Earth Science

The relaxed style of western quakes

The West Coast's laid-back lifestyle apparently extends even to its earthquakes. Three seismologists proposed last week that quakes west of the Rocky Mountains are significantly less stressful than their counterparts in eastern North America.

Seismologists have long known that seismic waves travel much farther in the East than they do through the heavily faulted crust in the West. Many researchers therefore suspected that eastern quakes would damage larger areas, but reports in the last year questioned that presumption.

So, Gilbert A. Bollinger and his colleagues at the Virginia Polytechnic Institute and State University in Blacksburg compared damage from 100 western and 40 eastern earthquakes ranging from magnitude 5 to magnitude 7. At a Geological Society of America meeting in Harrisburg, Pa., they reported that damage from eastern earthquakes spreads twice as far as damage from shocks of similar magnitude in the West.

To explain the difference in damage, the group proposes that eastern faults release about twice as much stress during earthquakes as do western ones – an idea that runs counter to conventional seismological wisdom. They also suggest sediment layers in the East may amplify seismic shaking more than western sediments do.

Searching for signs of an eastern killer

In 1886, an earthquake leveled parts of Charleston, S.C., killing some 60 people. Geological investigations in recent years have shown that this quake – estimated at magnitude 7.5 – was not the first large shock to hit the Charleston region. Although no historical records exist for these previous quakes, they left behind telltale clues in the soil of the area.

Geologists with Ebasco Services in Greensboro, N.C., have now gone to other eastern regions looking for the same buried evidence of prehistoric shaking. The researchers looked for ancient signs of liquefaction – a process that occurs when strong vibrations weaken water-saturated sediments, turning them into something resembling a liquid. Liquefaction occurs during quakes of magnitude 5.8 or more.

Heading out from Charleston, Kerry D. Cato and his colleagues first focused their attention on the region about 100 kilometers to the northwest, near Bowman, S.C. This area has hosted very small earthquakes in the last few decades, and some researchers think that the fault responsible for the Charleston earthquake may continue inland toward Bowman. The Ebasco geologists, however, found no evidence of prehistoric liquefaction, they reported last month at a Geological Society of America meeting in Winston-Salem, N.C.

Farther inland, in the foothills of the Appalachians, Cato and co-workers found no signs of liquefaction near Union, S.C., site of a magnitude 4.8 earthquake in 1913. By carbon dating the sediments, the researchers determined that no earthquake above 5.8 had occurred in the region in the last 2,000 years. Their results suggest that in the East, areas currently rattled by low-level seismic activity were not hit by large earthquakes in the recent past. Researchers looking for evidence of strong prehistoric shocks may have to broaden their search to include areas now quiet, Cato says.

Eastern California rattled by swarm

For the last six weeks, a prolonged series of small earthquakes has shaken the area around Coco Junction, Calif., southeast of Sequoia National Park. The seismic swarm – whose largest event measured magnitude 4.1 – may result from the movement of heated groundwater through the region, says Thomas H. Heaton of the U.S. Geological Survey in Pasadena. Seismologists cannot tell whether larger earthquakes are likely to occur, though the swarm appeared to quiet down last week.

Physics

Ivars Peterson reports from Indianapolis at an American Physical Society meeting

Quantum dot to dot

Squeezing electrons into specially fabricated, microscopic "boxes" can have a drastic effect on their behavior. At such small dimensions, quantum effects become important, and the confined electrons exhibit a variety of properties unlike those of mobile electrons in a metal. Moreover, these electron boxes, or "quantum dots," are so small that electrical currents through them can no longer be treated as continuous flows of charge.

"You see new effects that people didn't think of before, and you try to understand them," says theorist Yigal Meir of the University of California, Santa Barbara. In addition, "You can check the predictions of quantum mechanics."

Researchers create quantum dots by building semiconductor structures that confine electrons to a volume only a few nanometers across. Because these structures have dimensions comparable to wavelengths typically associated with electrons in semiconductors, electrons trapped in a quantum dot can exist only in a handful of specific quantum states that depend on the shape of the dot's boundaries. In a sense, they start behaving like electrons bound to an atomic nucleus.

The existence of discrete energy levels means that the addition or subtraction of even a single electron markedly alters a quantum dot's characteristic energy spectrum. Moreover, the precise number of electrons occupying a quantum dot strongly affects the transport of electrons through the dot. For example, at sufficiently low temperatures (near 1 kelvin), adding one electron to a quantum dot can change the current allowed through by a factor of at least 100. This effect can be used to construct an extremely sensitive transistor capable of switching surprisingly large currents on or off.

. . . to capacitor

Raymond C. Ashoori of AT&T Bell Laboratories in Murray Hill, N.J., and his co-workers have developed an extraordinarily sensitive technique for probing a single quantum dot to observe what distinct and different energy levels an electron can occupy. This new type of spectroscopy relies on the tiny signal generated when single electrons tunnel between a metallic layer and a quantum dot built into gallium arsenide. In effect, the quantum dot acts as a miniature capacitor – a device for storing electrical energy.

Because electron tunneling into the dot occurs only for particular values of a voltage applied across the device, the researchers can deduce the energy required for adding successive electrons to an initially vacant quantum dot. The sequence of peaks seen at these voltages reflects the quantum dot's electronic spectrum, Ashoori says.

. . . to turnstile

Leo P. Kouwenhoven of the Delft University of Technology in the Netherlands and his collaborators have created an ingenious quantum-dot device that packages electrical current into bundles of a certain number of electrons each. Constructed by putting metal "gates," or barriers, at the entrance and exit to a quantum dot fabricated at the boundary between layers of gallium arsenide and aluminum gallium arsenide, the device acts as a turnstile. An oscillating voltage alternately raises and lowers the barriers so that one is down when the other is up. This permits a certain number of electrons to tunnel into, then out of, the quantum dot during each cycle. By selecting the appropriate frequency, researchers can specify the number of electrons in each bundle.

Such a device for counting electrons may serve as a means of setting a standard for the measurement of electrical current. Thus, an ampere – the fundamental unit of electrical current – could be defined directly as the passage of a certain number of elementary charges per second.