

Advances are also helping companies after they locate oil. Three-dimensional seismic imaging has improved the mapping of fields, and whereas engineers once bored only vertically through Earth's crust, they now can steer their drilling, even horizontally.

In its 1998 International Energy Outlook, the U.S. Energy Information Administration concluded that "technologies continue to evolve that significantly enhance both exploration and production capabilities." It does not forecast production to peak during the time frame of its analysis, which runs to 2020.

Economist Morris Adelman of the Massachusetts Institute of Technology challenges the practice of estimating oil reserves. "Nobody knows how much hydrocarbon exists or what percentage of that will be recoverable," he says.

Judging from the histories of other geologic commodities, Adelman sees reasons to expect an increasing petroleum supply. "The tendency to deplete [a resource] is counteracted by increases in knowledge," he says. —R. *Monastersky*

Big shocks push volcanoes over the edge

Earthquakes and volcanoes are alike in at least one way: They cluster along the margins where tectonic plates grate against each other as they move across the planet. Yet scientists have had little evidence that one earth-shaking event can trigger the other. Now, Alan T. Linde and I. Selwyn Sacks of the Carnegie Institution of Washington (D.C.) say that some of the world's most powerful quakes seem to set off volcanic eruptions.

A handful of researchers previously have tried to link individual shocks and eruptions, but "you could never be sure they weren't just coincidences," Linde says. There is one link between a quake and a volcano that everyone agrees was no coincidence, and it caught Linde's eye.

In 1992, a magnitude 7.5 earthquake near Landers, Calif., triggered knots of activity far away. It set off rumbling under Long Valley, a collapsed volcano 400 kilometers to the north. The valley shuddered hundreds of times a day. What's more, sen-

sitive instruments detected swelling of the pool of magma stewing below the surface.

Long Valley did not erupt, but a question burned in Linde's mind. "Suppose the Long Valley system had been poised, just ready to go," he says. "Could this type of thing be the trigger that tips it over the edge?"

To see whether past earthquakes had ever pushed volcanoes over the brink, Linde and Sacks scoured global records dating back as far as the 1500s. They chose earthquakes greater than magnitude 7.0 and volcanoes for which the eruption start date was known.

The geophysicists reported in the Oct. 29 *NATURE* that 8 of the study's 204 earthquakes of magnitude 8.0 or greater seemed to trigger same-day eruptions within 750 km. Altogether, 11 volcanoes blew their tops on the same day as these big quakes, but only 5 or fewer erupted on any of the 1,000 days before or after.

"If that's not just a fluke, it means earthquakes can cause things to happen at a distance where the shaking can't even be felt," says David D. Jackson of the University of California, Los Angeles.

To test the strength of the finding, Linde and Sacks randomly selected dates before or after each of the earthquakes and then recorded the number of eruptions on these dates. In 100,000 trials, only once did even eight eruptions cluster on one of the random dates. The chance of coincidentally having 11 eruptions, as in the historical data, is "terribly, terribly teeny," Linde says.

Jackson points out that the study's parameters limited the possible outcomes. If they had chosen a hypothesis that included different magnitude cutoffs or different time intervals, he says, the results might have been different.

Even Linde says that scientists won't be using earthquakes to predict eruptions any time soon. "You need a coincidence of physics," Linde says. "[The volcano] must be sitting and waiting to erupt for the earthquake to trigger anything."

Although a triggering effect is rare, "this is another tool for looking into how volcanoes prepare for eruption," Linde says. "The more you know about the physics of the volcanic system, the better you can tell what's going on."

Eruptions aren't the whole story, he adds. "There are probably a lot more like the Long Valley case, where the earthquake goes off and there's no eruption, but there is some flurry of activity at the volcano."

Few volcanoes, however, are monitored well enough to detect the kind of small changes seen in Long Valley's magma chamber. Such monitoring is bound to catch on, Linde says. "Just a couple of weeks ago, we put our first strainmeter on the slopes of Vesuvius, and we're hoping to get them on Etna and Mauna Loa as well." —S. *Simpson*

Blood, semen harbor distinct HIV mutations

Research on AIDS has hinted that HIV can evolve along distinct lines in an infected man's blood and semen. Studies also have shown that the virus mutates in ways that make it resistant to some drugs. U.S. and Swiss researchers now report findings that combine these concepts: Genetic mutations sometimes lead to different patterns of drug resistance in a man's blood and semen.

The scientists find, for example, that viral mutations providing resistance to anti-HIV drugs emerge in the blood but not the semen of some men, that the opposite also occurs, and that sometimes two distinct mutations bestowing resistance against the same drug arise in the different locations in the same man. They report this compartmentalization of HIV mutations in the Oct. 22 journal *AIDS*.

The drug-resistant HIV probably derives from a mutated virus that survived the drugs that killed off the main viral population, says Ann A. Kiessling, a virologist at Harvard Medical School and Beth Israel Deaconess Medical Center in Boston. In a study released last year, Kiessling and her colleagues analyzed semen and blood from an HIV-positive man who had taken antiviral drugs for several years and a protease inhibitor for 4 months. The man's blood revealed HIV resistance to protease inhibitors, but his semen didn't.

In the new, larger study led by researchers at the University of North Carolina (UNC) at Chapel Hill, HIV showed mutations associated with resistance to medication in 8 of 11 HIV-positive men whose blood and semen were tested periodically for up to 58 weeks. As in Kiessling's study, not all of the mutations arose on parallel tracks in blood and semen.

Of the eight men who developed resistance to anti-HIV drugs, seven had viral substrains in their semen that were different from those in their blood. For example, one patient developed viral mutations indicating resistance to the drug AZT in his blood but not in his semen. Three other men developed AZT-resistance mutations in both semen and blood, but the timing varied. Surprisingly, one showed resistance in his semen earlier than in his blood.

Resistance to protease inhibitors, drugs that dramatically slow replication of virus-infected cells, varied as well. In two patients, mutations subverting these drugs appeared only in the blood. "This suggests the possibility that the protease inhibitors were not getting into the semen [in these men]," says study coauthor Myron S. Cohen, an infectious disease specialist at UNC.

The compartmentalization indicates that blood tests for HIV may not reveal a drug-resistant virus in semen. "If men are sexually active and pass it on, the next person will have that much more difficulty benefiting from the drugs," Cohen says.

"This underscores [the point] that just because you're on antiviral therapy, it doesn't mean you don't have to practice safe sex," says Anthony S. Fauci, director of the National Institute of Allergy and Infectious Diseases in Bethesda, Md. —N. *Seppa*