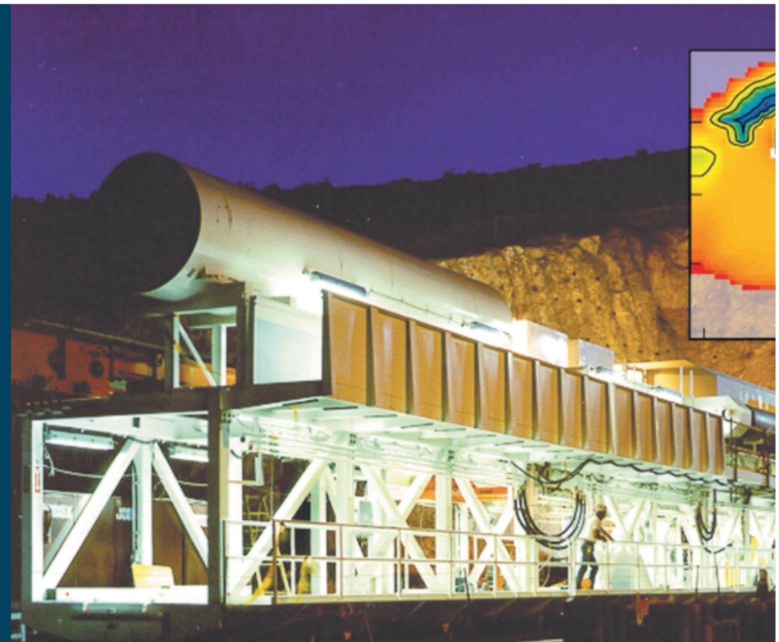
Livermore's activities in energy and environmental science support DOE priorities for enhancing the nation's energy security, developing and making available clean energy, cleaning up former nuclear weapon sites, and finding a more effective and timely approach to nuclear waste disposal.



Improving Energy Security and Environmental Management

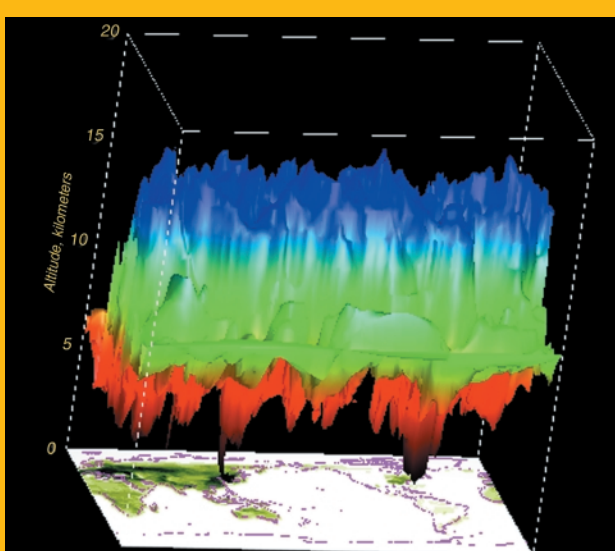
Waste Storage for the Millennia

Yucca Mountain, at the Nevada Test Site, is the nation's potential site for a high-level nuclear waste repository. The Laboratory is helping DOE to address some of the major scientific challenges in nuclear waste storage. We are making major contributions toward the selection of materials for the waste package and engineered barrier, pioneering the analysis of how heat affects the mountain. Livermore researchers led the preparation of three of the nine Process Model Reports—for the waste package, engineered barrier system, and near-field environment. Completed in 2000, these reports provide the basis for the Secretary of Energy's site recommendation to the President.

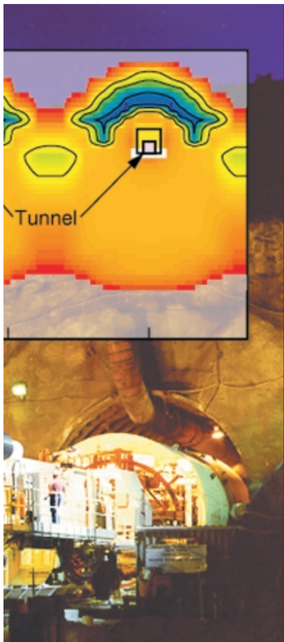
Scientists need to know whether geologic responses over thousands of years could cause the waste packages to corrode and release radioactivity. We have been testing the materials for making waste storage containers and researching the site's geology to accurately predict the effect on nearby geology of the heat from the buried wastes. In addition, using Livermore's supercomputers, we have constructed a code to simulate the geologic evolution of the repository for 100,000 years or more. The code is being used to predict the temperature evolution surrounding the buried nuclear waste and the possible means by which water will enter the repository's tunnels over the eons.

Deep Ocean Sequestration of Carbon

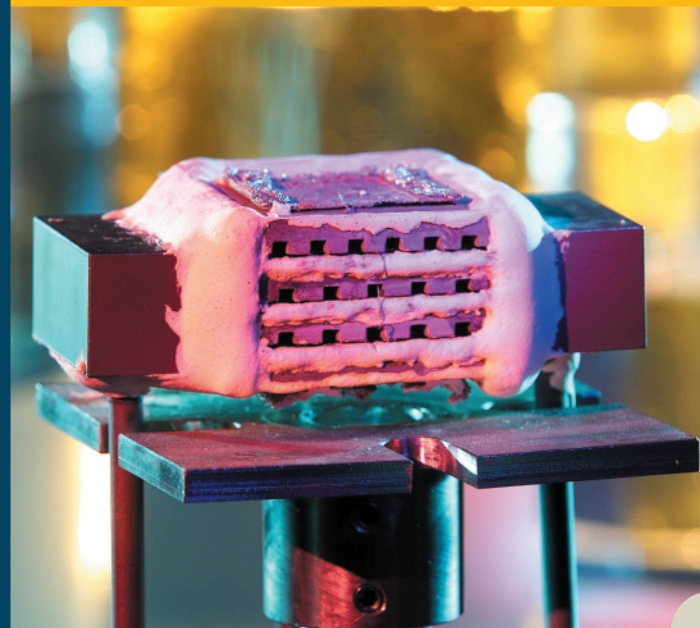
The Laboratory co-directs DOE's Center for Research on Ocean Carbon Sequestration (DOCS) and leads its efforts in numerical simulation. Researchers are investigating



Atmospheric chemistry models are an important part of global climate simulations. Livermore modeling results show that in various locations, ozone in the lower stratosphere, which is typically in 100-parts-per-billion concentrations, is transported to near-surface altitudes.



Detailed models of waste packages and the surrounding geology are used in simulations of the long-term evolution of tunnels at Yucca Mountain. A cross section through two tunnels shows the formation of domes of low-porosity rock above hot (pink) waste packages of spent nuclear reactor fuel after about 500 years. Fractures in the rock are irreversibly sealed, preventing water from entering the tunnel.



Tests of a 3-x-5-inch, three-cell stack of solid-oxide fuel cells developed by Laboratory researchers achieved record-setting power density (over 1 watt per square centimeter), generating 61 watts of peak power. The fuel-cell design incorporates the benefits of thin-film processing techniques that reduce manufacturing costs and should help bring the technology to commercialization.

ways that fossils can be burned without releasing into the atmosphere carbon dioxide (CO_2), a greenhouse gas that contributes to global warming. CO_2 is produced by the burning of fossil fuels, and the use of coal, oil, and gas are mainstays of the U.S. economy, supplying about 85 percent of the nation's energy needs.

Because the deep ocean is able to store additional CO_2, DOCS is examining the effectiveness of various strategies to sequester carbon in the ocean. One possibility is the storage of CO_2 in deep underwater geologic reservoirs. As part of the DOE effort, the Laboratory is developing criteria for identifying subsurface geologic formations useful for sequestration. Researchers are also developing a first-cut model of CO_2 injection and sequestration processes.

Improved Climate Modeling

Improved simulations of the global climate are needed to better understand the changes in Earth's climate that may be caused by human activities. The ever-increasing speed of Livermore's supercomputers is making it possible to "push the envelope" of global climate simulations and the science behind it. Future high-resolution global climate simulations should lead to improved predictions of future climate—not just future weather—on both global and regional scales.

In one study, detailed models of the troposphere and stratosphere were combined to examine how natural and human-made emissions of chemical species may alter the distribution of ozone and, more important, how these regions interact. We found that at various geographic locations (such as northeastern United States and eastern China), stratospheric ozone is being transported to altitudes near Earth's surface. These results indicate that atmospheric ozone chemistry—in both the stratosphere and troposphere—must be considered in any quantification of global surface ozone distributions.

Fuel-Cell Breakthrough

We are improving the design of solid-oxide fuel cells with the goal of making the technology an attractive option for clean and efficient power generation for the 21st century. By applying their materials science expertise, Livermore researchers are developing a very-high-power-density prototype that operates at a temperature low enough so that more affordable materials and manufacturing technologies can be used. In 2000, we built and tested a prototype modular fuel cell consisting of a stack of three single cells. For the stack, we obtained a power density of 1.05 watts per square centimeter at 800°C, a result for a stack of cells that is at least 50 percent higher than previously reported.