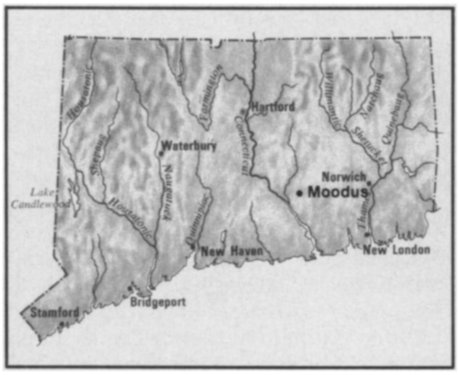
Sounds From the Ground

Geologists dig into the heart of the mystery known as the 'Moodus noises'

By RICHARD MONASTERSKY

When sudden booms or thunderous rumbles echo off the hills of Moodus, the residents of this small south-central Connecticut town seldom dive for cover. It's just another one of the "Moodus noises" – created by the small, shallow earthquakes that have frequented the area for at least 300 years and perhaps much longer. But while modern Moodus residents may be more or less unimpressed with these sounds from beneath, the quakes that create the noises have captured the attention of earth scientists from around the United States.



Since 1979, when Boston College's Weston Observatory established a network of seismometers near Moodus, this area has hosted four swarms of dish-rattling earthquakes that peaked at about magnitude 2.5 and lasted up to several months long. Each swarm consisted of hundreds of tiny earthquakes, all originating from a small spot in the earth's crust near the north end of town.

"The mystery is: Why are these earthquakes occurring there?" says seismologist John Ebel of the Weston Observatory. "Most areas in the eastern United States that we watch seismically don't seem to have such a persistent earthquake activity centered in one very small locality as Moodus does."

The quest to understand the Moodus quakes has drawn together researchers from many branches of the earth sciences, who met to discuss their work at a recent all-day symposium of the American Geophysical Union in Baltimore. Studying the area from the surface, geologists have mapped out the faults and folds that tell the history of the earth's crust around Moodus. Seismologists have peered into the subsurface through measurements of the ground's motion during earthquakes.

The Moodus quakes have also interested companies that run electric power plants in New York and Connecticut – including one nuclear facility located in Haddam, Conn., only 20 miles from Moodus. In an effort to assess the potential for large earthquakes in the area, these utilities funded the drilling last year of a 1.5-kilometer-deep hole close to the earthquake epicenters.

Yet, despite of all the information they have gathered, scientists remain puzzled. Says Ebel, "I think the sum total of all the evidence is that it's not entirely clear why the earthquakes are occurring there, why there aren't other areas like this a few miles away."

Experiments in the borehole are revealing the crustal forces beneath Moodus related to the earthquakes, and in the process they are correcting some earlier ideas about the geologic stress in this area. Earlier, less reliable studies in shallower boreholes had suggested that the crust of Moodus differed markedly from most areas east of the Rockies. In the midcontinent and East, tectonic forces are squeezing the crust principally along an axis that runs essentially east-west. Yet the stress in Moodus seemed to point along a northwest-trending axis.

Studies in the new, deeper borehole apparently have resolved this conflict. They indicate that the stress in Moodus does indeed run in the normal east-west direction, says Tom Statton of Woodward-Clyde Consultants in Wayne, N.J., which supervised the borehole project.

As if on cue, the most recent earthquake swarm started in September of 1987, only a month after researchers ended the borehole stress experiments. While the quakes continued, Woodward-Clyde obtained funds to set up a network of eight seismometers, placed within a kilometer of the borehole. They found that during the earthquakes, subsurface rocks broke along north-south fractures. This pattern suggests that the stress producing the earthquakes pointed in the direction indicated by the borehole tests.

The network also told researchers the earthquake centers are quite concentrated. All the seismic energy emanated from a small plot of crust – a sphere with a radius of one-quarter kilometer and centered at a depth of 1.5 km, says Statton.

Putting all this together, scientists can tell where the earthquakes are occurring and how the rocks are moving below ground. But one big problem remains: They can't link the rock movement to any known fault in the area.

By mapping the surface geology, scientists located the major faults that dominate this part of Connecticut. In fact, the borehole intersects one of these old, large structures, the Honey Hill fault, which is visible at the surface farther to the south. Yet this fault faces the wrong direction to account for the motions measured in Moodus, says David London, a geologist at the University of Oklahoma in Norman, who has mapped the region.

Other known faults also fail the test. "We have not identified any fault that we confidently feel is moving in the modern earthquakes," Ebel says.

Part of the problem is that the fractures driving the Moodus earthquakes never reach the surface. In this respect, Moodus behaves as its geologic neighbors do. "In eastern North America, there has never been a documented case of an earthquake breaking the surface," says Shelton S. Alexander of Pennsylvania State University in University Park. This stands in contrast to the West, where faults, like the well-known San Andreas, often rupture the surface.

The fractures behind the Moodus earthquakes are small, probably a few hundred meters at most in length, Ebel says. They could be isolated ruptures on an older fault that has moved in the past, or they could be new breaks that do not fit

Anatomy of the Moodus noises

This sometimes quiet site near the Connecticut River owes its modern name to the Wangunk Indians, who called it Machemoodus, or "place of noises." For generations before the arrival of the first colonists in 1670, the tribe gathered for powwows in the presence of the "terrible roarings of the atmosphere," according to a historian writing in the 1800s. In one Wangunk myth, an angry god created the sounds by blowing air out of a cave on nearby Mount Tom, says Alison Guiness, a Moodus-area resident who has researched the history of the noises.

The first written account of the noises, which dates to 1702, demonstrates that the early colonists clearly associated the sounds with activity underfoot. Through the centuries, scientists at local universities have invoked a number of mechanisms to explain the noises, from exploding subsurface minerals to electrical currents deep in the ground.

Sometimes silent for decades, the audible earthquakes seem to come in clusters, says Guiness. "They were very inactive after the 1940s, and then since 1981 they've been going like gangbusters."

Depending on their size and depth, they can sound like pistol shots or like heavy trucks passing nearby. Cathy Wilson, who lives in the north end of Moodus near the epicenters of the current quakes, has kept detailed notes of the sounds for the last decade to help seismologists. "It's kind of like a thunder feeling, except that it's not above your head, it's below your feet," she says of the noise. "If it's a good-enough-sized one, you can feel the actual vibrations. If it's a big one, it's like you got hit on the bottom of your feet with a sledgehammer."

All earthquakes generate a spectrum of seismic waves that can range in length from meters to hundreds of kilometers. When these waves reach the ground surface, most of the wave energy reflects back into the earth, but some can pass from ground to air, creating compressional waves of sound. The shorter-length seismic waves are the ones that produce sounds audible to humans; but because the ground quickly absorbs these kinds of seismic waves, deep earthquakes are generally less noisy.

"The Moodus noises are not a unique occurrence, but they're certainly not routine," says geologist Tom Statton. Large earthquakes are often audible, and small earthquakes have created sounds in other areas such as Annsville, N.Y., in the early 1980s. "What may be unique about Moodus is that very small sounds are audible," Statton says.

According to seismologist John Ebel, earthquakes as small as magnitude -2 generate booms in Moodus. (Magnitudes are based on a logarithmic scale, so a magnitude -2 is a hundred times weaker than a magnitude 0 quake in terms of ground shaking.) At around magnitude 1, the ground-shaking becomes noticeable.

The very small Moodus quakes are audible because they are quite shallow and there is good coupling between the ground and the atmosphere, says Statton. For reasons not entirely clear, sound passes relatively freely between the ground and the air in Moodus – a characteristic of a few other locations as well. While working with seismometers along the Gulf Coast, Statton found that thunder could shake the ground to such an extent that it looked almost like an earthquake on the seismogram.

These days, the Moodus noises are taking a back seat in scientific circles while geologists focus their studies on the earthquakes themselves. Says Ebel with an air of 20th-century rationalism, "As far as the noises are concerned, there is no mystery."

– R. Monastersky

on any major fault. The distinction is important because scientists use fault length to estimate the size of possible future earthquakes. "If we can't identify the fault, we have no idea about what the maximum-size earthquake could be," says Ebel.

"Moodus is part of a larger problem that we're coming to grips with, and that is that it's very difficult to identify the active structures," he adds. Earth scientists once believed it would be easy to pinpoint which faults move during an earthquake. In areas such as the East, however, the visible surface faults are not related to the modern quakes. "Moodus is probably a shining example of how difficult that problem is," says Ebel.

This realization comes during a time when geoscientists are paying more attention than ever to the possibility of large eastern quakes. For years, seismologists concerned with earthquake hazards in the East had focused their attention on Charleston, S.C., and a few other areas such as Cape Ann, Mass., and the Charlevoix region along the St. Lawrence River. These spots have hosted the seaboard's greatest temblors, and it was assumed that there was something unique about the crust there that made them more prone to large quakes.

In the early 1980s, however, the U.S. Geological Survey circulated a letter warning that a Charleston-type quake, estimated at magnitude 7, could occur at other locations in the East. Since then, geologists have attempted to locate the most likely sites for large future earthquakes in the East.

Moodus is capturing scientists' attention right now because of its current activity, albeit on a microseismic level. Moreover, the earlier borehole measurements had suggested that this area might be an anomaly in the stress maps of the East. But researchers have found no indications that this area will host a large quake, Statton says.

While Moodus has been rumbling for hundreds of years, it is only in the last 10 years that scientists have gathered high-quality seismic data on the region. This makes it difficult to determine the location of the historical earthquakes.

"It may be that not one, but a whole series of patches have been active. And different patches may become active at different times," says Ebel. If the present patch has only been active for 10 years – a relatively short time span by seismic standards – there wouldn't be much of a mystery to the Moodus earthquakes.

Yet Ebel says there is reason to believe that this one spot may have generated quakes for at least several decades. Some Moodus earthquakes in the 1940s and the 1960s were large enough to register on seismographs in Weston, which indicated that the quakes were quite shallow, from about the same depth as the present events. If one small area produced this 40-year span of episodic activity, Moodus would present a difficult situation for scientists to explain, says Ebel.

Others think Moodus may only seem unusual because seismologists have been monitoring it more closely than other areas. "It may be an observational anomaly, not a physical one," Statton says.

More geophysical measurements in the area might help resolve what is going on beneath Moodus. Continued monitoring with seismometers would also provide valuable information, especially if nature cooperated by starting another swarm of earthquakes. But research funds are tight, and there are many other areas to study in the East.

After finishing work at the borehole, the utility-sponsored scientists have sent their equipment elsewhere. The U.S. Nuclear Regulatory Commission, which sponsors the Weston Observatory's seismic network, plans to terminate the program as of April 1990.

So the current flare of scientific interest begins to fade, and the claim-to-fame of this old New England town remains a question mark, waiting for some future geologists who may attempt, once more, to explain the Moodus earthquakes. ☐