SEISMOLOGICAL ANALYSIS AND THE EFFECTS OF EARTHQUAKES IN NEW YORK AND LONG ISLAND

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Introduction

Contrary to popular belief, Long Island and New York have a fair share of earthquakes, and this research set out to prove it. Not only was the data conclusive to this, but it revealed more seismic activity than previously hypothesized.

An earthquake is a sudden, often violent movement of the earth's surface as a result of the release of energy from the earth's crust. The cause of this is that the earth is always bending slightly from tectonic forces. When this stressor pressure exceeds the strength of the rocks, the crust breaks and can snap into a new position. Vibrations from this are called seismic waves, which travel through and along the earth's surface. These seismic waves are called earthquakes (Bolt 1993).

Earthquakes often occur at faults. A fault is where two large blocks of crustal rock have slipped or moved against each other. They can move up and down or horizontally to the left and right. Essentially, faults are weaknesses in the crust. The three main kinds of faults are strike-slip, dip-slip, and thrust fault.

More than 1,000,000 earthquakes occur worldwide in one year (Berlin 1980). This number includes quakes too small to be felt but large enough to be recorded as an earthquake. Ninety-five percent of them are along tectonic or crustal plate boundaries. Major boundaries include California, Alaska, Japan, west coast South America and the Philippines. Four thousand of these earthquakes occur in Alaska alone. Alaska happens to be located over a subduction zone, which is where one plate is sliding over another. The largest earthquake the U.S. has ever experienced was in Alaska. Earthquakes are quite common natural events, contrary to what some people might believe. They can occur as deep as 5,000 miles below the surface.

Seismologists are scientists who study earthquakes. They use two different names to describe the types of waves that are given off by the earthly vibrations. The first is a P-wave, primary preliminary waves, which is the first to arrive at a seismic station after movement. It compresses and dilates the rock as it travels. Its usual speed is less than 6km/s in the crust and can get up to 13km/s traveling through the core. The speed is comparable to that of sound waves. S-waves, second preliminary waves, follow a similar path to that of the P-waves, though it is believed that they can't travel through the core. These waves shake the rock sideways as it advances at half the speed of a P-wave. A combination of these two waves is used to locate the epicenter of an earthquake, based on their time intervals. The epicenter is most easily described as the spot of a rock hitting the water when tossed into a still pond. The surrounding waves represent the P and S waves (Bolt 1988). The waves are measured using a seismometer, which senses the earth's motion, and a seismograph, which combines with the seismometer to obtain a printout.

Seismology of New York and Long Island

There are earthquakes in New York and on Long Island. The Ramapo fault runs from Westchester County to the Hudson River at Stony Point. It is a hairline fracture, 50 miles long, compared to the San Andreas fault of California, which is 700 miles long. The Ramapo is one of the oldest faults, being 1 billion years old. It was very active 200 million years ago, and starting in the 1970's, began to act up again. This fault is

located a mere 35 miles from New York City, but people don't seem to worry about it (Heppenheimer 1988). (Figure 1)

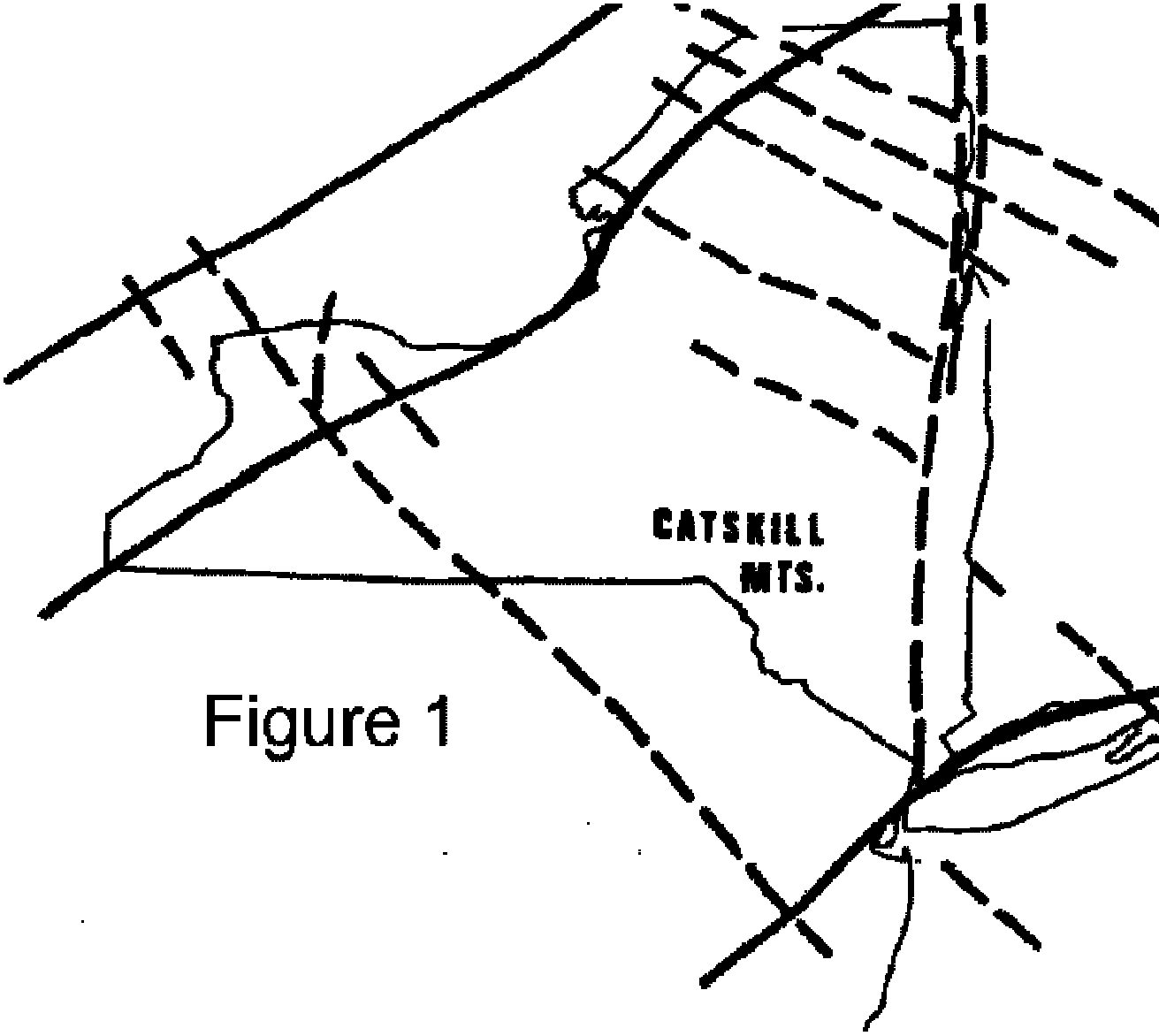


Figure 1

It is also now believed that the belt of rocks surrounding New York City have broken into two major faults, the St. Nicholas Thrust and Cameron's Line. Future seismic activity may occur among these Northwest trending (running) faults. The rock that these faults are located in is eroded Proterozoic to Lower Paleozoic, and this type of rock widens as you move northeastward. The means of separating these two forms of rock is the ductile St. Nicholas thrust and Cameron's Line (Neibling 1999). They were developed during a long process of deformation and folding, which is an extremely slow form of faulting. Cameron's Line shows this to the extreme in western Queens and Brooklyn. There is a "famous" 14th Street fault that commands the low structures between Manhattan's 23rd and Canal streets. (Figure 2) New York City and its' vicinity is not safe from the hazards of seismic activity. The Ramapo fault is also responsible for New Yorkers to be able to live where they do because it's height, however slight, prevented the sea from filling in the Newark basin, which was formed around the same time (Sullivan 1985). (Figure 3)

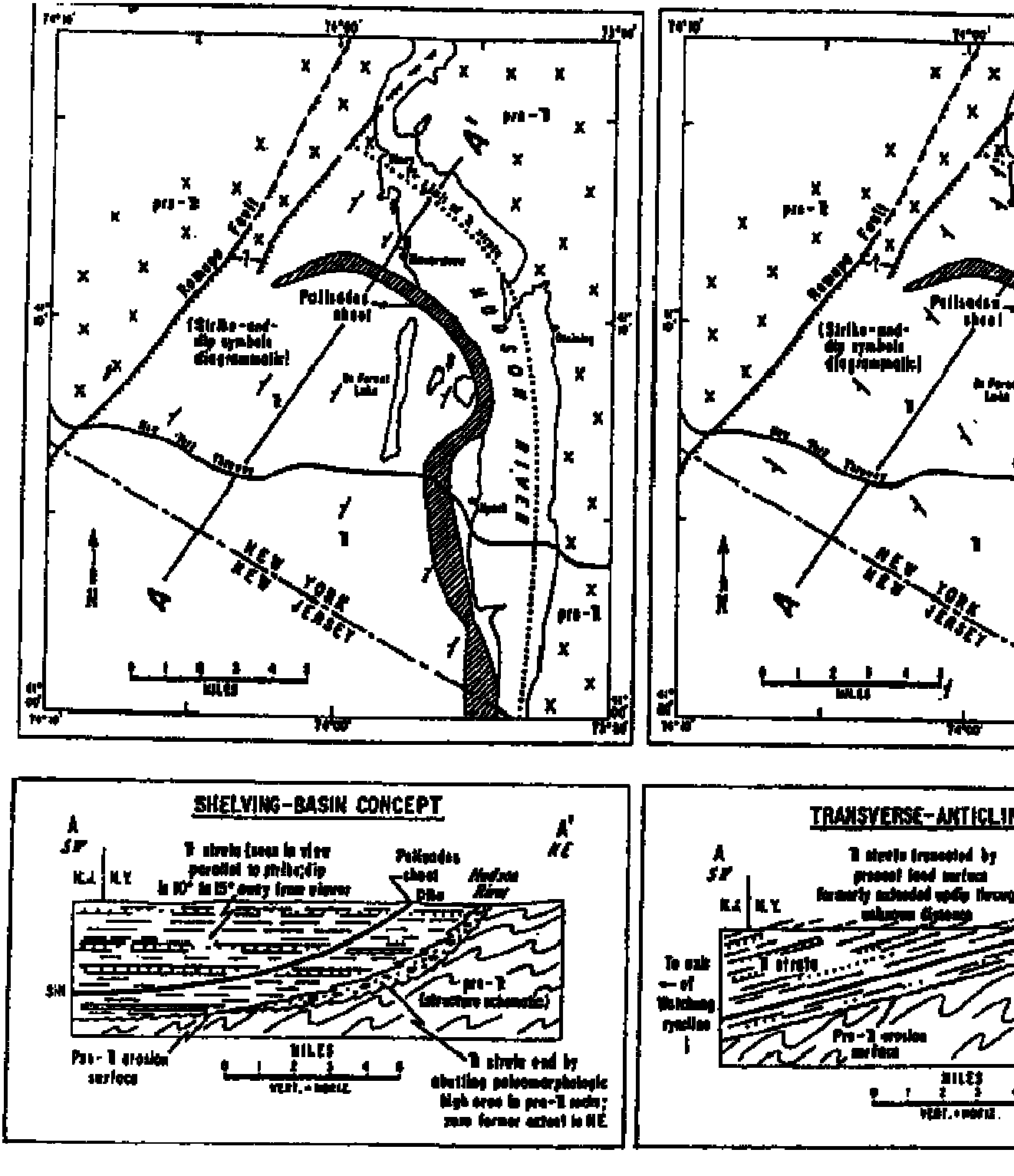
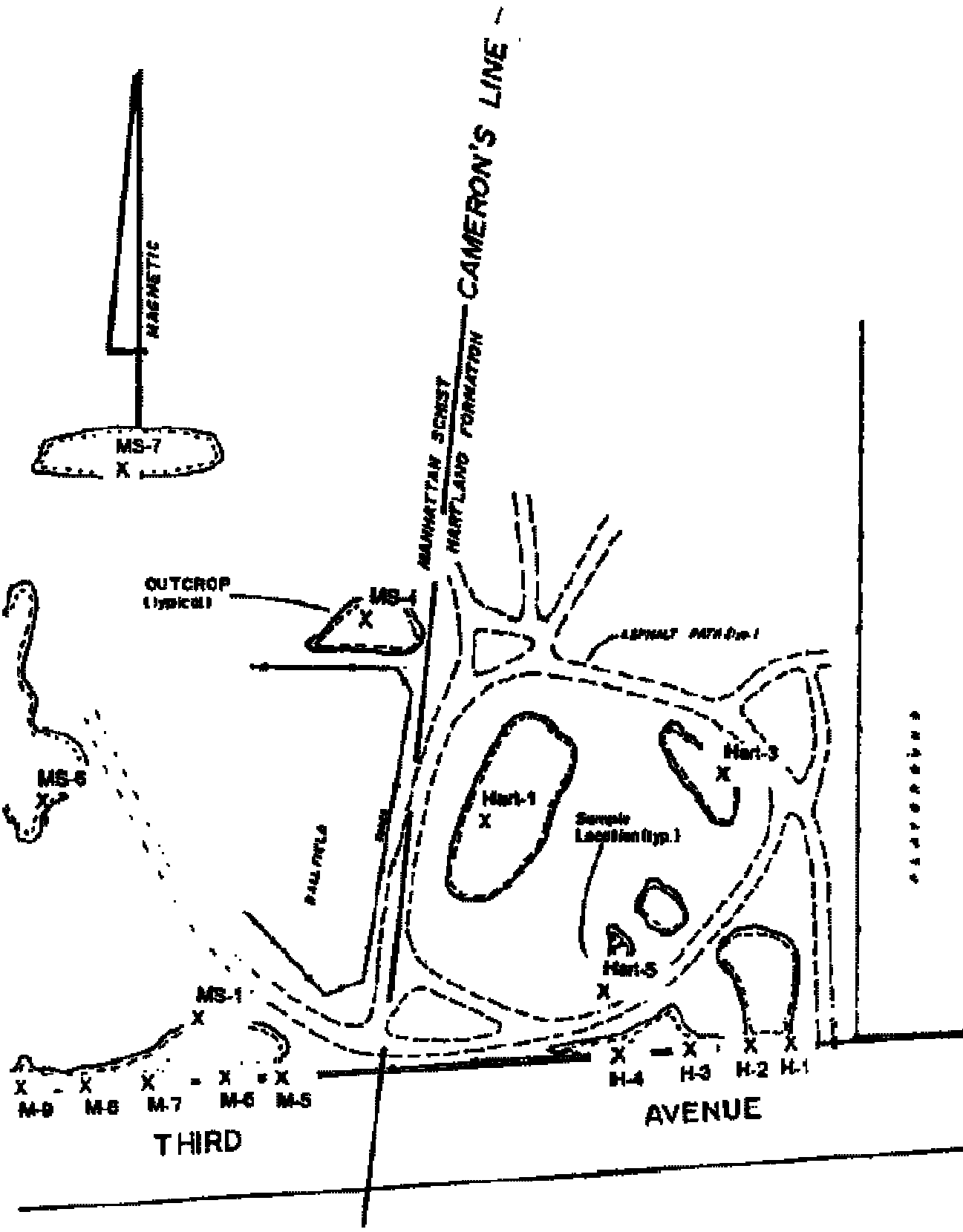


Figure 1. Schematic geologic maps of NE end of Newark basin in
County, NY (above) and profile sections from Hudson River at Ha
NJ state line showing contrasting interpretations of the geolog
relationships. (J. E. Sanders, 1974, figs. 7 and 8, p. 24-27;



MAP OF BORO HILL PARK (SOUTH EAST)
BOROUGH OF BRONX
NEW YORK CITY

Plate tectonics is the widely accepted theory that the crust of the earth is divided into rigid plates that are constantly in motion, moving continents and ocean basins. Where two of these plates meet, rubbing can occur, which causes an earthquake. Scientists are not sure, then, how earthquakes occur in New York. North America is located in the middle of a plate that stretches from California to the mid-Atlantic, but plates could still be responsible for our earthquakes. The New Madrid area, which is the central part of the U.S., has had some of the worst quakes the country has ever experienced, and it is located in the middle of the plate as well (Levy 1995). (Table 1)

EARTHQUAKES IN THE UNITED STATES, 1980-1991

The table below shows the number of earthquakes located in each state by the U.S. Geological Survey, National Earthquake Information Center during the time period from January 1, 1980 through December 31, 1991. The column titled "Largest Magnitude" gives the magnitude of the largest event in that state during this time period. Note that it does NOT give the largest magnitude on record for that state.

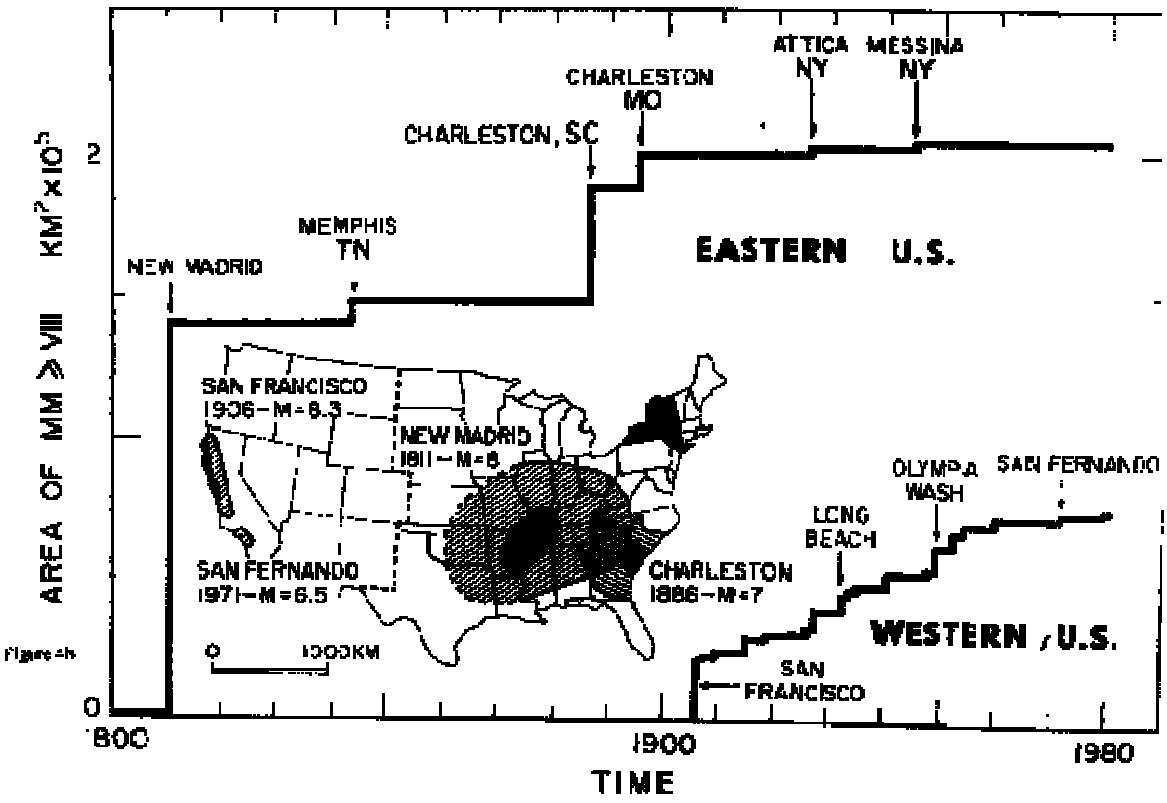
	No. of Events	Largest Magnitude
Alabama	6	4.5
Alaska	10253	7.9
Arizona	35	4.0
Arkansas	48	4.7
California	6732	7.2
Colorado	87	4.5
Connecticut	6	3.8
Delaware	1	2.4
D.C.	0	---
Florida	0	---
Georgia	8	4.2
Hawaii	186	6.7
Idaho	536	7.3
Illinois	23	5.1
Indiana	11	4.1
Iowa	0	---
Kansas	12	4.0
Kentucky	22	5.2
Louisiana	1	3.8
Maine	13	4.3
Maryland	2	2.6
Massachusetts	10	3.0
Michigan	1	3.6
Minnesota	0	---
Mississippi	1	2.9
Missouri	32	5.0
Montana	338	4.8
Nebraska	8	3.8
Nevada	398	5.6
New Hampshire	15	4.7
New Jersey	5	3.2
New Mexico	59	4.8
New York	24	5.3
North Carolina	11	3.5
North Dakota	1	3.3
Ohio	14	5.0
Oklahoma	89	3.7
Oregon	64	6.9*
Pennsylvania	10	4.4
Rhode Island	2	2.7
South Carolina	24	3.5
South Dakota	11	4.6
Tennessee	40	4.3
Texas	25	4.5
Utah	366	5.4
Vermont	0	---
Virginia	5	3.5
Washington	615	5.5
West Virginia	2	3.5
Wisconsin	0	---
Wyoming	179	5.5

* This quake occurred in the Pacific Ocean about 70 miles off the coast of Oregon. The largest earthquake within Oregon during this time period was magnitude 4.3.

Comparison 2.

East Coast quakes have never produced surface-visible disruptions, unlike the San Andreas Fault of California. Because the crust on the East coast is cooler and more rigid, earthquakes are generally felt over a larger area than those on the West coast, since these conditions allow seismic waves to travel further, but they do so with less force. Seismic wave velocities are also related to the type of rock, the temperature, and the pressure conditions under which they occur (Weidner 1999).

Studies of earthquakes on various instruments are increasing as the numbers of quakes are. A concern involves Consolidated Edison's nuclear power plant at Indian Point. Should an earthquake cause a disruption in the cooling system, radioactive gases would be released into the atmosphere. In addition, buildings like the World Trade Center were not built in accordance with recommended earthquake guidelines. While it can withstand up to 150-mph winds, that would do nothing to protect it in the event of a substantial earthquake. (Figure 4a) It was just in recent years that people have started to recognize the possibility of an earthquake in New York. (Figure 4b)



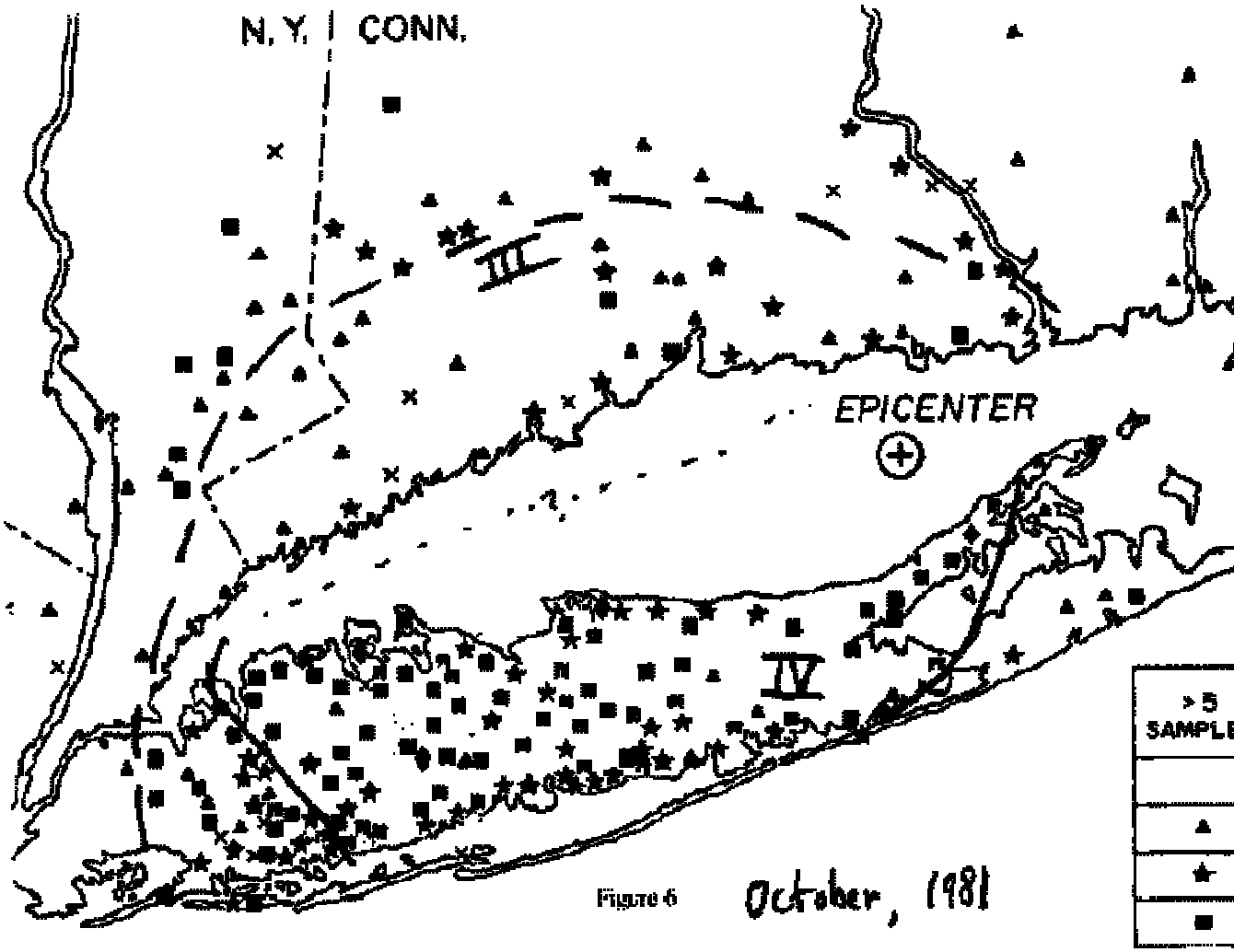
The materials of the rock do not affect the probability of having an earthquake, though it does affect how the earthquake will be felt, and how severe the sink and rise damage is. Long Island sits on a bed of sand and water, which amplifies waves and makes it susceptible to liquidfaction in the case of a major event. "Eastern quakes shake over bigger distances because the upper mantle and lower crust here (30-100 km deep) are cooler. This is because the east is less geologically active; older", says Dr. Dan Davis of SUNY Stony Brook. The first correct prediction in the United States was of a 2.6 magnitude at Blue Mountain Lake, NY.

Historical Perspective

1779 had the oldest earthquake published about in modern *Newsday*. On February 2nd, a 3.5 rumble shook northern New Jersey and Long Island. It was centered in Cheesequake State Park, NJ. No injuries or damage was reported. (Brasley 1979) Often times, people in NYC just assume that tremors are the result of normal traffic vibrations, and people of the island chalk it up to a passing truck. People don't expect earthquakes in New York, but to prove this thinking incorrect, one of the best sources is first hand accounts. From *Sketches from Local History,* a man writes about Nathan Ropping Cook, a man who built a house somewhere between 1793 and 1800 on Long Island, and the earthquake that occurred during that time period. He also describes that, in the aftershock of one he experienced, graves were 15 to 20 inches out of line in the Seuttle Hole graveyard. Ponds supposedly settled towards the center of the chain they were located on.

Another one of a Sunday afternoon in August of 1882 had north to south waves and upset some vases and dishes. Distinct sulfur smells were also said to be quite perceptible. New York City was also rocked by a 5.0 earthquake on August 10,1884, which caused some considerable damage. February 28th, 1925 at 9:22 another north to south quake occurred, swinging lamps and pictures, as well as nauseating some people.

October 22, 1981 had to the most powerful quake to hit Long Island since 1937, and possibly the strongest in a hundred years. It measured a 3.5 on the Richter scale, and the epicenter was in the Long Island Sound. It occurred at 12:49 PM, and did no major damage, though some plaster cracked, and a chandelier fell (Gatewood 1981). (Figure 6) In New Brunswick, New Jersey, a quake struck and was felt in most of the eastern provinces of Canada and in New England as a result of its' 5.9 degree shock waves. (Sommer 1982) Another earthquake occurred on October 8, 1983. It was felt from Quebec to Baltimore, though most residents of Long Island slept through the 6:18 AM tremor. The 5.2 quake was centered near Blue Mountain Lake, NY. This particular disturbance was caused by a coin-shaped mass of rock that slipped a few inches approximately 10 miles below the earth's surface. Shock waves were measured for about 10 minutes at Stony Brook. (Freedman 1983)



On October 24, 1985, a 4.0 earthquake rattled Smithtown, New York (Long Island) at about 6:07am. It was the largest to hit the area in 48 years. Its epicenter was in Ardsley, New York, which was located in northern Westchester County. The shaking lasted for less than a minute. (Wojtas 1985) On June 18, 1991, an earthquake centered 40 miles west of Albany shook three states, and measured between a 3.9 and 4.4 on the Richter scale. (*NY Times*)

The year 1992 was also had a number of earthquakes. On March 11, a quake centered 15 miles south of Montauk registered a 2.8 tremor. It occurred at 6:51 p.m. according to Prof. Don Weidner of SUNY Stony Brook. It was centered about 15 miles south of Montauk and measured a 2.8 on the Richter scale. The quake was felt in Connecticut, and picked up by seismometers in Massachusetts and New Hampshire. (Mintz 1992)

Data and Discussion

So, where were you on January 28, 1999? If you were on Long Island, you would have been standing over seismic waves rumbling through the rock to be registered on the seismograph located in the basement of the Earth and Space Sciences (ESS) building at SUNY Stony Brook. It occurred at 8:10 p.m. at 52.92N and 177.73W. It was a magnitude 6.60 quake.

On March 8, 1999, another earthquake was recorded on the seismometer located at Stony Brook University. This one was centered in the Kodiak Island region of Alaska, at approximately 58.337N and 151.710W. Ten stations were used to determine its' epicenter. The epicenter was located about 47 kilometers down inside the earth. It occurred at 13:03:47.5 GMT. March 20, 1999, had another earthquake recorded on the Stony Brook seismometer. This one occurred at 10:47:45 GMT, and was located at 51.61N and 177.73W, which is Andreanof Island, of the Aleutian Islands of Alaska. It registered a 6.8 on the Richter scale. The next earthquake, on March 31, 1999, was located just south of Panama. It was at 5.80N and 82.30W. The quake registered a 6.0 on the Richter scale. A 2.9 earthquake occurred in South Carolina on the 29th of March.

At 16.263S and 72.498W, the coast of Peru, a 6.2 magnitude earthquake struck on April 3, 1999. Papua New Guinea was the site of the next recorded event. This event took place on April 15, 1999 at 9:15:57.87 at 6.43S and 147.08E. It was 43 km below the surface and measured a 4.90 on the Richter scale.

Long Island definitely had its share of earthquakes, and is a very open-armed receiver of the shock waves of others. (Figure 7) Almost every visit revealed yet another event. The data collected proved that Long Island has and receives more earthquakes than previously hypothesized. It is time that people start to take notice of this and take steps to protect themselves in the event of a seismic event of significance.

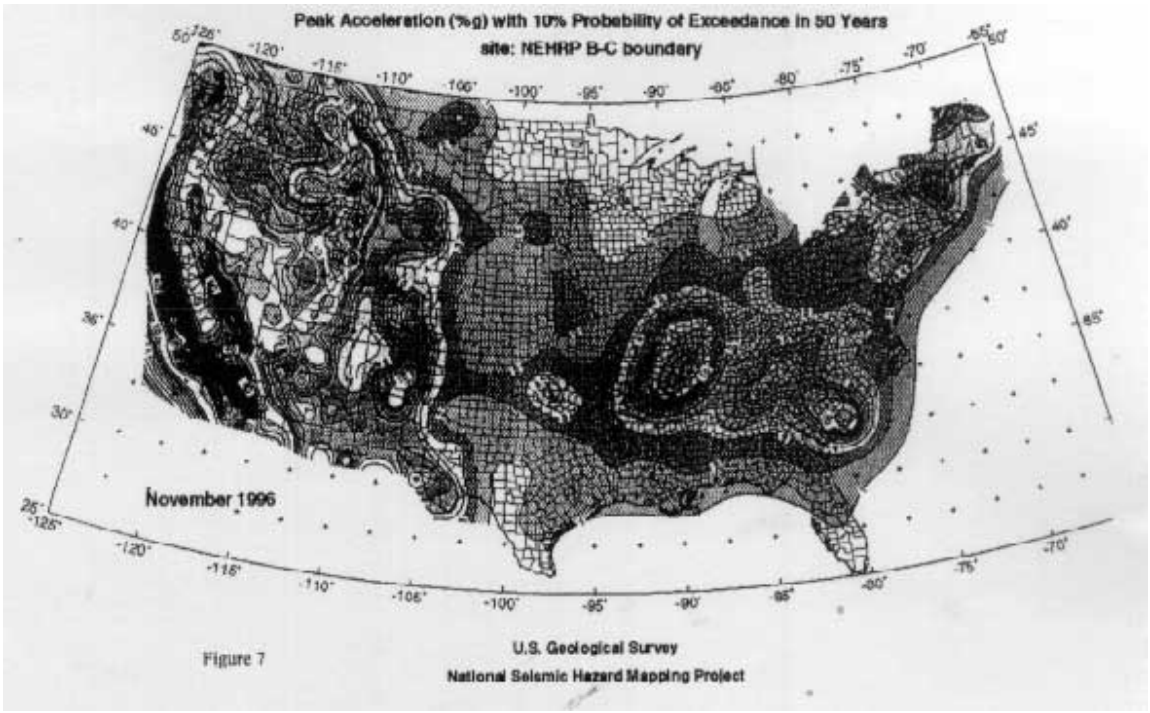


Figure 7