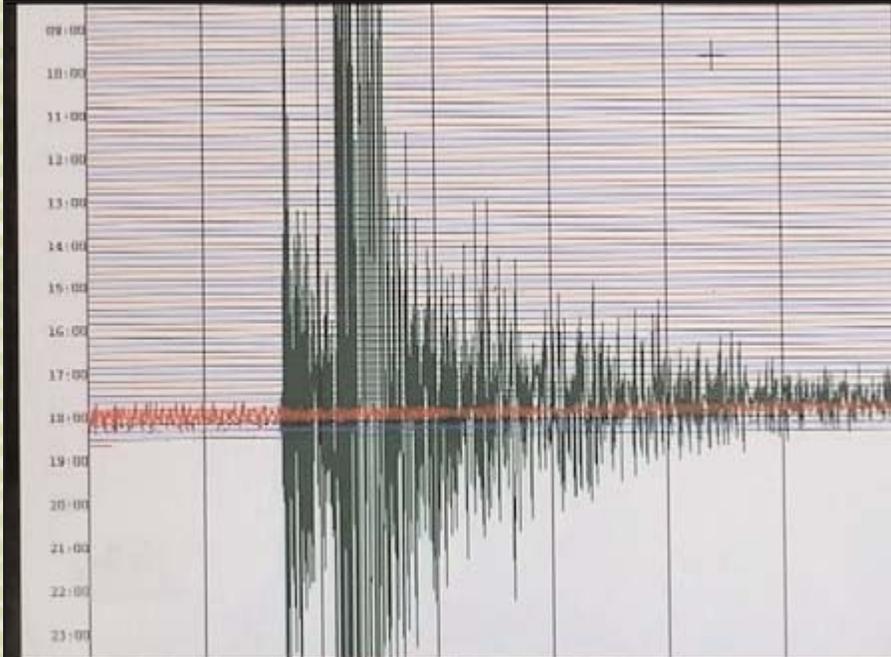


New Jersey isn't known for earthquakes. Yet the Garden has shaken more than you might realize...



QUAKEKES **in the Garden**

by Gordon *Bond*



A seismograph showing the 5.8 magnitude Virginia earthquake on August 23, 2011.

Following the earthquake that shook up the east coast on August 23, 2011, someone created a webpage with pictures showing the “damage.” It was silly things like a bottle of water tipped over or a crooked picture. It was a goof on what, to some in the more quake-prone parts of the country, seemed like an overreaction to what was, in fact, a relatively minor seismic event. Certainly people on the west coast have known far worse. And the people of Japan could scoff at all of us, assuming, that is, they could take the time away from still cleaning up after the devastating and deadly earthquakes and accompanying tsunami of last May.

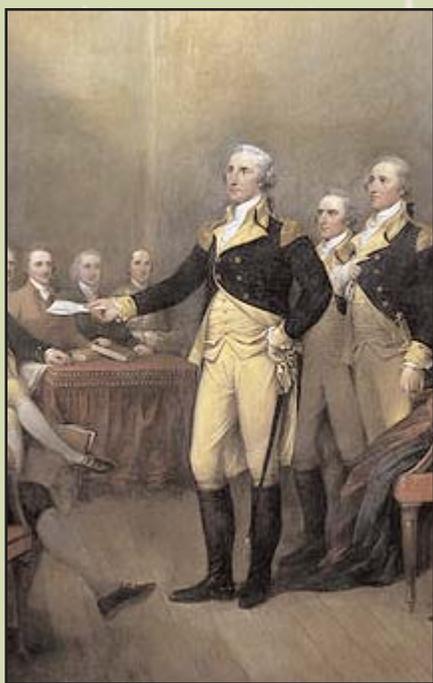
That the August quake fueled such regional jibes underscores the fact that earthquakes of any real magnitude are—fortunately—kind of rare over here on this side of the continent. But even a little tremor can be rather unnerving for someone not familiar with the sensation. And, it also didn’t help that the tenth anniversary of 9/11 was right around the corner and in the news. A sudden shaking like that in Washington D.C. and New York City gave more than a few residents flashbacks.

But even quake-seasoned west coasters might be surprised to know that there have been 173 earthquakes with epicenters inside New Jersey’s borders between 1783 and June 2011.¹ And there have probably been more. Most are minor events that need modern seismometers to detect, so there were likely more events that slipped by unrecorded before their advent. This also doesn’t include the quakes with epicenters elsewhere that we happened to also feel—the August event was centered in Virginia.

Obviously, earthquakes have happened or been felt in New Jersey since long before there even *was* a “New Jersey.” This article will look at the four strongest recorded quakes—magnitude 4.0 and up—to take place within the Garden State.



Detail from the painting, "Cincinato abandona el arado para dictar leyes a Roma," c.1806 by Juan Antonio Ribera.



Detail from John Trumbull's painting depicting George Washington resigning his command on December 23, 1783.

1783

The year 1783 was pretty earthshaking as it was, even without any literal interpretations by Mother Nature. This was the year American colonists did what many thought was impossible—shake itself free from the British Empire, among the most powerful forces of the human variety on the planet.

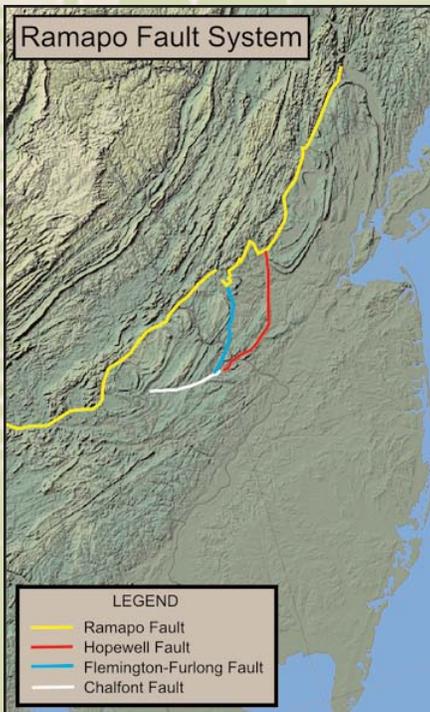
But while New Jerseyans and others read the amazing news, they would have also been getting sketchy details of a natural disaster from far-away Italy. These reports stand in stark contrast to those near-real time accounts from last August, via Facebook, Twitter and so on. An earthquake had struck the Calabria region and parts of Sicily on February 5th, but the first reports didn't reach Naples until the 18th. American newspapers only started covering it in mid-May.²

A more detailed account finally appeared in *The New-York Gazetteer* on May 19th—over three months after the fact. The quake had struck at around 11:00 a.m. The first shock lasted “no less than six minutes,” but tremors shook the inhabitants thirty-two times more before midnight. The last of that day was particularly violent, but they endured more tremors for the next two days, accompanied by flooding and—as if to add insult to injury—survivors were drenched by rain. Out of the 375 villages in the region, 320 were all but wiped out. The Prince of Sicily drowned when the sloop he was trying to escape in sank and Princess Garace de Grimaldi was buried beneath the ruins of her home in a town that bore her name. Casualty estimates numbered over 200,000.³

By the July 7th edition, *The New-York Gazette, and Weekly Mercury* had received reports dated April 5th. Apparently, the earthquake was volcanic in origin, beneath the sea, as lava was said to be washing daily onto the shores. The captain of a Swedish ship some twenty miles off the coast told of his boat hitting a temporary island of lava that was then consumed again by the sea.⁴

On December 1st, *The Independent Journal*, a paper out of New York, recorded the quake in America fairly simply: “Saturday evening about the hours of nine and eleven, the inhabitants were alarmed by three successive shocks of an earthquake. That at eleven seems to have been the loudest and most severely felt. Happily little damage has been sustained.”⁵

The earthquake was, evidently, eclipsed by General George Washington's arrival in New York. He was there for a dinner party at Fraunce's Tavern on what amounted to a little farewell tour. On November 2nd, he had delivered an eloquent goodbye to his troops and was about to do the same to his officers at



The Ramapo Fault System.

Fraunce's on December 4th. By this point, Washington had become the poster-boy of the American Revolution and could have been crowned King of America, had he so desired it. But he didn't, much to the surprise of European and some American assumptions. On the 23rd, he would resign from the army to return to his farm—albeit a very grand “farm.” But that he would willingly eschew power impressed many on both sides of the Atlantic. He was likened to the famed Roman, Lucius Quinctius Cincinnatus, who left his farm to lead Rome against invaders and then immediately resigned once the crisis had passed and returned to his plow. It was Washington's willingness to give up power that convinced others that he could be trusted with it in the first place and made him seem the perfect candidate to be President of the new nation he helped to create.

As for the earthquake, we can learn a little more of the details from the December 15th edition of *The New-York Packet*. “Most of the houses were sensibly shaken,” it reported, “so that in many the china and pewter, &c. were thrown off the shelves, and several persons were waked from their sleep—We hope that the country has sustained no damage by this convulsion of nature, which brings to our remembrance the late calamities of Italy, &c. &c.”⁶

Earthquakes, both large and (mostly) small, happen every day, all over the world. The planet is covered in tectonic plates, afloat on seas of magma. They brush up against one another, sometimes getting caught until the pressure builds and the pent up energy gets released in an earthquake when they break free. While it's hard to draw direct cause-and-effect between the events in Italy and America, they are all manifestations of the same dynamic and energetic planet.

The Ramapo Fault

The epicenter of the 1783 quake, according to the United States Geological Service (USGS), was most likely up around the Ramapo Fault system. The Ramapo Mountains are part of the larger geological structures of the northern reaches of the Appalachian Mountains. These were formed between 250 and 450 million years ago when Africa did a *really* slow hit-and-run. The continents collided during the formation of the Pangaea “supercontinent,” but then separated again when it began to break apart around 200 million years ago, filling in the gap with what is now the Atlantic Ocean. The process, known as “rifting,” created the Newark Rift Basin some 100 million years ago.

It is this geology that explains why those of us in the north-east don't know earthquakes in the same way as those on the



Charles Richter, c. 1970.

other side of the country. The bedrock beneath us is like one big slab. The energy from an epicenter is propagated away more efficiently as a result, causing it to dissipate. So the intensity near the epicenter is less, but the waves travel farther, meaning it is felt for greater distances away from the source—hence why we felt an earthquake all the way south in Virginia. By contrast, the bedrock on the west coast is more fragmented, impeding the transfer of the energy. California’s quakes, for example, tend to remain more concentrated, so the intensity around the epicenter is greater, causing more damage.

Interestingly, living near the Ramapo fault lines doesn’t make you any more vulnerable to earthquakes. While some geologists believe the system is still capable of delivering a real doozie, seismic events seem fairly randomly spread throughout the state, on up into New York and out into Pennsylvania, hinting at the complex geology most of us don’t realize is beneath our feet.⁷

Magnitude and Intensity

But how do we know that the 1783 event was really the strongest magnitude earthquake epicentered in New Jersey’s recorded history? There were no seismometers collecting data, obviously. Nevertheless, the descriptions from the newspapers offer enough clues that modern seismologists can at least make an educated guess. Indeed, it was by such observations that earthquakes had been measured until the 1930s.

In the absence of a network of reliable mechanical measuring devices, early students of seismology recognized that populations in the afflicted areas were, in effect, a *de facto* network of measuring devices. People would likely nervously notice, for example, that their prized china was rattling on the shelves. If it was enough to wake someone up out of a sound sleep, it would be a topic of conversation the next morning. Toppled chimneys or houses slid from broken foundations were records of the degree of violence that could be seen for days after the event. By using things that most people would typically notice as gages, and then collecting as many such observations as possible, a reasonable idea of a quake’s intensity might be arrived at.

Intensity, it should be noted, is different from *magnitude*. Magnitude measures the energy of the quake in the amplitude of the vibrations and is expressed in the Richter scale most are familiar with (though there are other scales in use, particularly in different countries). But, as we just saw, these are affected by the material through which the waves are propagated. A small amount of energy—magnitude—focused to a small area by the geology can mean greater actual shaking—intensity—than if it

were trying to propagate through a more stable material. If, for example, the August 23, 2011 quake had happened in California, the magnitude would be the same but intensity would have been greater.

If historic records give enough eyewitness clues as to the intensity, by knowing the geology of the given areas, a pretty reasonable magnitude can be worked out and a Richter scale number assigned to the event.

The first to formalize categories of intensity were Michele Stefano Conte de Rossi of Italy and François-Alphonse Forel of Switzerland whose 1873 scale included ten degrees, indicated by Roman numerals. A class VI intensity, for example, was considered a “fairly strong shock” and described by “general awakening of those asleep. General ringing of bells. Oscillation of chandeliers, stopping of clocks, visible agitation of trees and shrubs. Some startled persons leaving their dwellings”—all stuff that would be noted by even casual observers.

The Rossi-Forel scale, as it was known, would undergo a series of refinements and expansions on into the 20th century. With widespread construction of railroads, for example, noting the effects of a quake on rails could be added to the things to look for. Giuseppe Mercalli, an Italian volcanologist, expanded it in 1884. In 1902, another Italian, this time a physicist by the name of Adolfo Cancani, expanded it to include twelve degrees. Mercalli returned to it again with another refinement in 1906 before the German geophysicist, August Heinrich Sieberg, pretty much completely rewrote the whole thing. When Harry O. Wood and Frank Neumann created an English language translation in 1931, they took the opportunity to add to it further still.⁸

But the intensity scale seismologists use today is largely thanks to Charles Richter of the California Institute of Technology. He is, of course, better known for his 1935 Richter scale which quantifies the magnitude. For the mathematically-inclined (of which I am not), it will be worth mentioning that it is a base-10 logarithmic scale that is obtained by calculating the logarithm of the amplitude of the waves measured by seismographs. What that means in practice is that an earthquake of magnitude 5.0 on the Richter Scale has an amplitude ten times greater than one at 4.0.⁹

Richter’s modifications of the intensity scale were based on Mercalli’s and, since there is already a “Richter scale,” the result is known as the Modified Mercalli. And this is what it looks like:

Instrumental Generally not felt by people unless in favorable conditions.

Weak Felt only by a few people at best, especially on the upper floors of buildings. Delicately suspended objects may swing.

Slight Felt quite noticeably by people indoors, especially on the upper floors of buildings. Many do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.

Moderate Felt indoors by many people, outdoors by few people during the day. At night, some awaken. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rock noticeably. Dishes and windows rattle alarmingly.

Rather Strong Felt outside by most, may not be felt by some outside in non-favorable conditions. Dishes and windows may break and large bells will ring. Vibrations like large train passing close to house.



Houses knocked from their foundations in the San Francisco earthquake of 1906.



Collapsed roadways from the 1994 Northridge, California quake.

Strong Felt by all; many frightened and run outdoors, walk unsteadily. Windows, dishes, glassware broken; books fall off shelves; some heavy furniture moved or overturned; a few instances of fallen plaster. Damage slight.

Very Strong Difficult to stand; furniture broken; damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by people driving motor cars.

Destructive Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture moved.

Violent General panic; damage considerable in specially designed structures, well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

Intense Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundation. Rails bent.

Extreme Few, if any masonry structures remain standing. Bridges destroyed. Rails bent greatly.

Cataclysmic Total destruction. Everything is destroyed. Lines of sight and level distorted. Objects thrown into the air. The ground moves in waves or ripples. Large amounts of rock move position. Landscape altered, or leveled by several meters. In some cases, even the routes of rivers are changed.¹⁰

Using contemporary descriptions of historic events, it is possible to equate it with the intensity scale. Based on all the evidence, the 1783 New Jersey quake is considered to be most consistent with VI. And, taking into consideration the geology involved, it is also possible to equate the intensity with a magnitude on the Richter scale: New Jersey was hit that day by a 5.3 magnitude earthquake.

While that certainly is strong for this area (the August 2011 event was 5.8 near the epicenter in Virginia), a little perspective is in order. Readers may recall the January 17, 1994 Northridge, California, quake that killed 61 and caused some \$15 billion in damages. That one registered 6.7.¹¹ The one which devastated Haiti on January 12, 2010 came in at 7.0.¹² The famed April 18, 1906 San Francisco quake, which killed over 3,000 and did \$25 million in damage, was 7.9.¹³ But the deadly quake that hit Japan

in May of 2011 was a huge 9.0.¹⁴

Intensity is defined, in part, by the observation of damage. Yet, this can be at least somewhat relative. A country like Haiti had buildings ill-equipped to withstand an earthquake of that magnitude, resulting in more damage and humanitarian misery than might arguably have been suffered elsewhere. Buildings in 1906 San Francisco were also hardly quake-proof, but what really did them in was the subsequent fires which raged out of control—some estimate the fire accounted for 90% of the total damage when it was all done.¹⁵

While the 1783 event is New Jersey's strongest in terms of *magnitude* as measured by Richter's scale, it is actually not the worst in terms of *intensity*. That distinction, as we will see later in this article, belongs to a 1927 quake.

1895

The next worst quake to occur within New Jersey, as ranked by magnitude, occurred in 1895 and is believed to have been 4.1 on the Richter scale. Fortunately damage was minimal, but like the 1783 event, it was preceded by a far more devastating event in another part of the world.

On January 17th when some 11,000 people were said to have perished in a quake that struck the town of Quchan, in northeast Persia (now Iran), a region then and now prone to earthquakes. Some 600 alone were entombed by the collapse of their mosque. Reports described scenes of utter devastation with not a single building surviving to provide shelter. Many escaped the quake itself only to die later from lack of food and water, exposure to the cold and for want of medical attention.¹⁶ In 1895, getting aide to such a remote region took time, even on a good day.

Certainly what happened in New Jersey wasn't much when compared with Persia's tragedy. But it was enough to startle people from their sleep on that Sunday morning of September first, shortly after 6:00 a.m. According to the next day's report in *The Trenton Evening Times*, the northern part of the state felt most of it, while "the southern section appears to have escaped the experience entirely." For those who felt it, there was a low rumbling and the vibrations, which came in three distinct waves in rapid succession, lasted between three to twenty seconds, depending on who was estimating. "Houses were shaken, dishes were broken but nothing worse than this has been reported."

Areas on mountainous bedrock seemed to shake more than lowlands—residents of upper Paterson reported violent shaking while those in the lower portions of the town hardly knew there had been an earthquake. Newark's tenements shook, sending partly-clad residents into the streets, where they waiting until they were reasonably sure it was over. The Elizabeth waterfront seemed to have felt it more than the interior, and the rumbling noise seemed louder. Sandy Hook reported feeling it, but many thought at first it was an explosion in the munitions depot. It was only later that they realized it had been an earthquake.

While the physical damage to buildings and property was minimal, the psychological effect was worse on at least some. The *Evening Times* report told of the three daughters of Phillip Barnes, a gasfitter living on Lafayette Street in Elizabeth, springing from their beds and running in their nightdresses to a neighbor house, where one fainted on arrival. "It was only after the lapse of a considerable period of time," the article reported, "and after prolonged efforts and the application of restoratives by friends that she recovered consciousness." Reports out of Plainfield told of residents "seriously ill" from the effects of the quake.

The quake was felt primarily in New Jersey, Pennsylvania and New York. But, according to the USGS, the full extent was from Maine to Virginia, covering an elongated area of some 57,166 square miles. At first, the epicenter was believed to be near High Bridge, New Jersey, near the previously described Ramapo Fault system. But subsequent studies have moved it further down, near South Amboy.

The Jersey Shore, as we will see, was not immune to doing some shaking of its own.

1927

You might think it would be pretty straight forward to answer what the biggest New Jersey earthquake was. But, as we've seen, it depends on *how* you measure "big." In terms of magnitude, the 1783 event ranks at the top with a 5.3 on Mr. Richter's scale and an intensity of VI on the Modified Mercalli scale. But a curious event down the shore in 1927, while ranking only 3.9 in magnitude, comes in at a higher VII in intensity—"Very Strong."

As might be expected from these numbers, this appears to have been a far more localized event than the others, limited roughly to a fifty mile area between Toms River and Sandy Hook and centered around Asbury Park. It came in three distinct shocks on June 1, 1927. Seismographs at Fordham University recorded them at 8:23, 8:31 and 8:40 a.m., respectively.¹⁷

According to the Associated Press report, "[a]llmost every office building in the city [Asbury Park] was shaken, and in the basement of the Asbury Park Press, the first shock dislodged the heavy rolls of newsprint."¹⁸

Yet the U.S. Army base at Fort Hancock at Sandy Hook called it "slight," likely because they were on the outskirts of where it was felt. By contrast, Long Branch seven miles north of Asbury Park saw at least two chimneys come tumbling down and cracked plaster.¹⁹ The relative containment of the shaking and the sounds of a "dull thud" and "distant rolls of thunder" led some at first to think they were explosions. In fact, some experts didn't think it was even an earthquake—at least not of the tectonic variety. A "Director Tondorf," overseeing the seismographs at Georgetown University in Washington D.C., claimed his instruments recorded nothing and suggested it was a localized, if large, shifting of sand on the beach.²⁰

The USGS differs from Mr. Tondorf, however, and lists it as "[t]he highest intensity earthquake ever observed in New Jersey."²¹ Still, not everything that shakes is seismic in origins, leading the USGS to hedge their bets on at least one event. According to their website, "[o]n January 24, 1933, a sharp jolt was felt over central New Jersey from Lakehurst to Trenton. Although there is some doubt whether the shock was of seismic origin, the event was felt most strongly at Lakehurst, where people reported they were rolled out of bed (intensity V). Other people reported pictures shaken from walls. The shock was also felt at Bordentown, Burlington, Columbus, Englishtown, Freehold, Hightstown, New Egypt, Robbinsville, and White Horse."

1938

When an earthquake hit Osaka, Japan, on January 12, 1938, the news hit *The Trenton Evening Times* the same day. While a reader from 1783 would be amazed at how quickly the news travelled compared to that from Italy in the 18th century, they would be more familiar with the extent of the simple, one-line coverage: "An earthquake of considerable intensity rocked western Japan today, rattling houses, waking their sleeping inhabitants and causing many persons to rush in panic to the streets."²²

The Earth was particularly restless in Montana, underscoring just what a dynamic piece of real estate our planet can be. The next day they saw just two minor tremors, but those two tremors brought to the total number of quakes the state felt since the fall 1935 to an amazing 2,441.²³

Earthquake news was prominent in the January 24th edition of *The Trenton Evening Times*. Seismologist Reverend Daniel Linehan at Massachusetts' Weston College reported on that he detected a "very severe" earthquake 7,450 miles away "probably was in India or the Southwestern Pacific."²⁴ They also ran an article about Dr. and Mrs. David Raw of Trenton's East State Street, who while watching a bullfight in Mexico, experienced an earthquake. The piece sat next to an article recounting an earthquake that had rattled Hawaii, likely the result of volcanic activities.²⁵

When New Jersey's quake hit, on August 23, 1938 at magnitude 4.0, residents were alarmed by the sudden jolts that awoke them just after 5 that morning. According to the USGS, there were actually two events—a 3.8 at 3:36 a.m., epicentered northeast of New Egypt, NJ and then the 4.0 at 5:04 a.m. epicentered near Freehold.²⁶ Minor quakes followed for the next five days—many small enough that only the seismographs knew they had happened. But two around 6:30 p.m. on the 27th were strong enough that some feared a repeat performance.²⁷

"The earthquake caused minor damage at Gloucester City and Hightstown (intensity V)," summarized the USGS website. "The total felt area was about 13,000 square kilometers, including bordering portions of Delaware and Pennsylvania. Glassware was broken at Gloucester City and Hightstown and some furniture was displaced at Pitman. A few windows and some glassware were reported broken at Ardmore, Pennsylvania. Four smaller shocks occurred on August 23rd and one on August 27th."

The Trenton Evening Times took a rather laidback—if somewhat snarky—approach to the whole thing. It seems the same sort of rivalries that inspired the August 2011 mocking of the "damage" by west coasters was alive and well in 1938 too. The *Times* reporters found cause for some tongue-in-cheek east coast pride in the tremors felt in Trenton. "Now that it's over and there has not been too much damage," they wrote, "it provides quite a thrill for us to say that we took part in an earthquake, which, naturally, will give the Native Sons of California cause to grind their teeth in frustrated anger. Californians appear to have all the fun when it comes to fancy and assorted conditions in the department of air, sky and earth, but from now on any native of the Trenton section should have no hesitancy in traveling anywhere, especially to California. Nor will he have to hang his head in shame when anyone starts to say something about that big flood, or that temblor, or that landslide, for we, too, are very proud of our floods, our landslides and especially our temblors. This is a mental state of mind that may very well be transmitted to one's son or grandson with eminent results."²⁸

But lest *either* coast feel too special about their temblors (yes, that's a word), consider that in the time it took me to write this article (August 25th to 29th), over 300 quakes of varying magnitude and intensity were recorded by the USGS all over the world. And west coasters can call me a wimp if they want, but I for one am glad to live in a state where earthquakes are both small and rare!

Now...anyone want to talk about hurricanes?



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