

tions are produced by the withdrawal of steam for electric power production and the injection of steam condensate back into the ground.

If the Geysers quakes are manmade, notes David Oppenheimer of the USGS in Menlo Park, they should not be connected with a TIP. They could not be induced by the buildup of strain at Loma Prieta, but conversely, given conventional views of how the crust behaves, it is unreasonable to suggest they helped trigger the distant earthquake.

Matthews' discovery is not a fatal flaw in M8: Two overlapping TIP regions both predicted the Loma Prieta earthquake. But it's the kind of problem most skeptics feel the Soviets haven't done a very good job of explaining.

Both American and Soviet researchers agree that to prove the usefulness of the prediction method, it will have to forecast more earthquakes successfully. Healy, in cooperation with Keilis-Borok and his group, is setting up a version of M8 at Menlo Park that

will never be altered as it cranks out forecasts of earthquakes around the Pacific rim. Then it will be a question of time, probably 5 to 10 years, until matters of style become irrelevant and unassailable results decide whether a broad view of earthquakes really works.

■ RICHARD A. KERR

ADDITIONAL READING

V. I. Keilis-Borok *et al.*, "Intermediate-term prediction in advance of the Loma Prieta earthquake," *Geophys. Res. Letts.* 17, 1461 (1990).

Radioastronomers Seek a Clear Line to the Stars

The chatter of voices and data beamed to Earth from communications and surveillance satellites is beginning to drown out whispers from the cosmos, radioastronomers say. Navigational satellites such as the United States' Navstar and the Soviets' Glonass—as well as radio broadcasts, airplane telephones, and even taxi dispatches—have been interfering with radio signals from distant galaxies. And radioastronomers expect the problem to get worse. The chief reason: since the mid 1980s it has become easier and cheaper to make equipment that transmits radio waves at frequencies of interest to astronomers.

There are, however, two recent indications that the astronomers' concerns are being heard. Scientists struggling to protect threatened radio space have persuaded at least two encroaching organizations, the U.S. Customs Service and Motorola Communications Inc., to back off.

Motorola could have created a major new headache in 1994 with its planned launch of Iridium, a communications network of 77 satellites that will connect people with cellular phones who live or work in remote areas untouched by existing cellular phone networks. Lawrence Moore, a public affairs officer with Motorola's Government Electronics Group, said the company is seeking approval from the Federal Communications Commission to operate the Iridium network at frequencies ranging from 1610 to 1626.5 megahertz. Unchecked broadcasts in this range, astronomers say, would interfere with the radio waves emitted by hydroxyl radicals—electrically charged molecules that signal the presence of hydrogen and oxygen, and, potentially, developmental shifts in the formation of stars. Astronomers detect the spectral lines of hydroxyl radicals in four bandwidths, one of which falls between 1610.6 and 1613.8 MHz.

After learning of astronomers' concerns, however, Motorola is modifying its satellite. Company scientists, Moore said, aim to program the Iridium system to switch bandwidths whenever the satellites come within range of a sensitive radioastronomy antenna.

"Legally they don't have to do this, but morally they probably feel like they should," said A. Richard Thompson, a radioastronomer at the National Radio Astronomy Observatory (NRAO) in Charlottesville, Virginia. Thompson and Tomas E. Gergely of the National Science Foundation negotiated with Motorola to preserve researchers' access to stellar radio waves. The astronomers had no legal leverage because the FCC is poised

to give Motorola primary user status, entitling it to exclusive use of this frequency band, while radioastronomy would be relegated to secondary status. However, a footnote in the International Telecommunications Union regulations states that primary users should try to "take all practicable steps to protect the radioastronomy service from harmful interference."

Similar problems arose recently with transmitters belonging to the U.S. Customs Service. Since the mid 1980s, Customs has installed six "aerostat" surveillance balloons around the southern perimeter of the continental United States to watch for small planes that may be smuggling drugs across the border. The aerostats, tethered helium-filled blimps that hover about 10,000 feet in the air, transmit radio waves in the 1215 to 1350 MHz range.

It is in this range, however, that radioastronomers detect atomic hydrogen spectra emitted by distant galaxies whose radio waves are greatly red-shifted. Some of the farthest galaxies from the Milky Way are detected by atomic hydrogen spectra in the low 1300s MHz, Thompson said, and "these spectra have been enormously important for mapping out the structure of galaxies."

Recently, radioastronomers were concerned that interference from the SOWRBALL aerostat, located above Fort Huachuca, Arizona, might interfere with their observations at Kitt Peak. However, they discussed the problem with Customs officials before SOWRBALL was deployed and agreed that whenever its swivelling radar pointed toward the telescope, the signal would be cut off, unless the radar was tracking a plane. On the other hand, according to NRAO scientist Pat Crane, an aerostat above Marfa, Texas is close enough to a research antenna in Fort Davis that the radioastronomers there must use a special filter to "clean up" the signal they get from space.

Despite these compromises, Thompson foresees a future in which an increasing demand for the radio waves erodes the ability of radioastronomers to collect data. Said Thompson, "We're just trying to preserve useful frequencies for as long as we can." Over the long term, astronomers fear their prospects for halting the spread of commercial transmissions are about good as King Canute's in the 11th century, when he set his throne on the beach and commanded the tide to withdraw. ■ RICHARD STONE

Richard Stone is in the science writing program at the University of California, Santa Cruz.

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—RICHARD THOMPSON