reactors to determine whether some of them are oscillating into undetectable muon antineutrinos. "It's an amazing coincidence that Kamioka is just the right distance from these reactors" for the oscillations to show up if neutrinos do indeed have mass, says Stuart Freedman, a physicist at Lawrence Berkeley National Laboratory in California and one of the U.S. spokespersons for the collaboration.

Evidence of oscillations may shed light on the solar neutrino deficit. The current favorite explanation for the deficit is that the missing solar neutrinos, on their way to Earth, are oscillating into flavors not seen by the detectors. But theorists have four different scenarios for how this might happen. Suzuki says that KamLAND will be able to investigate all four, using the reactor neutrinos for one and its observations of solar neutrinos to examine the others. KamLAND also will be sensitive to critical neutrino energies that have eluded previous detectors.

In addition, KamLAND will be looking downward at Earth's own internal processes. The decay of radioactive isotopes of uranium and thorium is one of the major sources of Earth's internally generated heat, but nobody knows just how much heat this source produces or how the uranium and thorium are distributed within the crust and mantle. Fortunately, the low-energy antineutrinos generated by this decay fall within KamLAND's range of sensitivity, and their signature can be distinguished from reactor antineutrinos. By tracking neutrinos coming from the deep Earth to their origins, investigators hope to get a better fix on the nature and location of the planet's internal heat source.

Suzuki expects KamLAND to yield most of its useful data within the first few years, although the experiment is capable of running for a decade or longer. If it succeeds, it will add another link to the chain that connects neutrinos with nuclear reactors.

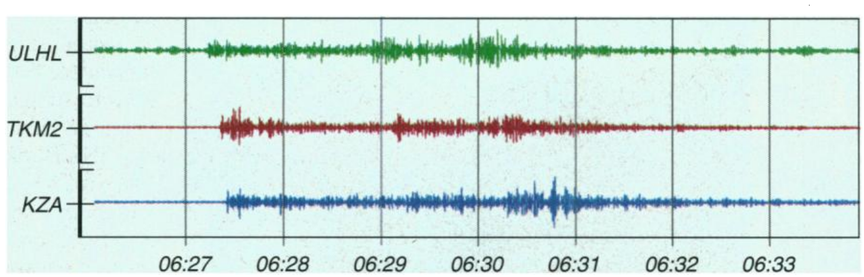
–DENNIS NORMILE

CENTRAL ASIA

Survival Test for Geophysics Center

In the mountains of Kyrgyzstan, a research station that monitors earthquakes and nuclear tests faces an uncertain future

BISHKEK, KYRGYZSTAN—When the ground trembled beneath the Lop Nor nuclear test site in western China on 27 January, the shock waves lit up a string of sensors in Central Asia and jolted an international scientific network to life. Within seconds the recordings were uploaded to a Russian satellite and sent via the Internet halfway around the world to the United States, where analysts began decoding the seismic signatures. Did China resume nuclear testing after signing the Comprehensive Test Ban Treaty in 1996, 2 months after its last blast? Or was the power unleashed by a natural event: an earthquake or a meteorite strike, perhaps? The answer was important to security and diplomacy—even before allegations of espionage in U.S. weapons labs suggested that China has acquired knowledge to upgrade its nuclear arsenal.



Quake, not nuke. The three KNET stations nearest China's Lop Nor test site recorded these signals on 27 January and transmitted them to the United States in a matter of seconds.

Thanks to 10 sensors in mountainous Kyrgyzstan, one of 15 countries created after the breakup of the Soviet Union, scientists were able to determine quickly that the event was an earthquake measuring 3.9 on the Richter scale. The seismic patterns recorded by the network, about 1200 kilometers west of Lop Nor, "provided essential information for detecting and discriminating the earthquake," says Frank Vernon, a research seismologist at the University of California, San Diego, who oversees the Kyrgyz Broadband Seismic Network (KNET). The nonclassified data helped reassure treaty-monitoring agencies that they weren't seeing an encore to last year's Indian and Pakistani nuclear tests, which KNET tracked as well.

But, in spite of such successes, the seismic sentinel faces an uncertain future. KNET is currently operating with stopgap funds from the U.S. State Department, which run out on 1 July. A proposal to maintain KNET is pending at the U.S. Civilian Research and Development Foundation (CRDF), a nonprofit in Arlington, Virginia. And the array is not the only important geophysics facility in Kyrgyzstan that's in jeopardy. When the U.S. government stepped in last year to prop up KNET, it also helped set up an International Geodynamics Research Center (IGRC), based at a Russian field station outside Bishkek, the Kyrgyz capital. Initial funding for the center is also drying up. Now, geophysicists are waiting to hear whether the U.S. National Science Foundation (NSF) or other agencies will ante up funds to help keep the center afloat.

Geophysicists who study the rapid mountain building in the mighty Tien Shan range, which dominates Kyrgyzstan and spills into neighboring countries, have a big stake in the outcome of these two funding decisions. The seismic network churns out a wealth of data for research as well as treaty monitoring, and Western researchers say the center provides an invaluable base to study a region where the crust is deforming at an intriguingly fast rate because of stresses generated as India plows into Asia. "This is a pretty exciting part of the world," says David Simpson, president of IRIS, a Washington, D.C.–based consortium of universities involved in seismological research. "They have magnitude 6 [earthquakes] like California has magnitude 3's," says Steve Roecker, a geophysicist at Rensselaer Polytechnic Institute in Troy, New York. If the funding for either facility ends, says Vernon, "I am afraid that the earth science community will lose a valuable resource which, once lost, cannot be resurrected."

The fact that there are valuable research resources at all in Kyrgyzstan owes a lot to a Russian geophysicist named Yuri Trapeznikov. In 1978 Trapeznikov, of the Institute of High Temperatures (IVTAN) in Moscow, was tapped to open a field station in Bishkek to study rock layers in the Tien Shan using a device called a magnetohydrodynamic generator. Developed at a Soviet military institute, the machine shoots huge bolts of current into the ground that can travel tens of kilometers through the crust to receiving instruments. Changes in electrical resistance give clues to the forces compressing the rock layers. "IVTAN is a world leader" in these sorts of measurements, says Vernon.

CREDIT: J. EAKINS, C. GEDDES, F. VERNON/IGPP/UCSD

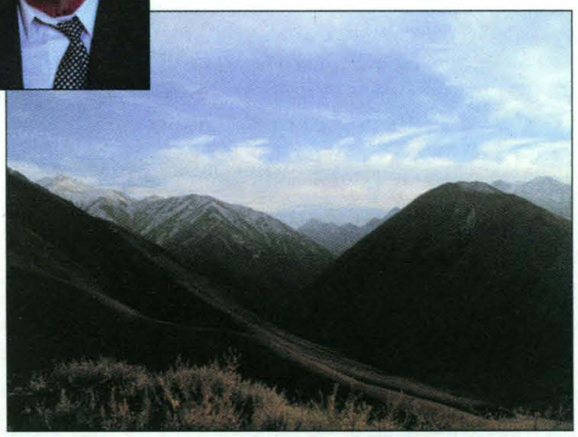
Trapeznikov, a hulking figure with a slight stoop and a booming baritone, ran IVTAN's Bishkek Proving Grounds until he died from a heart attack in April. Colleagues credit him with creating a bastion of solid scientific expertise. "He had a talent for raising research personnel," like one raises a family, says Gennady Schelochkov, IVTAN's deputy director. Indeed, Trapeznikov told *Science* in an interview last winter, presiding over a research fiefdom in the hills above Bishkek suited him well. "As a child I dreamed of becoming the chief of a collective farm," he said. "I think my dream came true. Here we had everything necessary—it was like a collective farm."

Trapeznikov managed to sustain a thriving program for a time after the Soviet Union dissolved. First he and Vladimir Zeigarnik, executive director of IVTAN Association in Moscow, pulled off a political coup: They helped persuade Kyrgyz officials to let Russia retain the field station. And Zeigarnik kept funds flowing so the Bishkek outfit could pull its weight in international collaborations. When the U.S. government sent Global Positioning System equipment to the Kyrgyz highlands in 1993, for example, a phalanx of IVTAN trucks and staff carried out the installation at 85 sites. But the crumbling Russian economy eroded the station's resources to the point that Western researchers over the last few years have started to pay the lion's share of expenses for joint projects.

The IVTAN field station's plight caught the attention of Askar Akayev, president of Kyrgyzstan. A physicist and former president of the Kyrgyz Academy of Sciences, Akayev in 1995 sent letters to U.S. Vice President Al Gore and Viktor Chernomyrdin, then Russia's prime minister, suggesting that an international center be established at the Bishkek Proving Grounds. Akayev foresaw that a center would "raise the profile of Kyrgyz science very much," says Tynymbek Ormonbekov, science chair at Kyrgyzstan's Ministry of Education, Science, and Culture. But the idea languished until July 1997, when Akayev met Gore in Washington, D.C. This time more was at stake: Funding for KNET, deployed 6 years earlier, was drying up.

The Soviet Union had invited the United States to set up KNET and a network in the Caucasus mountains after a devastating earthquake in Armenia in 1989. Political instability in the Caucasus doomed that network before it was deployed, but KNET got off the ground thanks to funds from NSF and the U.S. Department of Defense. The idea was that IRIS, which managed the project, would install the sensors—which can detect seismic waves ranging in frequency from 0.008 to 50 Hertz—and leave them to the Kyrgyz Institute of Seismology to maintain, as it was in the country's interest to monitor earthquake hazards, says Simpson. But with the Kyrgyz economy languishing, the seismic array by 1997 seemed destined to deteriorate.

After his meeting with Akayev, Gore instructed the State Department to find a way to give both KNET and IGRC a 1-year lease on life, with the hope that the Kyrgyz government would rally continuing support. State officials farmed the job out to CRDF, which supports mostly former Soviet weapons scientists and has a system for transferring funds to Central Asia. By March 1998, an agreement was in place in which CRDF would transfer $150,000 to maintain KNET for 1 year (much of the expense goes to renting helicopters and other vehicles to service the remote sensors) and $100,000 to launch IGRC. The Russians kicked in $50,000 and the Kyrgyz $5000. Last year, KNET ran 99% of the time and lost less than 3% of recorded data. "There are no seismic networks in the United States that can approach these data returns," says Vernon.



Unstable ground. Yuri Trapeznikov's geophysics bastion, overlooking the Kyrgyz range, is hoping for an infusion of Western cash.

Meanwhile, Western scientists who have set up collaborations with the IGRC are thrilled to have a base in this corner of the world. "This is the best place to study intracontinental deformation," says Roecker. He's part of a team led by Brad Hager, a geophysicist at the Massachusetts Institute of Technology, that's in the middle of a 5-year NSF grant to explore mountain building in the Tien Shan. Already the team, which includes Kyrgyz collaborators, has made a surprising finding: The area encompassing the mountains is compressing 20 millimeters a year—that is, the land south of the mountains is squeezing up against the land to the north, thrusting the Tien Shan higher—about twice as fast as earlier estimates. The deformation rate suggests that the Tien Shan range is about 10 million years old, corroborating the idea that the Tibetan Plateau rapidly rose as much as 2.5 kilometers some 5 million to 10 million years ago—a phenomenon that would have perturbed air circulation patterns, perhaps strengthening the monsoon.

The findings also suggest that millions of people are sitting on a powder keg. Central Asia has endured some devastating earthquakes, including one in 1966 that leveled Tashkent, the capital of Uzbekistan. In the 1800s two magnitude 8 temblors shook the Tien Shan, and three more struck between 1902 and 1911. The historical record and the high deformation rate, the researchers say, indicate that the Tien Shan is primed for an imminent major earthquake.

U.S. scientists say their colleagues in Bishkek are critical to keeping an eye on the situation. "For a Western team to make similar-quality measurements, they would have to live in Kyrgyzstan, speak the languages fluently, understand the local culture, and be able to work within the regional political systems," says Vernon. That's "a nearly impossible order in my experience." Instead, westerners can draw on local researchers—for a fraction of the cost of sending additional staff to Central Asia. "They are a great source of cheap labor and expertise," says Roecker.

Indeed, Hager's group finds the IGRC so valuable that it plans to seek funds from NSF to support the center. Without this support, Zeigarnik, who will manage IVTAN's Bishkek branch and IGRC from Moscow, foresees "a remarkable narrowing of our research activities." Meanwhile, a decision on the CRDF funding for the seismic network is expected in the next few weeks. For KNET, it's all or nothing. If the grant doesn't come through, says Vernon, "there are no contingency plans. So we have to hope for the best."

Even if money materializes, the scientists at IVTAN and IGRC know they face a daunting challenge in preserving Trapeznikov's legacy. Hager represented his Western colleagues at a memorial service for the dynamic former director in Bishkek last month. He says he encountered three strong emotions from the local researchers: sadness at the loss of their leader, determination to continue his dream, and fear. "I felt from them a sense of the jitters," says Hager. "They seem scared of the awful big job ahead." But they are resolved to see it through. —**RICHARD STONE**

CREDITS: MUTSUMI STONE