanese map shows the Kuwagasaki Coast, an area affected by the tsunami in 1700.

Cascadia Subduction Zone (from British Columbia to Northern California)

Date: Jan. 26, 1700

Magnitude: 9.0

Damage: A resulting tsunami destroyed villages in the Pacific Northwest of the United States and damaged coastal areas in Japan, as

geologic evidence corroborated by Native American oral traditions and Japanese written records indicate. The dollar amount of property losses is not known.

Number of deaths: unknown



Taken in 1935, this image shows the ruins of the first La Purisima Concepcion Mission near Lompoc, Calif.

Wrightwood and Ventura, California

Dates: Dec. 8 and Dec. 21, 1812

Magnitude: ~7.5 and 7.1

Damage: These potentially related earthquakes damaged several missions, including the Mission San Juan Capistrano, where the church

collapsed during mass. The Dec. 21 earthquake destroyed the Mission La Purisima Concepcion, near present-day Lompoc, Calif. The dollar amount of property losses is not known.

Number of deaths: 41 (40 in the San Juan Capistrano collapse)



This 19th-century illustration depicts the damage and chaos resulting from the 1811-1812 New Madrid earthquakes.

New Madrid, Mo.

Dates: Dec. 16, 1811; Jan. 23, 1812; Feb. 07, 1812

Magnitude: All estimated to be in an approximate range from 7.5 to 8.0

Damage: Structures collapsed or were damaged from Cincinnati to St. Louis; New Madrid was destroyed in the

Feb. 7 earthquake. Areas in Arkansas, Illinois, Kentucky, Missouri and Tennessee experienced landslides, land uplifted and trees destroyed. At area rivers, banks collapsed, islands disappeared and waves overwhelmed or beached boats. The dollar amount of property losses is not known.

Number of deaths: unknown

Ka'u District, Hawaii

Date: April 2, 1868

Magnitude: 7.9

Damage: The earthquake and resulting tsunami and landslides destroyed homes, a large church and warehouses. The dollar amount of property losses is not

known. More recently, the magnitude-7.2 Kalapana, Hawaii, earthquake in 1975 led to a local tsunami of more than 40 feet.

Number of deaths: 77 (tsunami, 46; landslide, 31)

# A Look Back in Time

## An Interview with a Survivor of the 1906 San Francisco Earthquake

(Excerpts reprinted from "Earthquake Information Bulletin" May-June 1977, Volume 9, Number 3)

By: Henry Spall

Bert L. Smith, Jr., was born in Eureka, Nev., and was in the Palace Hotel, San Francisco, at the time of the great earthquake of 1906. Now retired, he lives with his wife, Emily, in Santa Rosa, Calif., 45 mi north of San Francisco. From 1926 to his retirement in 1966, he had various assignments in the field of agriculture with such organizations as the U.S. Department of Agriculture and State and Federal farm and water agencies. For 18 yr he was involved with the Commonwealth Club of California and has been a Regent of the University of California.

### H.S. What brought your family to San Francisco on April 18, 1906?

**Smith.** First let me back up a little. My mother's family founded Centennial, Wyo. My father's family was in the woolen business in Massachusetts. My father decided to come out West with his brother, and he landed in Wyoming long enough to work in the bank and marry my mother. After a short time in Mexico, my parents followed the mining boom into Nevada. You have to understand that in those days mining was either boom or bust.

### H.S. Where were you living in 1906?

**Smith.** Eureka, Nev. My father was in banking and had various interests in the mining business. The year 1906 was a good one, and my father was enjoying a period of temporary affluence. So we decided to visit San Francisco for the shopping, but largely so my parents could go to the Opera and hear the great Italian tenor, Enrico Caruso.

### H.S. And you stayed at the Palace Hotel?

**Smith.** Of course. That was what you did in those days if you were affluent. Caruso stayed there, too — although we didn't see him. We brought 1 or 2 trunks with us, rather more modest than the 200 trunks we were told that Caruso had brought with him.

### H.S. What happened at 5:18 am the next morning?

**Smith.** Well, of course, it was dark at the time. I remember distinctly being awakened by the earthquake — and the shock, the terror of it all. And the efforts of my mother to calm us children as best she could. Then, we heard the panic from the room next door where our friends, the George Bartletts, were staying. They couldn't get to their children in an adjoining room because the earthquake had jammed the door shut.

### H.S. What did your family do then?

**Smith.** Well, you must remember that I was a small child at the time, and at the age you don't recall all the minute details. But several distinct memories have stuck in my mind. I recall being dressed on the bottom steps of the magnificent stairway in the lobby of the hotel. There was fallen plaster from the ceiling all around us, and I couldn't help wondering if the chandeliers were going to fall, too.

One of my most vivid memories was of my mother with her hair uncombed and not braided around her head as she usually had it. That made a distinct impression on me.

I recall the discussions about if the Palace would burn and when it would burn. As you know, it survived the earthquake rather well, but it burned down later as the fire swept through the city. The answer from the hotel manager was that despite the very latest fire-prevention measures in the hotel, he thought it was probably going to burn. Perhaps because of this he gave us all our room keys as mementos.

### H.S. What then?

**Smith.** We moved out of the hotel, and I recall our family riding on a wagon to Golden Gate Park. Here we lived for a few days in the tents that the Army had provided. We didn't have anything. All we had were the clothes we had walked out of the hotel with. At Golden Gate Park, I recall seeing the soldiers and the discussions about whether they were going to dynamite to try to check the fire.

Eventually the family was able to get on a train (at the station at Third and Townsend) to San Jose and then go up the east side of the Bay to Berkeley. Here we stayed with the Dewey Powell family for a few days until we were back on our feet and could return to Nevada.

In those days it used to be up over the hill on Southern Pacific, then

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As instructed in a telegram from USGS Director Charles D. Walcott, Robert B. Marshall, the geographer-in-charge of the USGS Topographic Mapping Office in Sacramento, announced to the Relief Committee that the USGS stood ready to send a complete outfit of camp property, horses, wagons and men sufficient to take care of 500 people and that he could be ready to leave that day. The offer was gratefully accepted, and Marshall was assigned to take charge of purchasing additional supplies, using the more than \$50,000 in donations collected that day from the citizens of Sacramento.

"Men in the Sacramento office ... hurried to the warehouses and packed blankets, tents, cooking stoves and utensils, folding tables, chairs, axes, picks, shovels and much other equipment. [They] loaded the big camp wagons, buckboards, and hitched teams to water tank wagons and brought them all to the wharf in Sacramento," wrote USGS stenographer Adelena Marie Fontaine.

In addition, Marshall bought large quantities of canned goods, milk, baby food, soup and other prepared food. At his request, a factory ran all night producing crackers and cookies. Marshall and the other USGS topographers soon had an old stern-wheeler, *San Joaquin*, "loaded to the waters edge with relief supplies."

At some point during the night of the 19<sup>th</sup>, the *San Joaquin* began its trip down the Sacramento River toward San Francisco. Aboard were Marshall; topographers A. Benson Searle, Sidney Stoner and Albert H. Sylvester; and field

assistant Jake W. Muller. George Davis and Clarence Nelson were also on board. (After relocating the elder Davis in a hotel in Oakland and returning to Sacramento by train, the pair was informed that the *San Joaquin* was about to depart along with their USGS colleagues. The two decided to embark as well — their second trip to the beleaguered city in 48 hours.) The boat was accompanied by a barge under the direction of Almerin Sprague, the father of Sidney Stoner's fiancée, Marjorie Sprague. The barge carried wagons, horses and water barrels.

At 8 a.m. on the morning of April 20, the *San Joaquin*, with its load of relief supplies and USGS topographers, landed at the Presidio of San Francisco, where it was greeted with cheers. The military officer who met the boat immediately asked about baby food and milk and was overjoyed by Marshall's reply of "a carload." Volunteer stevedores, soldiers and citizens assisted the

USGS men in unloading the shipment.

By this time, uncontrolled fires and continuous dynamiting had filled the air of San Francisco with heat, smoke and dust, making it unpleasant to breathe. Davis and Nelson attempted to renew their exploration of the ravaged city before the boat's return trip but were unable to bear the conditions for long. At one point, they quenched their thirst with cans of tomatoes found in an abandoned grocery store.

## Staffers Work Overtime Aiding Refugees

Back in Sacramento, the women of the USGS family were hard at work. Stenographer Adelena Fontaine, Marjorie Sprague and the wives of Robert Marshall and Albert H. Sylvester volunteered to assist the Sacramento Women's Council as they processed thousands of refugees from San Francisco. "I worked on [the] general Relief Committee several nights, meeting trains crowded to the doors with refugees," wrote Fontaine. "We fed them, clothed them, took them to friends if they had any, and those who were destitute we assigned to the homes in the city whose doors had kindly been opened to welcome the unfortunates."

Fontaine recounted the story of one refugee, a young man of about 20, whose brother was mistaken for a looter and shot to death. "[He was] endeavoring to extricate his brother and their belongings from the hotel where they had lived, [and] saw his brother shot down before his eyes by

a soldier. The soldier had made a mistake, and the boy was not stealing. This young refugee was a telegraph operator and volunteered his services [until] the building was abandoned; [he then] fled before the flames," wrote Fontaine. "He was in a dreadful state from exhaustion, hunger and exposure."

## Mapping the Fault

The topographers in Sacramento were not the only USGS employees working in the vicinity of San Francisco. By great coincidence, eminent USGS geologist Grove Karl (G.K.) Gilbert had been in Berkeley (7 miles across the Bay from San Francisco) studying sedimentation and the effect of hydraulic gold-mining debris in the Sacramento River. A vigorous 63 years old in 1906, Gilbert was considered one of the top field and experimental geologists of his day. He was one



USGS topographer George R. Davis (standing) in the field, circa 1908. Davis rushed to San Francisco after the earthquake on April 18, 1906, to look for his father, who was living there in a hotel. Photo: George R. Davis family.



This home was damaged in the magnitude-6.9 earthquake on the Hayward Fault on Nov. 21, 1868.

### Hayward, California

Date: Nov. 21, 1868

Magnitude: ~7.0

Damage: Communities along the Hayward Fault and in San Francisco and San Jose, Calif.,

suffered an estimated \$300,000 (1868 dollars) in property damage. Before 1906, this was known as the "Great San Francisco Earthquake."

Number of deaths: 30



This aerial image looks west toward the Sierra Nevada Mountains across Owens Valley, Calif., where an earthquake on March 26, 1872, caused heavy damage to the town of Lone Pine.

### Owens Valley, California

Date: March 26, 1872

Magnitude: 7.4

Damage: This earthquake on the eastern side of the Sierra Nevada Mountains caused the destruction of more than 50 houses in nearby

Lone Pine, Calif., and there were other reports of buildings collapsing, resulting in approximately \$250,000 (1872 dollars) damage.

Number of deaths: 27



Parts of Charleston, S.C., lie in ruin after the earthquake on Aug. 31, 1886. (Photo J.K. Hilliers)

### Charleston, South Carolina

Date: Aug. 31, 1886

Magnitude: 7.3

Damage: Many of the buildings in and around Charleston were damaged or destroyed, and railroad tracks around the city were

twisted and shifted. Property damage was estimated at \$5 to \$6 million (1886 dollars).

Number of deaths: 60



These are the remains of Jefferson Junior High in Long Beach, Calif., following the earthquake on March 10, 1933.

### Long Beach, California

Date: March 10, 1933

Magnitude: 6.4

Damage: Property loss was estimated at \$40 million (1933 dollars), as some sections of

southern Los Angeles County and northern Orange County were almost totally destroyed.

Number of deaths: 115

## A Look Back in Time

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of the first five principal geologists hired by the USGS when it was created in 1879 and served as its first “chief geologist.” His scientific reports are considered some of the best geologic papers ever written.

Gilbert wrote of his experiences on the morning of April 18: “It is the natural and legitimate ambition of a properly constituted geologist to see a glacier, witness an eruption and feel an earthquake. ... When, therefore, I was awakened in Berkeley on the eighteenth of April last by a tumult of motions and noises, it was with unalloyed pleasure that I became aware that a vigorous earthquake was in progress. ... In my immediate vicinity the destructive effects were trivial, and I did not learn until two hours later that a great disaster had been wrought on the opposite side of the bay and that San Francisco was in flames.”

As soon as regular ferry traffic to San Francisco was restored, Gilbert traveled across the Bay to observe the fires and the results of the earthquake firsthand. “The flames work with wonderful speed. While I lingered, whole squares were consumed. An hour is probably enough to raze a square of wooden houses.”

Gilbert’s assistant in Berkeley was 32-year-old François E. Matthes, a native of the Netherlands and a highly accomplished USGS topographer and geomorphologist. The USGS sent Matthes to California in 1905 for the express purpose of mapping Yosemite Valley. Matthes had garnered praise for his topographic map of the upper half of the Grand Canyon, which is one of the finest plane-table maps produced by the USGS. While Matthes was between field seasons in Yosemite, Gilbert hired him to research scientific articles that were written in Dutch and French.

Matthes, too, was jolted awake on April 18 by the earthquake: “Woke up 5 a.m. by violent earthquake, lasting 28 seconds. Found on getting up San Francisco enveloped in flames. Severe quake 8:15 while eat[ing] breakfast... Made tour of inspection of Berkeley; found brick chimneys demolished by the wholesale; many brick houses badly damaged. All day long dynamite blasts are heard from the city... Fire rages all night.”

There was no lack of scientific interest in the earthquake. Geologists and other scientists quickly flocked

to the area. Local geologists gravitated around Andrew C. Lawson, chairman of the geology department at the University of California at Berkeley, and John C. Branner, professor of geology at Stanford University, both of whom worked part time for the USGS.

Three days after the earthquake, the governor of California appointed the California State Earthquake Investigation Commission, chaired by Lawson, to oversee and consolidate all of the scientific investigations. Gilbert was one of eight men assigned to the commission. Only Gilbert and one other had any experience with earthquake research. The commission ultimately brought together more than 21 scientists, architects and engineers to examine the earthquake. This included several members of Japan’s Imperial Earthquake



Investigating Committee, considered at the time to be a leading authority on earthquake research. The commission primarily focused on studying surface changes caused by the earthquake, earthquake intensity, earthquake arrival times and the geophysics of the earthquake. Gilbert wrote several reports about the earthquake, and both he and Matthes took many post-earthquake photographs.

The Earthquake Commission quickly appropriated the services of François Matthes by sending him into the field to examine the effects of the earthquake north of San Francisco. He later mapped the

Fault through the northern part of the state. His maps were included in an atlas published by the commission, and his field observations were incorporated into the commission’s final report.

The USGS and the Army Corps of Engineers collaborated on a separate federal investigation of the earthquake’s effects on buildings and construction materials. Richard L. Humphrey from the structural materials division was the primary USGS representative on the team. He was dispatched to San Francisco one day after the earthquake. Gilbert contributed an overview of the earthquake to the team’s report.

It’s difficult to know what long-term impact the events of 1906 may have had on the USGS employees involved with it. They were all ordinary people who responded to a natural disaster in extraordinary ways.

back to Eureka over a narrow gauge railroad from Palisade (near Elko), which was just a wide place in the track.

**H.S. Did the earthquake have any long-lasting effects on your family?**

**Smith.** I don’t think my mother ever recovered from the shock of going through something like that. From that day on she too — always wanted to have a light on at night or a candle with matches. She was never going to be caught in the dark again. She always had a money belt with money in it of course. When you think about it, these were very sensible precautions.

**H.S. What about your father?**

**Smith.** My father took it almost routinely. After the ups and downs of the mining business, he was used to commotions. We moved back to Eureka and then to Rhyolite. The next year, 1907, was very bad in mining, and our affluence was gone. We moved to Tonopah, then to Elko. My father just moved around according to the changing fortunes of the mining ventures in Nevada.

**H.S. Have you been through many other earthquakes?**

**Smith.** I would guess that my wife and I have been through 15 to 20 earthquakes since we were married. Curiously one of the first ones I experienced after the 1906 earthquake, occurred while my family was living in Oakland for a short while from 1910 to 1911. We had all gone to the Curran Theater in San Francisco. As we approached the balcony, we got a rather severe shake. There was an incipient panic. Don’t forget that this was only a few years after the 1906 earthquake, so you didn’t know what was going to happen. We got seated, and the manager told the audience not to be alarmed. Everything was in order. He said that we were safer in the theater than anywhere else. Just to relax and the show would go on. And we did! And it did! Things like that stick in your mind.

**H.S. Any other memorable earthquakes?**

**Smith.** Yes, quite a few. While we were fishing off the pier on holiday at Long Beach in 1918, we had a little earthquake which rattled the whole pier and rippled the water. My aunt lost her precious heirlooms in the 1933 earthquake at Long Beach when a corner china cabinet tipped over. Ever since then we’ve always buckled our cabinets to the wall.

I recall my wife’s first earthquake experience. We were living in Berkeley at the time. She was getting breakfast, and suddenly the silverware began dancing around on the table. “Something is happening,” she called out to me. “It’s just an earthquake,” I replied, “don’t worry.” So she went on frying the eggs.

Then there was 1958. My office was on the 9<sup>th</sup> floor of 821 Market Street in San Francisco. My partner in the olive business came into the office and propped his chair back up against the wall. Suddenly, he said “I’m having a heart attack.” And I said “No, you’re not. We’re having an earthquake.” The building just shook a little, and that was that.

**H.S. Others?**

**Smith.** Yes. The first time our three children experienced an earthquake was in Berkeley once in the middle of the night, and they all dived into bed with us. We were at Santa Barbara during the summer of 1952 relaxing in front of a motel when we felt a severe shake. I said to my wife that somewhere, someone was getting a devil of an earthquake. That was the Tehachapi (Kern County) earthquake. Later on that summer we had ranching friends who went through the Bakersfield earthquake. The only thing that happened to *them* was that their liquor came out of a closet, and the husband cut his foot on the broken glass as he was running out of the door.

**H.S. Any earthquakes while you’ve lived in Santa Rosa?**

**Smith.** Yes — the big earthquake in 1969. It was about 10 o’clock at night. We had no damage, but the chandelier rocked back and forth. We went out into the street and said hello to the neighbors. That’s what you do afterwards: Check on everyone else.

**H.S. You were in the 1906 earthquake. Does it bother you that 70 years later you are now retired in the same general area?**

**Smith.** Not at all. Earthquakes are a fact of life. It’s just something you have to live with. You remember what you’re supposed to do and what you’re not supposed to do. You can take some precautions, like buckling down the cabinets, having a stock of food for a week or two, putting some money away. We have a wrench handy to shut off the gas. We live in a wood frame house, bolted to the concrete foundation. You don’t need to increase the hazard if you can avoid it.



This political clubhouse in Hilo, Hawaii, was shattered by the earthquake-generated tsunami on April 1, 1946. (Photo: NOAA)

### Aleutian Islands, Alaska

Date: April 1, 1946

Magnitude: 8.1

Damage: This earthquake generated a tsunami that struck Alaska, Hawaii and the west coasts of North and South America, causing

more than \$26 million (1946 dollars) in damage (mostly in Hawaii). Number of deaths: 165 (all tsunami-related: 149 in Hawaii; 5 in Alaska; 1 in California)



Residents of Tehachapi, Calif., fill the streets after the earthquake on July 25, 1952.

### Kern County, California

Date: July 25, 1952

Magnitude: 7.3

Damage: The nearby towns of Arvin, Bakersfield and Tehachapi suffered extensive damage, and structures as far away as San Diego and Las Vegas (both more

than 200 miles from the epicenter) were damaged. Property loss was estimated at \$60 million (1952 dollars).

Number of deaths: 12 (on Aug. 28, 1952, an aftershock caused two more deaths)

This road was broken by a landslide caused by the earthquake at Hebgen Lake, Mont., on Aug. 17, 1959.



### Hebgen Lake, Montana

Date: Aug. 17, 1959

Magnitude: 7.3

Damage: The most significant damage was caused by a large debris avalanche that dammed the Madison River, eventually

creating a lake more than 150 feet deep. Damage to homes, highways, timber and other property was estimated at \$11 million (1959 dollars). Number of deaths: 28 (most caused by rockslides)



Following the magnitude-9.2 earthquake on March 27, 1964, this section of a street in downtown Anchorage, Alaska, has subsided more than 10 feet.

### Prince William Sound, Alaska

Date: March 27, 1964

Magnitude: 9.2

Damage: The earthquake (the largest ever recorded in the US) and ensuing landslides caused heavy damage to towns along Prince William Sound, especially Anchorage, where about 30 downtown blocks were damaged or de-

stroyed. The earthquake also generated a tsunami that struck Alaska, the U.S. West Coast and Hawaii. Property loss was about \$311 million (1964 dollars).

Number of deaths: 125 (15 earthquake-related, all in Alaska; 110 tsunami related: 98 in Alaska; 11 in Calif.; 1 in Oregon)

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At one place it moved the streets from 10 to 15 feet to one side. Three blocks below us it moved the whole street and left cracks three or four feet wide. At Van Ness avenue, about seven blocks from here, it bulged the macadam into ridges two feet high. On Valencia street, for a block, where the ground was "made," it dropped about seven feet, and a hotel in that block sunk two stories out of sight, and as the large water mains broke there, it flooded into the hotel and about 50 people were killed.

As soon as I could dress I started down town to see what damage was done. Some buildings were shaken down and all were damaged to a greater or less extent. The dome of the city hall was nearly shaken down, but a number of the large buildings were not damaged at all by the 'quake,' but the fire burned them all. The most modern structures are still standing, although they are burned inside.

For three days everyone was packing, where they had time before the fire caught them, and most everyone was hauling all they could pull out to the parks and sands. Everything that had wheels was used to carry away the most valuable belongings. Some had two bicycles with a wooden frame between them carrying bedsteads, Morris chairs, baby carriages, trunks, etc. There were people with sheets containing their belongings. It was a sad sight.

I was driving the auto all day and most of the night, carrying Red Cross nurses, army officers, fire hose, water in boilers and about everything.

The night that the fire came to Van Ness avenue we worked all night, carrying dynamite and nitro-glycerine to the dynamiters. Van Ness avenue is 125 feet wide, and they blew up a whole block wide, the length of the street, and thus saved the residential part of the city. Van Ness was the best of the residential streets in the city and it looked awful to see those palaces blown up.

I carried the dynamite into the most beautiful house on the street. We put it in two cases. Most everyone was hurrying out of town, but Mr. Magee had all three of his machines working. One of them was running on a rim without any tire, but he did not care. I do not care to boast, but with those three machines and a small squad (about eight) of soldiers, we saved this end of the town. When we saw that the flames would not cross the avenue we went home at 5 a.m. At one place it crossed and it took some fast dynamiting to stop it. You see, the main trouble was no water, as the earthquake had broken the mains. While the fire was burning so fiercely, the city was light night and day. The smoke hung over the city in one vast cloud and the reflection of the fire on this smoke made a most terrible night.

They are now blowing down the dangerous walls that were left standing. A peculiar incident happened to me. A fellow came and got me to fix his carburetor for him, as he could not make it work. It was a Locomobile. After I had fixed it, I looked over the levers to see how it worked and took it out to see if I could run it. I had only gone a few steps when three soldiers stopped me and told me to take the machine to headquarters, which was only a block away, to drive a captain to the Presidio. They were ordered to seize the first auto and I happened to be the first. I told the captain I had never run a Locomobile before and that he was risking his life. He thought I was lying, and so he pulled his "six shooter" on me, and told me to run the car and to run it easy, too. I knew he meant it, so I thought I had better do the best I could. He said he would shoot me if I did not go easy. I drove him for four hours. Mr Magee was mad and he got me a pass signed by the governor of the state, the mayor of the city and the commander of this division of the army. It says: "Do not detain bearer for any cause whatever." These are the highest passes issued and only about a half dozen were given out.

I heard Mr Magee tell a man that he had lost about every source of income. Do not worry about me, as the fire is out and I will keep out of all danger.

Write soon.

Love to All from  
Percy J. Holmes

# When the Dust Settled – What Became of the USGS Employees Who Responded to the Great Earthquake?

By Liz Colvard and James Rogers

**A**fter 1906, what became of the USGS employees who responded to the great earthquake?

Chief Geographer Robert Marshall moved up to the position of chief geographer for the entire USGS in 1908. Although he did not go overseas, he served as a topographer with the U.S. Army during World War I and achieved the rank of colonel. Marshall was a close friend of John Muir and a charter member of the Sierra Club. In 1916, he was loaned out to serve as superintendent of all the national parks immediately prior to the creation of the National Park Service. Marshall left the USGS in 1919 and returned

Davis took over Robert Marshall's old position as chief geographer for the USGS Pacific Region.

Topographer Clarence Nelson stayed with the USGS for his entire career. He left California in 1907 and moved on to mapping projects in Puerto Rico, Argentina, Alaska and other parts of the United States. He went overseas with the Army during World War I, eventually reaching the rank of colonel with the Army Reserve. From 1922 to 1923, he was loaned out to the National Park Service to serve as acting superintendent of Mount Rainier National Park.

Topographer Hal Sylvester transferred to the U.S. Forest Service in 1907. In 1908, he became the superintendent of Wenatchee National Forest in the Cascade Mountains of Washington, where he remained until his retirement in 1931. He is credited with naming more than 1,000 geographic features in Washington. Historian Harry Majors calls him "one of the supreme figures in the history of the Cascade Mountains."

Topographer Sidney Stoner and Marjorie Sprague were married soon after the earthquake. Stoner did not remain employed with the USGS.

Geologist G.K. Gilbert published the results of his research on hydraulic gold-mining debris in 1914 and 1917. At the same time, he continued his interest in earthquake research by serving as a member

of the Scientific Committee of the Seismological Society of America, which was formed in the fall of 1906. Although he and the unconventional San Francisco botanist Alice Eastwood (whom he met through the Sierra Club) were intimate friends for many years, they did not get engaged until 1918, when Gilbert was 75 and Eastwood was 59. Gilbert died before the marriage took place.

Topographer François Matthes' topographic map of Yosemite Valley was published in 1907. It is considered by some to be one of the most beautiful topographic maps ever created. Between 1910 and 1911, he was in charge of mapping Mount Rainier National Park and twice hauled his heavy survey equipment to the summit of Mount Rainier. He spent the remainder of his career as a leader in USGS topographic mapping and in the study of the geology and geomorphology of Yosemite National Park.



Photo courtesy California Historical Society

to California, where he became known as the "Father of the Central Valley Project" when he obtained \$200,000 from the California legislature to study his plan for a series of dams, canals and aqueducts to bring water to California's fertile Central Valley.

Ten years after the earthquake, stenographer Adelena Fontaine married topographer George Davis. She remained with USGS until the birth of their only child, Anna Davis Rogers, who provided much of the information and some of the photographs for these articles. Their grandson, James Rogers, is also one of the authors of this article.

Topographer George Davis continued to map the High Sierra. He was the first person to take pack stock over Muir Pass and made the first ascents of Black Mountain, Milestone Mountain and Mount Baxter. In 1917, one year after he married stenographer Adelena Fontaine,

This freeway interchange in San Fernando, Calif., lies broken following the earthquake on Feb. 9, 1971. (Photo: R. Kachadoorian)



**San Fernando, California**  
Date: Feb. 9, 1971  
Magnitude: 6.6  
Damage: Losses were estimated at \$505 million (1971 dollars), as two hospitals and two dams were severely damaged, and several freeway overpasses collapsed.

Landslides also damaged highways, railroads and pipelines. More than 2,000 people were injured.  
Number of deaths: 65 (49 in collapses at the San Fernando Veteran's Administration hospital).

This wall's collapse killed two children in Challis, Idaho, during the earthquake on Oct. 28, 1983. (Photo: Sue Villard, Challis Messenger)



**Borah Peak, Idaho**  
Date: Oct. 28, 1983  
Magnitude: 7.0  
Damage: This was the largest quake ever recorded in Idaho. It caused \$12.5 million (1983 dollars) in damage to the Idaho towns of Challis

and Mackay. In addition to structure damage, the temblor resulted in several rock falls and landslides, a temporary lake and tremendous surface faulting.  
Number of deaths: 2

# Seismic Technology Evolves into the 21<sup>st</sup> Century

By Heidi Koontz

USGS scientist emeritus Waverly Person remembers the days when a rotary phone, a pen, a globe and a keen sense of geography were the required ingredients for locating earthquakes around the world.

Things have changed dramatically since he was a newly minted seismologist.

“We really had to scramble,” he says, referring to earthquake response in the '50s and '60s, when he and his fellow scientists did calculations on globes with tape measures and compasses. “It might take a day or a day-and-a-half to get information from remote locations.”

That struggle makes Waverly all the more appreciative of the real-time data and global-monitoring systems available now. “It’s great to be a part of the change and to have had a hand in getting there,” said Person, who recently retired after a 51-year career as a premier earthquake scientist. [See page 13.]

Today, the USGS has the most extensive seismic monitoring and response system in the nation and works with numerous universities to advance understanding of the cause and effects of earthquakes and with emergency response agencies in the interest of public safety and hazards mitigation.

Throughout history, a variety of instruments has been developed to measure movement of the earth.

By definition, seismographs, seismometers and seismoscopes are instruments used to detect and measure the intensity, direction and duration of movements of the ground (as caused by an earthquake).

The earliest account of such technology is a seismoscope invented by the Chinese philosopher Chang Heng in A.D. 132. The instrument consisted of eight dragonheads, facing the eight principal directions of the compass. Below each of the dragonheads was a toad with its mouth

opened toward the dragon. The mouth of each dragon held a ball, and when an earthquake occurred, one of the dragon mouths would release a ball into the open

mouth of the toad situated below. The direction of the shaking determined which of the dragons released its ball.

The ancestry of today’s USGS seismic

instrumentation can be traced back to the late 1800s. And while the dragonheads had been replaced by more advanced creations, the equipment of that era was still a long way from the sophistication of today’s machinery.

“At the time of the 1906 earthquake there were less than 100 seismographs operating around the world. Today there are thousands,” said USGS scientist Gray Jensen, who has been tracking earthquakes for the USGS for more than 30 years.

John Milne, an English seismologist and geologist, invented the first modern seismograph and promoted the building of seismological stations. In 1880, Sir James Alfred Ewing, Thomas Gray and Milne, all British scientists working in Japan, began to study earthquakes. They founded the Seismological Society of Japan, and the society funded the invention of seismographs to detect and measure earthquakes. Milne invented the horizontal pendulum seismograph in 1880.

The horizontal pendulum seismograph was improved after World War II with the Press-Ewing seismograph, developed in the United States for recording long-period waves. With the advent of modern electronics, conventional magnet-and-coil seismometers and geophones became the typical sensors. Electronic amplifiers were then used to produce highly sensitive seismographs. Electronic feedback was added to these devices to create sensors with the maximum in dynamic range, frequency range and sensitivity. Ultimately, arrays of these sensors were connected to computers to produce today’s fully automated seismic networks.

Although USGS scientists are currently unable to predict earthquakes, the advances in technology since 1906 allow them to provide much needed information for saving lives and pinpointing risk.

*Compiled with assistance from Gray Jensen, Steve Walter, Jack Van Schaack and David Hebert.*

“At the time of the 1906 earthquake there were less than 100 seismographs operating around the world. Today there are thousands.”

— Gray Jensen



This seismoscope, invented in A.D. 132, represents the earliest account of technology used to record information about earthquake shaking. During an earthquake, the direction of the shaking determines which dragon releases its ball.



Geotech Helicorder model drum recorder used widely since the mid 1900s to record and display seismic records. Now used mainly for visitor and press displays. Whole-day records like this can be produced on computer but requests still come in for the drums.



A room full of Developocorders. These were devices with a roll of 16mm photographic film in them. They also had 16 galvanometers with very tiny lights attached. The row of lights was focused on the film as it was drawn past. This caused a line to be drawn on the film for each light. The galvanometers would cause the light to move from side-to-side in response to the seismic signal which was then recorded on the film. The film was then developed internally over the next ten minutes. Finally the developed portion of the film was projected on a glass screen for viewing. The film was changed each day and the removed film could then be viewed on a larger projector for analysis of the records.



This section of San Francisco’s Marina District is destroyed following the earthquake on Oct. 17, 1989. (Photo: C.E. Meyer)

**Loma Prieta, California**  
 Date: Oct. 17, 1989  
 Magnitude: 6.9  
 Damage: The most severe damage occurred in Oakland and San Francisco, where many buildings and elevated-freeway and bridge spans collapsed. Pipelines, port facilities, airport runways and levees were also damaged, and more than 1,000 landslides occurred near the epicenter in the Santa Cruz Mountains. Damage was estimated at \$6 billion (1989 dollars), and more than 3,500 people were injured.  
 Number of deaths: 63



This section of a Los Angeles-area apartment complex is broken in half following the Northridge, Calif., earthquake on Jan. 17, 1994. (Photo: FEMA)

**Northridge, California**  
 Date: Jan. 17, 1994  
 Magnitude: 6.7  
 Damage: In the Los Angeles area, an estimated \$20 billion in losses were sustained through damage to more than 40,000 buildings, collapses of freeway overpasses and subsequent fires. More than 5,000 people were injured, and more than 20,000 lost their homes.  
 Number of deaths: 33



This business in Seattle has sustained heavy damage following the Nisqually, Wash., earthquake on Feb. 28, 2001. (Photo: Kevin Galvin, FEMA)

**Nisqually, Washington**  
 Date: Feb. 28, 2001  
 Magnitude: 6.8  
 Damage: This earthquake, including its resulting landslides, caused \$4 billion in damages to buildings, highways and other structures in the cities of Olympia, Seattle and Tacoma. Approximately 400 people were injured.  
 Number of deaths: 1



The Trans Alaska Pipeline System near the Denali Fault has shifted but remains intact following the earthquake on Nov. 3, 2002, thanks to its slider bar supports. (Photo: Rod Combellick, Alaska Division of Geological and Geophysical Surveys)

**Denali, Alaska**  
 Date: Nov. 3, 2002  
 Magnitude: 7.9  
 Damage: Despite being the largest onshore earthquake in nearly a century, the Denali quake was significant for what it did not do: rupture the Trans Alaska Pipeline System. In anticipation of just such an event, the pipeline was engineered to shift on Teflon-coated slider bars where it crossed the fault. Despite nearly 20 feet of displacement, the pipeline did not spill a drop and was quickly back in service.  
 Number of deaths: 0