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## RATTLER

When The Great Quake Comes



# FUTURE SHOCK

It's "inevitable" a major quake will strike the East, and New York's one of four cities on the hit list.

By DICK SHERIDAN

**T**HE SCENES PLAYED out last month on New York TV sets were hardly holiday fare. No miracles on 34th Street in Stipak. Few wonderful lives in Yerevan. On Dec. 7, the towns and cities of the mountainous land of Armenia were laid flat by a killer quake.

As New Yorkers prayed for the tens of thousands dead and joined a worldwide aid effort for the hundreds of thousands injured and homeless, few envisioned their bedrock-steady city meeting a similar fate.

But only two months earlier, U.S. quake specialists had met in Washington with government and private-sector disaster planners to discuss "The Catastrophic Earthquake: The Federal Response to the Inevitable Eastern Earthquake." They had heard Robert Ketter, director of the National Center for Earthquake Engineering Research (NCEER) at the State University of New York in Buffalo, warn that New York was one of four eastern cities on the likely hit list of a major quake—magnitude 7 or higher on the Richter scale—"almost certain" to strike the eastern United States by the year 2010. The probabilities, according

to Ketter, were "75% to 95% that an earthquake will occur somewhere in the eastern United States before the year 2000. Before the year 2010, the numbers are nearly 100%."

Indeed, on Nov. 25, shock waves from a massive quake did rumble through the city. Shortly after 7 p.m., with shoppers and tourists and homebound workers jamming subways and highways, bridges and tunnels, New York's storied bedrock rattled. Tremors shook the gneiss and schist rock that millions of years ago had been laid down to become the footing to the present-day towers of the city. In Queens, the geologically younger Ice Age sediment quivered.

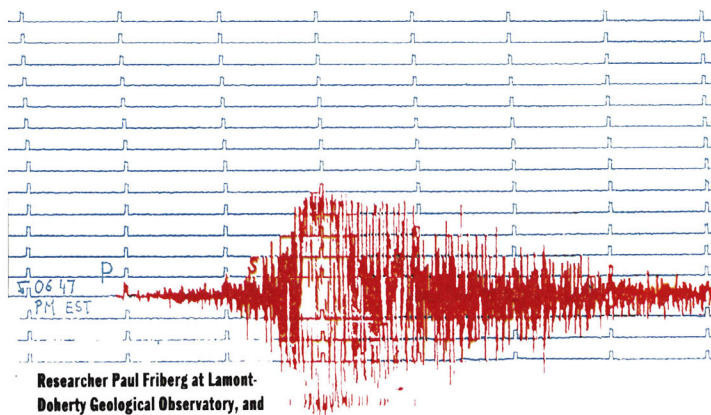
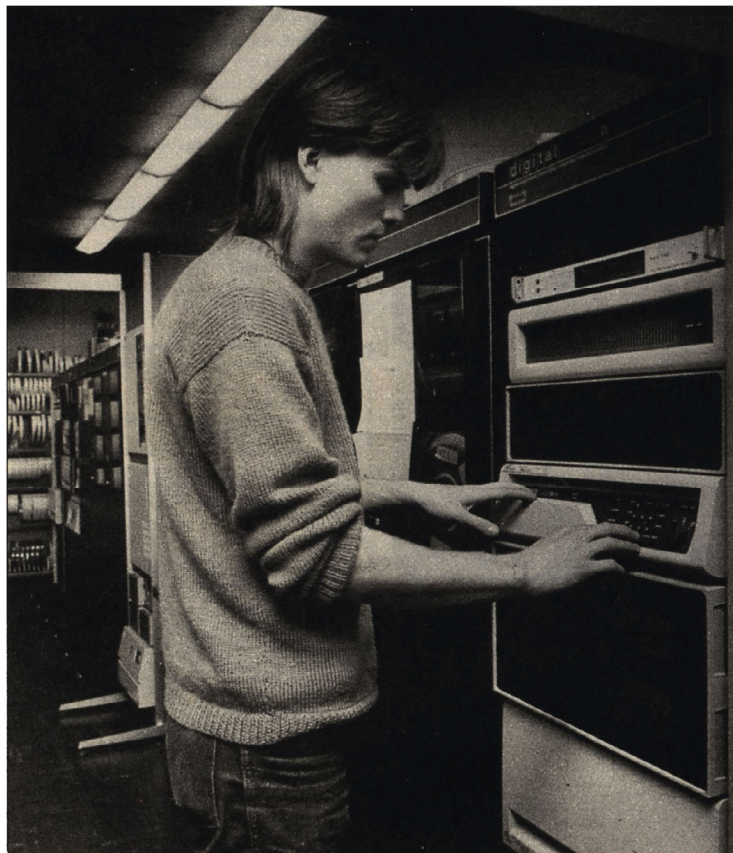
Within seconds, the city settled back into rock-solid routine. No reported injuries, no real damage.

Most New Yorkers hadn't even noticed. But seismologists in Canada and the U.S. had: 6.0 on the Richter scale. In Ottawa, Peter Basham, chief of seismology and geomagnetism at his nation's Geological Survey, said the temblor had struck at 6:46 p.m., about 12 miles below the evergreen forests of central Quebec Province, near the small mill and lumbering town of Chicoutimi. It was "the largest earthquake to hit eastern North America since a

magnitude 6.2 quake near Timiskiming in western Quebec" 53 years ago. Basham calls the likelihood of a major, destructive quake striking the East "a perfectly reasonable one, based on the fact that we haven't had a magnitude 7 event since 1929"—when an offshore quake struck the Grand Banks, off Nova Scotia—"and the kind of activity we've had this century."

A spokesman at the National Earthquake Information Center in Lakewood, Colo., confirms Chicoutimi's power. "Quakes registering 6 could cause considerable loss of life and property damage in a heavily populated area," he says. And at the U.S. Geological Survey's (USGS) eastern headquarters in Reston, Va., Randall Updike, deputy chief of the Office of Earthquakes, Volcanoes and Engineering, says it was not merely the quake's power that had caused it to be felt from Canada's eastern seaboard as far west as Detroit and south to Washington. "The rocks in the East are much older, more brittle than those in the West," he notes. "They ring like a bell when struck."

Though no deaths were reported and damage was "minimal," scientists along the East Coast are concerned: Chicoutimi gives added proof that large



Researcher Paul Friberg at Lamont-Doherty Geological Observatory, and (above) graph of Nov. 25 quake.

quakes can happen in the normally tranquil eastern half of North America — even the New York City area. Cautions one quake watcher: The Nov. 25 tremor was “a very timely warning . . . We should certainly be doing something about it.”

“Nobody is predicting a particular quake at any particular place or time,” stresses Ketter. “What we are saying is that a major earthquake will strike.” And New York is a possible victim of this “inevitable” quake (along with Memphis Tenn., and Charleston, S.C., scenes of past destructive

tremors), he adds, because the city lies at the southern end of a proven earthquake-prone arc that runs up the coast through Boston, another likely target, to the Grand Banks — the site of the '29 jolt.

“Earthquakes certainly can and do occur in southern New York State, in the vicinity of the city,” concurs Dr. Klaus Jacob, a senior research scientist with Columbia University's Lamont-Doherty Geological Observatory in Palisades, N.Y. “Large quakes apparently occur here at intervals of something like 50 to 100 or 200 years.”

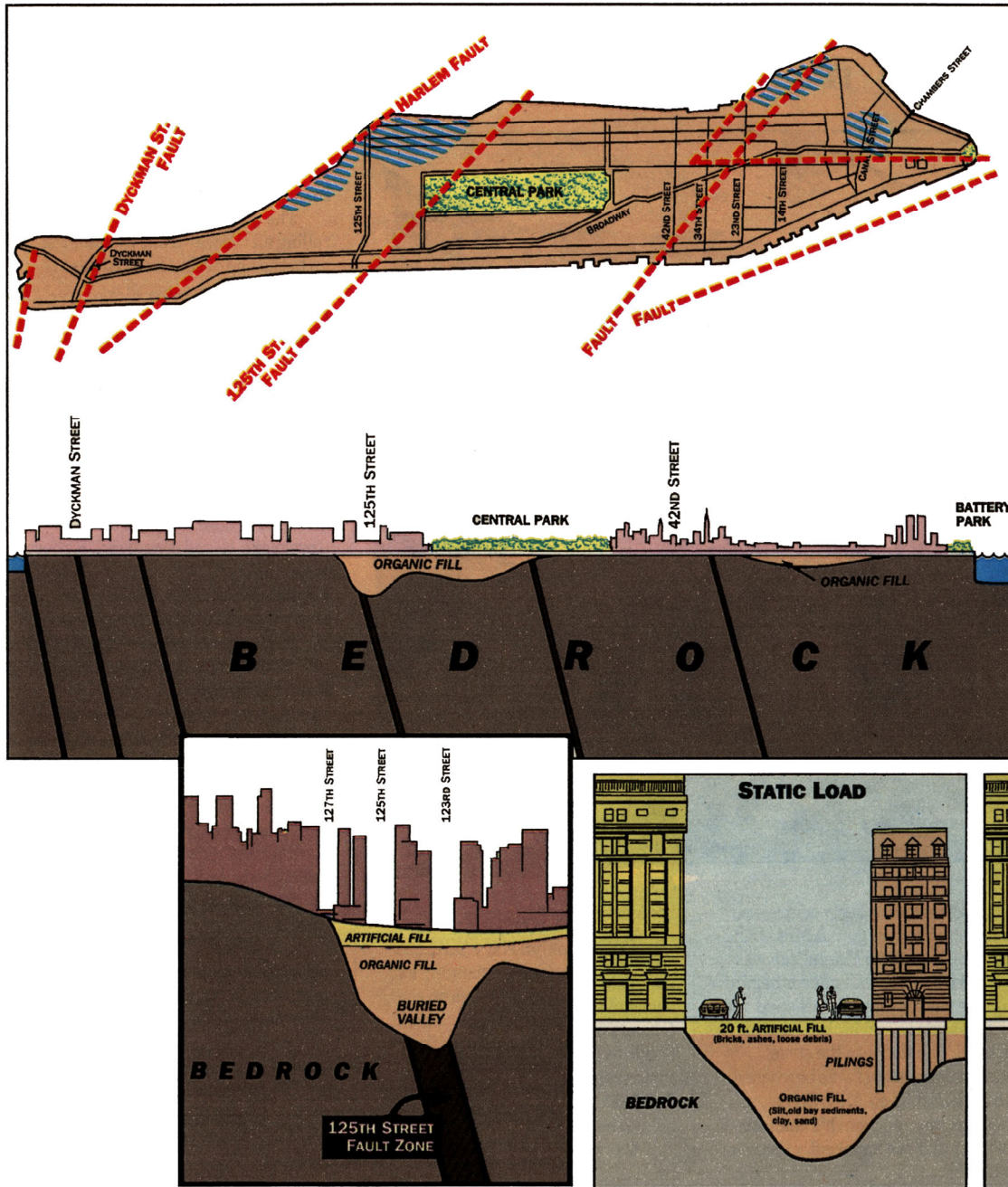
But tremors strong enough to topple chimneys occurred in the city in 1737 and 1783 — before any accurate records of such events were kept — and in 1884 (see page 12). “The '84 quake was the most severe we know about,” says Jacob. “It did limited damage, but could do considerably more harm were it to recur today — perhaps as much as \$7 billion.” (On Oct. 19, 1985, the latest news-making quake, a magnitude 4 shiver, spilled morning coffee when it rumbled through the Westchester community of Ardsley, 20 miles north of the city.

The Ardsley tremor, by one account, was the 16th of magnitude 3.5 or more to hit since colonial times.)

The infrequency of quakes in New York and elsewhere in the East make them difficult to study, Jacob and others say. Explains USGS' Updike: “The data set here is so small that it's difficult to make any kind of real estimate of when or where an earthquake is likely to occur. . . . You have no repeat times on which to base a prediction. For example, we know a major quake hit Charleston, S.C., in 1886. However, we don't know whether that kind of event is likely to repeat every 100 years, every 150 years, or every 200 years.”

A lack of knowledge of eastern U.S. faults — cracks in the rock — also hampers studies here, Updike says. “Out West, an airline pilot can look down and see faults. Here, they're buried underground — beneath trees, pavement, buildings — and people.” Yet faults are the stuff of earthquakes. These shakers occur when the underlying rock — the lithosphere, a brittle, 60-mile-thick shell that forms

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**Left: Manhattan's skyline, with tallest towers seated on bedrock and lower buildings on pockets of organic and man-made fill that could spell disaster in a quake. Former marshes (blue areas) and faults, cracks in the rock, running beneath some of island's major cross-streets are also troubling. Particularly worrisome is the deep layer of fill (below left) that overlays 125th Street Fault.**

**Below: Static load (center) shows buildings at rest on bedrock and on pilings driven into soft fill. As quake strikes (right), shaking sets off initial body waves that ripple through rock and below pilings. When waves hit fill, they amplify into surface waves, liquefying soil and further endangering pilings.**

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the Earth's outer crust — breaks or moves. The shell itself is composed of a dozen or more pieces called "tectonic plates" that are continually colliding with or sliding past each other. Because the sliding and colliding builds up tremendous pressure, quakes most frequently occur on or near the edges of the plates, where the pressure is greatest and faults are most liable to form.

Last month's Armenian temblor, for example, took place along the boundary of the Eurasian plate, in a region made volatile by pressure from the African and Arabian plates. The eons-long tectonic collisions of these plates have raised the Caucasus Mountains and dotted history with recurring destruction. An even worse record has been piled up by the 24,000-mile-long Pacific plate boundary — the site of nearly half the world's great quakes. California sits astride this zone — with its infamous San Andreas and related faults forming the boundary between the northward-moving Pacific plate and the westward-moving North American plate.

So far, the U.S. has been spared truly catastrophic temblors. Only three quakes have caused more than 100 deaths — the highest toll, 452, occurred in the 1906 San Francisco quake — and areas away from plate boundaries (New York lies near the center of the North American plate) are considered relatively inactive. However, the strongest U.S. quake, or series of quakes, shook not California but the heart of the continent. Between December 1811 and February 1812, three huge tremors rumbled along the Missouri-Tennessee border near current-day Memphis. Known as the New Madrid quake — for the Missouri town nearest the epicenter — they caused little human misery because at the time the area was only sparsely populated. But they set church bells ringing in Boston, 1,000 miles away, and changed the course of the mighty Father of Waters. Were they to recur now, experts say, present-day Memphis and five nearby cities could suffer thousands of deaths and crippling devastation.

The Mississippi Valley is not the only focus of concern for seismologists, however. Dr. Charles Merguerian, a professor of structural geology at Hofstra University in Hempstead, L.I., has studied the faults underlying New England and mapped those beneath New York City. His work has shown two major sets of faults under New York. One set trends northeasterly, the other northwesterly under Manhattan — beneath 155th, 125th, 96th and 14th Streets. The sets intersect in a crude checker-board pattern. Says Merguerian, "Where two sets of faults intersect, they form structures that are likely to move under stress." And, he notes, the North American plate is being stressed — pushed from the east by seafloor spreading in the mid-Atlantic Ocean at the same time that it's grating up against the Pacific plate on the west. "The real scary thing is that while there is a lot of movement, we don't have many earthquakes," which could act as small, nonlethal releases of energy. Instead, says Merguerian, "the strain on the plate is locked in; it builds up. So, you can't rule out a major quake in New York."

But it might not take a major trembler to stagger New York. Destructiveness isn't determined solely by size, experts say, but also by time of occurrence, building practices, soil conditions and population density. The city certainly has people enough and, perhaps, the right mix of older, nonquake-resistant buildings and soft soils that could stir up a disaster and bring death to hundreds, or even thousands, of New Yorkers.

No estimates of possible casualties from a major New York quake have been drawn up. The single existing study performed on the likely impact of a quake here was a 1987 preliminary report commissioned by NCEER. That study merely evaluated the potential building-stock damage that a quake of magnitude 6 would inflict on the city. Its conclusion: A New York-area quake — of the same magnitude as the Nov. 25 Chicoutimi shocker — would be "a disaster unparalleled in New York's history."

According to Charles Scawthorn, chief author of that report and vice president of research and development for San Francisco-based EQE, the largest U.S. engineering consultant firm specializing in earthquake design and damage mitigation, the study examined what would be likely to happen to New York's 800,000-odd buildings if the temblor hit 17 miles southeast of City Hall, off the Rockaways at about the same location as the quake of 1884. In such a case, says Scawthorn, "we found that New York's building stock would sustain roughly \$11.2 billion in damage — about 2.8% of a total estimated value of nearly \$404 billion in all five boroughs." At 11 miles from City Hall, somewhere around the Rockaway Inlet, Scawthorn's study found that the same quake would cause \$18 billion in structural damage, or about 4.5% of its total value; and at five miles from City Hall, in the Prospect Park section of Brooklyn, the damage total would soar to \$25.9 billion, or about 6.4%.

The destruction would be highest in sections of the city closest to the quake's epicenter — in these three instances, around Jamaica Bay, in southern and southwestern Brooklyn and in lower Manhattan. And in all three scenarios set up by the study, all kinds of building construction — wood, steel-frame, reinforced concrete, reinforced masonry and unreinforced masonry — would fall prey, in varying degrees, to the quake's shaking. The hardest-hit structures would not be New York's famed towers, but rather its numerous old brownstones and rowhouses, its unreinforced masonry structures, says Scawthorn.

"However," he notes, "we did not look at possible tall-building resonance," the swaying effect that proved disastrous in the 1985 Mexico City quake when about 200 mid- to high-rise buildings toppled and 10,000 died.

Where a New Yorker lives and works might determine his chances for survival during a large quake, since all areas of the city do not share the same grounding in bedrock. Softer soils in some of the boroughs may increase the

vibrations of the shaking caused by an earthquake, says Lamont-Doherty's Jacob. "A good portion of Manhattan and the Bronx — the higher areas in particular — are all right, geologically speaking," the earth scientist says. "But large sections of Queens and Brooklyn are on glacial sediments that are either Ice Age end moraines — the area along the Interboro Parkway in Brooklyn is an example — or coastal-plain sediments laid down at a period when the ocean covered part of the land — such as Flushing Meadows where Shea Stadium now sits. I wouldn't want to be at a ballgame during an earthquake. In a quake, such unconsolidated sediment could be subject to site amplification, what we call the 'Jell-O pudding effect.'"

That same effect could give some large housing projects a bad case of the jitters as well — even in Manhattan. "You just have to drive along the East River Drive," notes Jacob. "Those projects in East Harlem, for instance, were built on stuff nobody else wanted. Landfill, reclaimed land, the kind of low-lying area that during the time of the Dutch was marshland. That's very poor building ground." Battery Park City and the World Trade Center are among other Manhattan sites that might be on very shaky ground, he adds.

And the timing of a quake also might influence New Yorkers' chances of survival. Were a quake to hit during rush hour, when the city's overworked, undermaintained roadways, bridges and tunnels are packed with commuters, "unsound seismic engineering" might put this infrastructure to a severe stress test, according to Hofstra's Merguerian. For example, he says, New York's tunnels aren't totally rooted in bedrock, but sit in mud "that could liquefy during a quake, and it would flow. The tunnels would be left without support" while above water, some city bridges "aren't seated in the same material at both ends. Dissimilar materials may react differently in an earthquake, putting severe stress on the structures."

Both Jacob and Merguerian emphasize, however, that these scenarios are largely educated

guesses — based on their professional knowledge and experience — and not specific scientific analyses, which they urge should be carried out.

Meanwhile, city officials and others point out that no hard evidence yet indicates that New York faces any imminent threat from a killer quake. Building experts say that New York's high-rise buildings are designed to withstand extremely strong hurricane wind loads, which should help them resist the shaking of an earthquake. And George Zandalasini, deputy director for bridges at the city Transportation Department's division of highway engineering, says that New Yorkers "shouldn't get excited about our vulnerability. Though earthquake force is not the controlling factor in structure design here, we do conform to the standards for forces that this region can reasonably expect to face."

NCEER's Ketter, for one, has heard such reasoning before. Local authorities, he says, are slow to react to the warning signals. "The eastern United States — including New York — has no planning, no building codes, no zoning ordinances that take earthquakes into account," Ketter says. "We don't provide any education in schools to tell children how to cope, we don't teach businesses how to stay in business, we don't train hospital emergency units on what to do with patients in an earthquake. Weeks after the Thanksgiving weekend quake, we are still getting calls from hospitals about what they should have done to care for cardiac patients during that quake."

"The major problem regarding earthquakes in the eastern United States is a lack of awareness that there is a problem."

*Dick Sheridan is assistant editor of The Magazine.*

## RIDING OUT A QUAKE

What do to in those seconds an earthquake lasts? Some experts advise:

- "I'd like to be out in the open, away from structures liable to collapse or have things fall off." — *Charles Scawthorn, structural engineer*

- "I'd prefer to ride out a quake either in a wooden building of less than three stories or a newer building 15 stories or higher. These would be the safest. Don't run outside, because the first things that come down in a quake are architectural ornamentation as well as chimneys and water towers that many older buildings have. . . . Inside a building, I'd tell people to stay away from large plate-glass windows. The safest place might be a doorway in an older building. Doorways were solidly built in the old days. Stay away from top-heavy things like appliances or bulky equipment liable to topple."

— *Robert Ketter, director of the National Center for Earthquake Engineering Research*

**AFTERMATH:** Post-quake fires, caused by snapped power lines and gas-main ruptures, are an urban quake hazard. A 1987 study of a potential New York quake off the Rockaways shows 130 fires could be expected in the five boroughs, mostly in Brooklyn and Queens. Map shows possible sites.

