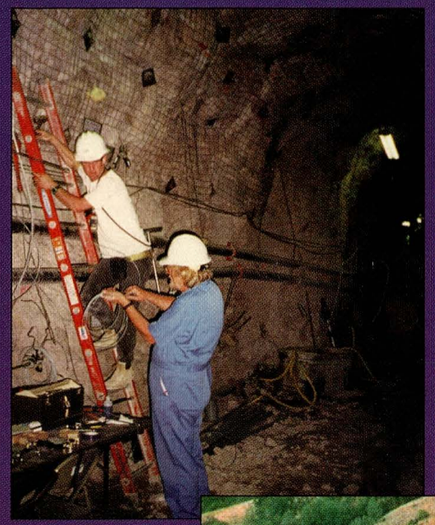
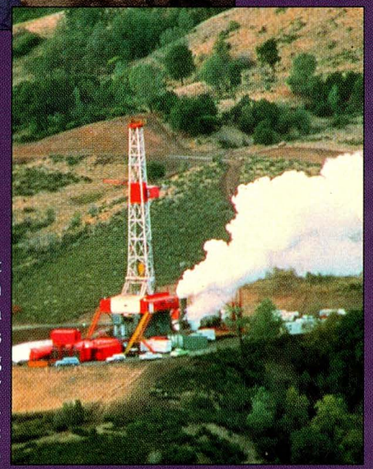
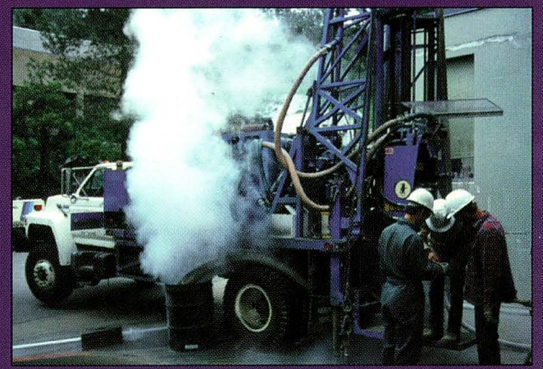


Berkeley Lab scientists in the Exploratory Studies Facility (ESF), a 25-foot-diameter, 6-mile-long tunnel carved through Yucca Mountain, Nevada. (Contact: Bo Bodvarsson)



A geothermal field at the Geysers in Northern California where ESD scientists are studying geothermal energy resources. (Contact: Larry Myer)



Berkeley Lab has developed cryogenic drilling, a technique used for drilling environmental monitoring and remediation wells in unstable soils and rock by freezing the borehole wall with nitrogen. (Contact: Sally Benson)

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The Earth Sciences Division (ESD) at Berkeley Lab brings together geoscientists, mathematicians, microbiologists, computer scientists, and engineers to address global, national, and local problems related to energy resources, environmental remediation, nuclear waste disposal, and global change. ESD blends fundamental and applied research to tackle some of this country's most pressing issues, while at the same time building the knowledge base to address future concerns.

The ESD team consists of 200 full and part-time geoscientists, many of whom are also affiliated with the University of California at Berkeley. To continually broaden our knowledge base, we also collaborate with scientists across the nation and around the world.

Through these collaborations we seek to build bridges and enhance synergy among scientists, disciplines, and institutions. In this way, we can deliver solutions to our most challenging energy resource and environmental problems.

For more information visit our web site at **http://www-esd.lbl.gov**, or contact:

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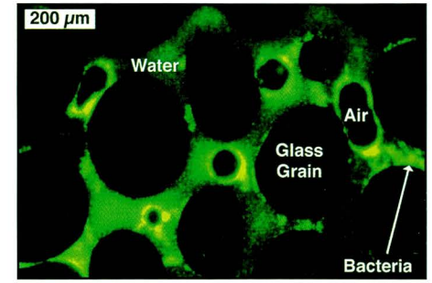
Ernest Orlando Lawrence Berkeley National Laboratory is operated for the DOE under Contract No. DE-AC03-76SF00098.
PUB-799

Improving Our Environment

ESD scientists are seeking solutions to soil and groundwater contamination caused by industrial, agricultural, and weapons production activities. One major accomplishment is the development of new materials for creating subsurface containment systems to prevent migration of contaminants. These materials are injected into the ground in an aqueous solution that gels to form a stable, long-term containment system that prevents further pollution of groundwater and soils.

We also are taking steps to solve one of California's most pressing environmental problems—selenium contamination of our waters, soils, and sediments. By addressing such key issues as what levels of selenium are safe and how to remove selenium before it enters the environment, ESD scientists have found solutions to challenging problems such as pollution of the Kesterson Reservoir. Through this and other projects we have learned about the critical role of microorganisms in environmental cleanup. We are now looking at how to apply these microbial processes to the bioremediation of radionuclides and other metals.

This focus on naturally occurring processes to remediate contaminants has led to a multidisciplinary environmental biotechnology program that brings together scientists to solve environmental pollution problems. Research focuses on biogeochemical transformations, environmental diagnostics, and environmental risk assessment based on bioavailibity.

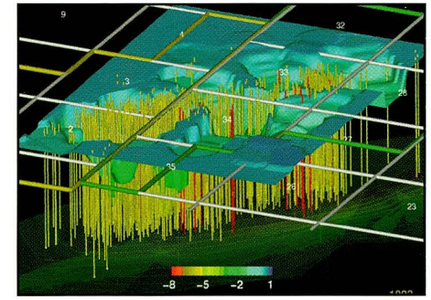


ESD laboratory study of bacteria: Epifluorescent bacteria (*P. putida* mt-2) biofilms growing in a partially water-saturated porous network (a glass micromodel) with trapped air bubbles, using toluene as the sole carbon source. (Contact: Ernie Majer or Jiamin Wan)

Protecting Our Energy Resources

Our country must have energy resources that are affordable, dependable, and protective of the environment. Together with the oil and gas industry, ESD scientists are developing methods to increase production from mature oil fields by obtaining a more accurate description of the reservoir structure. For example, we have developed new high-resolution seismic imaging techniques for locating fractures that transport reservoir fluids.

It is also vital to develop other energy resources. Geothermal energy is a clean alternative to fossil fuels. It can be used to produce electricity and can be utilized directly for heating without emission of harmful greenhouse gases. Over the past two decades, ESD scientists and engineers have developed a wealth of technology for locating geothermal resources and predicting the amount of energy that can be extracted from them. Through partnerships with domestic and international producers of geothermal energy, we have made a significant contribution to the current and growing use of this environmentally friendly energy source.



Berkeley Lab's visualization of land subsidence due to oil production at the South Belridge oil field, Kern County, California. (Contact: Larry Myer)

Understanding the Earth

The earth is a complex physical, chemical, and biological system. Through a dedicated program of fundamental research ESD researchers, together with our UC Berkeley faculty affiliates, have developed knowledge that allows us to probe the earth at many scales, from molecules to kilometers, in order to further understand the important processes and interactions that shape our planet. Significant advances include improved modeling of heat and mass transfer and of coupled physical-chemical-microbial interactions that control subsurface contaminant remediation. Advances in seismic and electromagnetic imaging techniques also have been made by ESD scientists.

To support these research activities, the ESD has built and maintains the following facilities:

- Center for Computational Seismology
- Center for Environmental Biotechnology
- Center for Isotope Geochemistry
- Environmental Measurements Laboratory
- Geosciences Measurement Center
- Rock and Soil Physics Laboratory

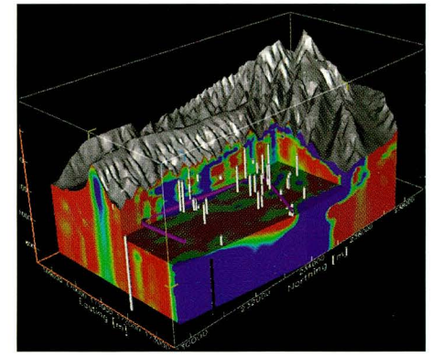
ESD scientists also can access the major user facilities at Berkeley Lab, including the Advanced Light Source, the National Center for Electron Microscopy, and the National Energy Research Scientific Computing Center.

Safely Disposing of Nuclear Waste

ESD has been involved for many years in nuclear waste disposal issues confronting the national and international community. Decades of generating electricity with nuclear reactors has led to our country's accumulation of large quantities of high-level radioactive waste. The preferred strategy for managing this waste is long-term isolation in geologic formations. Yucca Mountain, a remote site located in the Nevada desert, is being studied to assess the feasibility of storing wastes in unsaturated tuffs.

ESD scientists play a critical role in the DOE's characterization of this site. One of our key contributions is a 3D site-scale model of hydrologic flow within the unsaturated zone. The results of this modeling are used to assess how the mountain will perform as a deep geologic repository. ESD scientists also play key roles in field-scale heater tests designed to mimic how the site will behave when radioactive wastes are emplaced in the repository.

ESD also heads the International Center for Nuclear Waste Disposal, which was started at Berkeley Lab in response to the need to maintain communication and share information among countries involved in nuclear waste management and disposal. The Center will foster the development and application of technologies that will provide cost-effective and timely solutions to this ever-growing, world-wide problem.



ESD's computer modeling group in the Nuclear Waste Department developed the 3D site-scale model of the Unsaturated Zone of Yucca Mountain, Nevada. (Contact: Bo Bodvarsson)

Promoting Health and Education

Community involvement in solving environmental cleanup problems begins with education and training. ESD strives to generate awareness, interest, and understanding of the earth sciences and their importance to human and ecological health through public outreach and education programs. One example is the SELECT program, which seeks systematic and cost-effective methods to manage environmental cleanup. Its goal is to design and develop a flexible, PC-based software system that will provide environmental information to managers, scientists, and the public. The Bioremediation, Education, Science and Technology (BEST) program is another example of our educational activities. BEST is an environmental education program furnishing bioremediation curricula, courses, and fellowships to underrepresented groups. Innovative features of the BEST curricula include the use of distributed learning technologies and an academic Area of Concentration in Bioremediation. The BEST Centers at ESD, UC Berkeley, and Jackson State University provide student access to cutting-edge bioremediation research and advanced analytical technologies.

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