The Great American Quakes

Eight weeks that rocked the United States

By RICHARD MONASTERSKY

About 3 o'clock, on the morning of the 7th, we were waked by the violent agitation of the boat, attended with a noise more tremendous and terrific than I can describe or anyone can conceive, who was not present to such a scene. The constant discharge of heavy cannon might give some idea of the noise for loudness, but this was infinitely more terrible, on account of its appearing to be subterraneous.

— Mathias M. Speed, March 2, 1812

In spite of his rude awakening, Speed was one of the luckiest travelers tied up along the Mississippi River on the fateful night of Feb. 7, 1812. After coming to his senses, he cut his boat loose from the collapsing riverbank and moved out into the middle of the channel to avoid being crushed by falling trees. In the darkness, he rode out the great swells that threatened to sink his craft.

An untold number of other boatmen perished that night, but Speed and his companion found themselves still alive as the morning sun illuminated the devastation around them. Just after daybreak, the two men finally landed at the town of New Madrid, Mo., where "there was scarcely a house left entire" in the former settlement of 2,000 people.

The earthquake that nearly killed Speed capped a tremulous 8-week period in the history of the early United States. Starting on Dec. 16, 1811, the region around New Madrid suffered three great jolts, more than a dozen large aftershocks, and thousands of small, but unnerving, tremors that kept the ground shaking like Jell-O.

The New Madrid (mad´ rid) quakes ranked as the largest series of shocks in North America's recorded history: They rattled people as far away as New York City, nearly 1,500 kilometers to the northeast. Yet because the earthquakes originated in a sparsely inhabited region well before the time of modern seismometers, they inhabit a netherworld between myth and fact. According to some tales, the quakes created waterfalls in the Mississippi and caused the great river to run backward for 3 days.

"New Madrid has been sort of a legend back in the preinstrumental days, so you couldn't do anything with it," says Arch C. Johnston, a seismologist at the University of Memphis (Tenn.).

Johnston and his colleague Eugene S. Schweig are now trying to set the quakes on firm scientific footing by piecing together where the shocks originated and how they changed the landscape. "Nobody had ever sat down and tried to work out what the sequence was, which faults broke at what time. We've made good progress in actually modeling the faulting scenario to explain what happened in 1811–1812," says Johnston, who discussed his work in April at a meeting of the Seismological Society of America in St. Louis.

Although no instruments recorded the New Madrid quakes, seismologists can estimate their size by mapping the extent of damage and the area over which people could feel the vibrations. Such calculations set the three principal shocks, on Dec. 16, Jan. 23, and Feb. 7, at about magnitude 8.0, qualifying them as great quakes. Ten of the aftershocks equaled or exceeded magnitude 6.0, with three reaching magnitude 7.0—major shakes in their own right.

Placing these jolts on a map has proved more difficult. Ever since the early part of this century, when geologists first started studying the New Madrid quakes, they have struggled to identify the guilty faults. Unlike the western United States, where many faults reach up to the surface, the eastern states hide most quake-generating structures beneath thick blankets of sediment.

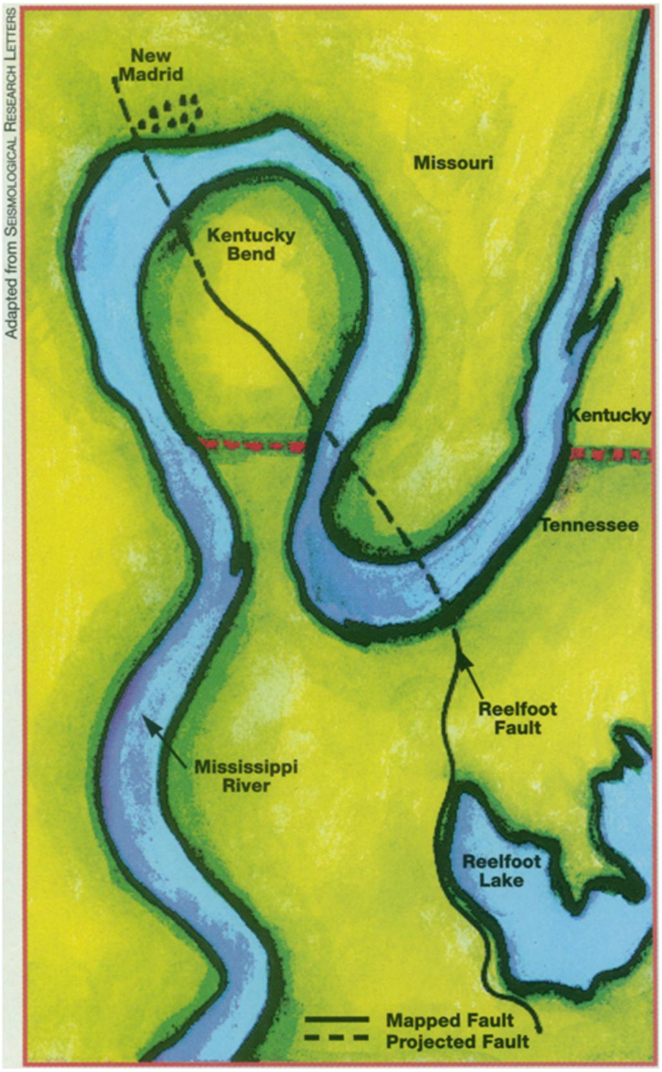
Networks of seismometers set up in the Missouri boot heel and surrounding areas beginning in 1974 provided the first clues about the invisible faults in the region. Thousands of microquakes detected in the crust revealed a zigzag fault pattern roughly paralleling the course of the Mississippi River at the junction of Kentucky, Missouri, Tennessee, and Arkansas.

Only one of these faults is known to continue up to the surface, where it creates a steep slope, or scarp, alongside Tennessee's Reelfoot Lake. But at just 11 kilometers in length, the Reelfoot fault was always considered too puny to shoulder the blame for any of the major New Madrid earthquakes, says Johnston.

Last year, however, his Memphis colleague Roy Van Arsdale found evidence that the Reelfoot fault actually continues for at least three times its previously mapped length. While working in a region where the Mississippi makes a loop called the Kentucky Bend, Van Arsdale found a surface scarp and subsurface warping that line up with the Reelfoot fault across the river. If the two scarps represent pieces of the same structure, the fault must stretch 32 km and possibly longer.

Van Arsdale's finding recently received support from Ron L. Street, a seismologist at the University of Kentucky in Lexington. In the March-April SEISMOLOGICAL RESEARCH LETTERS, Street and his colleagues report the results of a seismic survey they conducted in the Kentucky Bend area. To probe the subsurface, the scientists thumped the ground every 20 feet with a 45-kilogram steel slug and recorded the seismic waves that reflected off hidden geologic structures.

The seismic profiles show segments of a fault beneath the surface scarp identified by Van Arsdale. Because these segments have the same direction and orientation as the Reelfoot fault across the



Fatal flaw: Recent geologic studies show that the Reelfoot fault extends from Tennessee across the Mississippi River into the Kentucky Bend area and possibly across the river once more, near New Madrid, Mo. Movement of the fault in 1812 created rapids and barriers in the river, whose course has shifted somewhat since then.

river, Street believes they are part of one continuous fault. He hopes to prove the linkage by making seismic recordings between the two patches.

For Johnston, the extension of the Reelfoot fault provided a critical piece of evidence that enabled him to pin down one of the New Madrid earthquakes. The recent mapping also corroborates the accounts of Speed and other boatmen, whose reports appeared to disagree with each other and seemed a little too fanciful to swallow.

"When you think about it, it sounds pretty outrageous that the greatest river in North America was faulted three times by an earthquake, creating waterfalls or rapids on the Mississippi. But their descriptions were pretty accurate. It's like they had been telling us all along where the fault was, but it was just last year that we found it," says Johnston.

The sinuous Kentucky Bend crosses the Reelfoot fault at least two and probably three times. So when the fault sprang to life, it created different kinds of disruptions at several points along the river.

During the third great quake, on Feb. 7, land to the southwest of the fault rose several meters relative to the land to the northeast. In one place where the river crossed the fault, the sudden vertical shift created an instant waterfall. At the two other crossings, the shift created barriers, causing the water to pool.

In some places, the river flowed backward and surged over its banks, with a great wave heading upstream. Although modern legends about the quakes say the river ran backward for days, contemporary accounts suggest the reverse flow continued for only a few hours. By daylight, the Mississippi had worn through its barriers and reclaimed its former course.

Because the Feb. 7 quake reshaped the river so dramatically, Johnston and Schweig had little trouble linking that event with the Reelfoot fault. The matching game gets harder with the first and second great quakes, however, because they involved an unknown combination of perhaps six other faults.

The duo tried various combinations of the other faults to make plausible scenarios of the winter's events. Some steps in these hypothetical scenarios rest on solid evidence, such as the observations of people in a town downstream from New Madrid. Others represent little more than guesses, admits Johnston. Their report appeared last month in the 1996 Annual Review of Earth and Planetary Sciences.

The general progression of the earthquake sequence is coming together, however, enabling scientists to distinguish actual events from apocryphal ones. That's important, says Johnston, because New Madrid's 8 wild weeks are unique in recorded history. Great earthquakes typically strike along coastlines or within growing mountain belts, where two of Earth's surface plates collide. But the flat heartlands of continents tend to remain geologically quiet.

"This was the greatest sequence of earthquakes in a continental interior in the world, and so we want to understand it," says Johnston.

Only by probing the past can geoscientists hope to forecast when a New Madrid quake will strike again. □

Tales of once and future quakes

Like an old football injury that acts up without warning, the New Madrid region is North America's perennial sore spot. Several cycles of earthquakes have rocked this area in the past millennia, and the crust is currently storing stress for more shakers.

The geologic unrest stems from an ancient wound, suffered when North America began to tear apart some 600 million years ago. The rift eventually closed, but it left a weak zone that has spawned earthquakes in recent geologic time.

Geologists are piecing together the history of past tremors by studying sand blows—features created when violent shaking sends great geysers of wet sand into the air. Some of the sand deposits covered potsherds and other archaeological artifacts of known age, whereas others buried traces of wood that can be carbon-dated. Geologists have gained additional clues from lakes that formed when prehistoric earthquakes suddenly lowered the ground surface.

These studies indicate that tremors of magnitude 6.4 or greater have struck the region at least four times in the last 2 millennia, roughly around the years 500, 900, 1300, and 1600. The quakes in 900 and 1300 may have equaled the size of the shocks in 1811–1812, according to Eugene S. Schweig of the University of Memphis (Tenn.) and the U.S. Geological Survey. Schweig and his colleagues reported on studies of past earthquakes at the Seismological Society of America Meeting in St. Louis in April.

The past will surely repeat itself in some fashion. From precise surveying of the land surface, geophysicists know that the crust is currently being squeezed at a relatively rapid rate. The strain that builds up in the ground should store enough energy to power a magnitude 8.0 jolt about every 400 to 1,100 years, says Schweig.

Such numbers suggest that a great quake won't come for another few centuries. Yet even smaller ones, which occur more frequently, can damage Memphis and other cities that have sprouted in the Mississippi Valley since the last time the New Madrid region roared.

— *R. Monastersky*