rupture. As a result, said Haeussler, distant earthquake effects were most pronounced in one direction — southeast of the fault trace toward western Canada and the lower 48 states. Consequently, the Denali Fault earthquake was felt as far away as Louisiana. In the New Orleans area — more than 3,000 miles away — residents saw water in Lake Pontchartrain slosh about as a result of the earthquake's power. The earthquake also disturbed levels of water in Pennsylvania wells by up to two feet, damaged houseboats in Seattle from seismic sea waves, and triggered small earthquakes at many volcanic or geothermal areas in the direction of rupture. The most pronounced triggering was observed at Yellowstone, Wyo., with 130 small earthquakes recorded in the four hours following the 1,940-mile-away Alaskan rupture. By contrast, in the other direction, only one of the many active Alaskan volcanoes had triggered earthquakes.

"Research like this conducted by the USGS and collaborating institutions helps to anticipate the effects of future large earthquakes, such as the kind that will occur on the San Andreas Fault in the Los Angeles area," explained Lucy Jones, USGS scientist-in-charge for Southern California. "The effect of directivity may be important in hazard planning for future large Southern California earthquakes." The last time the San Andreas Fault ruptured in Southern California, in a magnitude-7.9 earthquake in 1857, the earthquake began in central California and ruptured southeastward toward the now highly urbanized Los Angeles region.

Thanks to George Gryc, Robert Page and Peter Haeussler.

Measuring Magnitude — What Do the Numbers Mean?

Compiled by Diane Noserale

Often two or more different magnitudes are reported for the same earthquake. Sometimes, years after an earthquake occurs, the magnitude is adjusted. Although this can cause some confusion in news reports, for the public and among scientists, there are good reasons for these adjustments.

Preliminary Magnitude

Following an earthquake, the first magnitudes that seismologists report are usually based on a subset of seismic-monitoring stations, especially in the case of a larger earthquake. This is done so that some information can be obtained immediately without waiting for all the data to be processed. As a result, the first magnitude reported is usually based on a small number of recordings. As additional data are processed and become available, the magnitude and location are refined and updated. Sometimes the assigned magnitude is "upgraded" or slightly increased, and sometimes it is "downgraded" or slightly decreased. It can take months before a magnitude is no longer "preliminary."

Sometimes the earthquake magnitude is reported by different networks of seismometers based on only their recordings. In that case, the different assigned magnitudes are a result of the slight differences in the instruments and their locations with respect to the earthquake epicenter. Depending on the specifics of the event, scientists might determine that the network closest to the event reports it most accurately. This is especially true where the instrumentation is denser. Other times, national networks, in which the instruments are often more state-of-the-art, produce the most reliable results.

Different Methods of Calculating Magnitude

The concept of using magnitude to describe earthquake size was first applied by Charles Richter in 1935. The magnitude scale is logarithmic so that a recording of 7.1, for example, indicates a disturbance with ground motion 10 times larger than a recording of 6.1. However, the difference in energy released is even bigger. In fact, an earthquake of magnitude 7.1 releases about 33 times the energy of a magnitude 6.1 or about 1,000 times the energy of a magnitude-5.1. Another way of thinking of this is that it takes about 1,000 magnitude-5.4 earthquakes to equal the energy released by just one magnitude-7.4 event. A earthquake of magnitude 2 is normally the smallest felt by people. Earthquakes with a magnitude of 7.0 or greater are commonly considered major; great earthquakes have a magnitude of 8.0 or greater.

Through the years, scientists have used a number of different magnitude scales, which are a mathematical formula, not a physical scale. Although news reports often call all magnitudes "Richter," scientists today rarely use Richter's original method. Unless further detail is warranted, USGS simply uses the terms magnitude or preliminary magnitude, noted with the symbol "M," in its news releases.

The Most Common Magnitude Scales in the United States

When earthquakes occur, energy is radiated from the origin in the form of different types of waves. Moment magnitude (M_W) is usually the most accurate measure of an earthquake's strength, particularly for larger earthquakes. Moment magnitude accounts for the full spectrum of energy radiated by the rupture and is generally computed for earthquakes of at least magnitude 5.5 when the additional data needed for this computation are available and the effort is warranted. Using some sophisticated regional networks in which noise is limited, seismologists can compute moment magnitudes for earthquakes down to less than magnitude 3.5.

Surface-wave magnitude (M_S) is computed only for shallow earthquakes, those with a depth of less than 30 miles. Body-wave magnitude (m_b) is computed for both shallow and deeper earthquakes, but with restrictions on the period of the wave. And local "Richter" magnitudes (ML) are computed for earthquakes recorded on a short-period seismometer local to (within 370 miles of) the focus of the earthquake.

Seismologists may measure an earthquake's magnitude with one scale. Then, once more data are available, reassign the magnitude using another scale deemed more accurate based on the additional data. For example, for the 1999 earthquake near Ismit, Turkey, the 7.8 magnitude first cited was a (M_S) surface-wave magnitude. The later figure of 7.4 is a (M_W) moment magnitude. Magnitudes assigned to a specific event for years can sometimes change.

Compiled with assistance from Steve Vandas.

USGS Earthquake Scientists — A Nationwide Notion of Pride

Brian Sherrod

Title: Research Geologist

Location: Seattle

Length of service with the USGS: 11 years

One of my most memorable times as a USGS scientist is when I found evidence of surface rupture along the Seattle Fault near Bellevue, Wash. I was looking for evidence of the Seattle Fault east of Seattle — using old aerial photographs taken from biplanes in the 1930s, more recent laser mapping data, geologic maps and lots of field work. I had a good idea where I thought a strand of the fault zone traversed the area I was working in, so I obtained permission to do some detailed work on an undeveloped parcel of land near the shoreline of Lake Sammamish.

After many hand-excavated test pits and soil auger holes, I thought I had found a trace of the fault that put weathered Miocene bedrock against young glacial deposits. The time had finally come to really test my ideas with a large excavation across what I thought was a fault. I remember being nervous when the backhoe arrived and we finally began excavating. Within a short time, though, we uncovered a thrust fault that placed weathered bedrock and old glacial deposits over a recent forest soil. The fault and buried soil were within a few meters of where I originally thought the fault was.

Want to know what was most satisfying about this discovery? I had many modern tools at my disposal, including LiDAR (laser) maps, geospatial information systems and a host of detailed geophysical studies, but it was getting down on my hands and knees in the dirt (oops, soil...) and doing the field geology that really made this study succeed.

Joan Gomberg

Title: Research Seismologist

Location: Memphis, Tenn.

Length of service with the USGS: 18 years

The most exciting thing for me was discovering the strong correlation between distant aftershocks and focusing of seismic waves (implying triggering by the waves) — a Eureka moment! Visiting Bhuj, India, was also memorable.