Yucca site: A conclusion and controversy

Geoscientists reported evidence this week that bolsters federal plans to store the United States' most dangerous nuclear wastes inside a Nevada ridge called Yucca Mountain. But even as they tried to lay to rest one subject of debate, they disclosed intriguing findings that will likely raise new questions about the long-term safety of the repository site.

The latest results counter a theory that has attracted considerable attention over the last year and has threatened the repository plan. That theory, put forth by geologist Jerry Szymanski of the Department of Energy, holds that earthquakes in the recent geologic past have caused the normally deep groundwater beneath Yucca Mountain to surge hundreds of meters toward the surface.

Such an event would spell disaster for the underground repository, which must remain extremely dry for the 10,000 years it will take waste from nuclear reactors to decay to safe levels. If groundwater flooded the repository during that time, it would carry away dangerous isotopes, spreading them into the environment.

Szymanski developed his groundwater theory to explain prominent subsurface mineral deposits found at a nearby site called Trench 14. According to the theory, the trench's calcite and opal deposits formed when upwelling warm waters carried deep minerals toward the surface along fractures in the rock.

A federal research team now reports it has ruled out that theory.

"What we have shown in the past year is that there is just no way for water to have come up to form those deposits in the last 500,000 years," says geochemist John S. Stuckless of the U.S. Geological Survey (USGS) in Denver.

At a meeting of the Geological Society of America in San Diego this week and in a paper in the Oct. 25 SCIENCE, Stuckless and his colleagues described numerous test results indicating the Trench 14 deposits formed from rainwater percolating down through the soil, rather than from floods of upwelling fluids.

The scientists "fingerprinted" the Trench 14 deposits by measuring five sets of isotope ratios for strontium, uranium, oxygen, carbon and lead. All of these elements come in several different forms, or isotopes, and the ratio of one isotope to another provides information about how a mineral deposit formed.

The isotope evidence has persuaded the Department of Energy, which runs efforts to evaluate the suitability of the Nevada site. "The evidence is overwhelming in favor of their results [contradicting the upwelling theory]," says Deputy Project Manager Maxwell B. Blanchard.

The Energy Department still awaits the conclusions of a National Academy of Sciences panel convened principally to resolve the Trench 14 issue. Although the panel will not present its final report until early next year, Stuckless says members have told him they find the isotope evidence "very compelling."

Panel chairman Barry Raleigh of the University of Hawaii told SCIENCE NEWS he could not discuss his group's conclusions, but he did say that "isotope methods are extremely powerful tools for determining where groundwater deposition in the Yucca Mountain area might have happened."

Szymanski, however, refuses to concede. "The fundamentals of their conception are just like people who thought that the Earth is flat," he says.

While the USGS scientists believe the isotope data settle the Trench 14 issue, a different set of deposits found in the mountain has raised new concerns. Carbon isotope ratios in almost all drill cores from the area reveal that calcite deposits above the present water table are depleted in the carbon-13 isotope — an indication that the water table has not changed much since the deposits formed. But one drill core, from Hole USW-G4, shows carbon-13-enriched deposits from 500 meters above the current water table.

On its own, this one piece of data would indicate that at some point in the past, the water table sat high enough to flood the planned repository, says Joseph F. Whelan of the USGS in Denver, who presented these preliminary findings at the meeting. But he and his colleagues say they are confused because nearby drill holes show no evidence of such high water levels.

Szymanski takes the new data as proof that Yucca Mountain should not serve as a nuclear waste repository. Stuckless counters that the unsolved puzzle need not threaten the repository plan because these deposits may be millions of years old — so ancient that they would have little bearing on modern geologic activity at the site. *— R. Monastersky*

USGS

Scientists standing in Trench 14 examine white veins of calcite and opal deposited in a fracture near Nevada's Yucca Mountain. The mineral veins lie at the heart of a scientific controversy about the safety of building a repository inside the mountain to hold spent fuel rods from the nation's nuclear power plants.

Bone savers: Rating lifestyle and drugs

Osteoporosis, an embrittling bone loss common among postmenopausal women, causes roughly 1.3 million fractures in the United States each year. A new Australian study — the first to pit the three most common preventive regimens head to head — confirms what other studies have suggested: Estrogen-replacement therapy offers the best protection against osteoporotic bone fractures. However, the same study shows that in the absence of hormone supplements, a combination of regular exercise and calcium-rich diet can significantly slow osteoporosis.

"I was surprised that this lifestyle approach was as successful as it was," says study director Richard L. Prince of the University of Western Australia in Perth.

He and his co-workers recruited 120 nonsmoking women, aged 52 to 60, and assayed their bone density at three forearm sites every three months for two years. Densities initially hovered in the lower 40 percent of those seen in women the researchers had studied previously, indicating a high risk of eventual fractures.

The researchers encouraged the women to take at least one hour-long, low-impact aerobics class and two brisk, 30-minute walks a week. In addition, they gave all 120 women identical-looking sets of pills. One-third received daily placebo pills, another third took 1 gram of calcium per day, and the rest received estrogen and progestins (other hormones in some estrogen-replacement therapies) at a dose taken by many U.S. women today.

The investigators compared these women with 42 others who had average-density bones. Though intended as a control group, those 42 proved nearly as active as the volunteers on the experimental regimens.

In the Oct. 24 NEW ENGLAND JOURNAL OF MEDICINE, Prince and his colleagues report that the women had to undertake the equivalent of two hours of brisk walking daily before they halted bone loss. Because most women did not reach that activity level, the exercise-only and control groups lost about 2.5 percent of their bone density each year. Women who combined calcium and exercise slowed their bone loss to between 0.5 and 1.3 percent annually, depending on the forearm site. Only those receiving the hormone showed a density increase, ranging from 0.8 to 2.7 percent per year.

Though interesting, these results may not reflect similar changes in the load-bearing bones, such as the hip and spine, which are most likely to undergo osteoporotic fractures, cautions Miriam E. Nelson of the Agriculture Department's Human Nutrition Research Center on Aging in Boston.

Still, the Australian investigators think their findings have important implications for public health. Because estrogen-replacement therapy requires medical supervision and may cause side effects, Prince and his co-workers suggest reserving the hormone treatment for women at highest risk – those with low bone density – and advising others simply to exercise and take calcium.

But estrogen's cardiovascular benefits, reported in the same journal, may tip the balance in favor of the hormone. Researchers at Harvard Medical School and Brigham and Women's Hospital in Boston have shown for the first time that even low doses of estrogen – 0.625 milligrams per day – can foster positive blood-cholesterol changes in postmenopausal women. Over time, they say, the observed decreases in low-density lipoprotein ("bad") cholesterol and increases in high-density lipoprotein ("good") cholesterol might reduce cardiovascular risk in women by more than 40 percent.

The Boston study, which involved 31 women aged 43 to 69, also shows why estrogen offers greater benefits when administered orally rather than through the skin or into the blood: It goes straight to the liver, the central organ in lipoprotein metabolism. "It now appears that women who take [oral] estrogen may produce a little more low-density lipoprotein cholesterol [in the liver] compared with women who don't take estrogen, but that their ability to get cholesterol out of their bloodstream is massively increased," explains Brian W. Walsh, who led the study. *– J. Raloff*

NMR improvements earn chemistry Nobel

A Swiss physical chemist who helped advance nuclear magnetic resonance (NMR) technology has won the 1991 Nobel Prize in Chemistry. Richard R. Ernst, 58, of the Federal Institute of Technology in Zurich, improved upon NMR techniques initially developed in 1945. His contributions paved the way for magnetic resonance imaging (MRI), a biomedical technique for depicting tissues deep within the body.

The Royal Swedish Academy of Sciences in Stockholm, which announced the $1 million award last week, calls NMR spectroscopy "perhaps the most important instrumental measuring technique within chemistry."

Basically, nuclear magnetic resonance works because atoms placed in a very strong magnetic field align with the field and behave as though they were spinning tops. The atomic tops wobble at certain frequencies, depending on what other atoms are nearby.

For imaging, scientists or physicians then bombard these atoms with high-frequency radio waves. When the radio waves encounter atoms wobbling at the same frequency as the waves, they cause the atoms to resonate. After the radio waves are turned off, the atoms give off a pulse of energy. A detector picks up the timing and type of pulses, which reveal the kinds of atoms emitting them. Thus, scientists can discern the chemical makeup of a sample.

Ernst spurred this technology by increasing its sensitivity and by making it easier to interpret the pulses. In 1966, he and a U.S. colleague, Weston A. Anderson, changed the type of radio wave from slow sweeps to short, intense pulses. Then

NIH

Human head depicted by magnetic resonance imaging, a tissue-scanning method based on an analytical technique called nuclear magnetic resonance.

Ernst discovered that he could obtain even more information about a sample by using sequences of short pulses of radio waves and varying the timing of the pauses in between. He later applied a mathematical technique called Fourier transformation to NMR spectroscopy and further increased NMR's sensitivity.

These and other advances have made it possible to determine the three-dimensional structure of large, complex molecules that contain hundreds of atoms, to examine interactions between molecules, to study molecular motion and rates of chemical reactions, and to image soft tissues not clearly revealed by X-rays.

Ernst learned of his Nobel last week from a pilot during a transatlantic flight. *– E. Pennisi*

Physics Nobelist linked materials with math

While most physicists prefer to study simple systems, this year's winner of the Nobel Prize in Physics proved that even "untidy" schemes can elucidate basic principles.

The $1 million prize goes to 59-year-old French physicist Pierre-Gilles de Gennes, of the University of Paris, for discovering broad mathematical methods to describe phenomena of order and chaos in such widely differing materials as liquid crystals, superconductors and polymers. In announcing the decision last week, the Royal Swedish Academy of Sciences called de Gennes "the Isaac Newton of our time."

"Some of the systems de Gennes has treated have been so complicated that few physicists had earlier thought it possible to incorporate them at all in a general physical description," the Academy observed.

Phase transitions – in which atoms or molecules in a material shift between ordered and disordered states – have long piqued de Gennes' interest. In the 1950s, he began studying how tiny atomic magnets alter their alignment with changes in temperature. In the 1960s, he worked with liquid crystals – which display characteristics of both solid and liquid phases – to test general physical theories. Those studies enabled him to explain how fluctuating molecular order in liquid crystals affects the scattering of light. De Gennes also mathematically demonstrated similarities between liquid crystals and superconductors.

In the 1970s, his curiosity extended to polymers. Seeking a way to describe how these long-chained molecules form a spaghetti-like tangle in a dilute solution, de Gennes discovered a mathematical way to link their complicated arrangements with general physical principles of phase transitions. *– K. Schmidt*