

THE CONSORTIUM FOR RESEARCH ON THE EARTH'S SUBSURFACE

D. P. Guillen, S. J. Kowall, R. C. Hertzog
Idaho National Engineering and Environmental Laboratory
P.O. Box 1625
Idaho Falls, Idaho 83415-3765

E. L. Majer, G. S. Bodvarsson
Ernest Orlando Lawrence Berkeley National Laboratory
1 Cyclotron Road, MS 90R1116
Berkeley, California 94720-1116

ABSTRACT

The continued security and prosperity of the United States is critically linked to maintaining a balance between national security, an adequate energy supply, and a clean environment. The health and welfare of Earth's ecosystems and human population depend upon safe, sustainable supplies of water, air, energy, and natural resources. Yet environmental degradation and uncertain energy supplies are straining our ability to maintain our way of life. Population growth and developing nations seeking to raise their standard of living will accelerate stress the Earth's energy and natural resources unless we take appropriate measures. New technologies and scientific understanding are required to solve these problems. Our current course of research in addressing these problems will not produce adequate results in a time frame to avert further energy and environmental crises. The creation of fundamental knowledge must be accelerated and rapidly transitioned into practical results. The Consortium for Research on the Earth's Subsurface (CORES) is being formed to provide timely solutions to critical national problems associated with the earth's subsurface. The mission of CORES is to ensure energy security and environmental protection by improving our understanding of crosscutting fundamental subsurface processes applicable to predicting the behavior and enabling cost-effective, safe management and treatment of contaminants in the subsurface, exploring for and production of fossil fuels, enabling more effective use of geothermal energy resources, ensuring the safe disposal of spent nuclear fuel and nuclear waste, developing strategies for subsurface carbon sequestration, predicting the subsurface fate of energy byproducts, and developing new energy resources (such as gas hydrates). CORES will be jointly led and coordinated by the Idaho National Engineering and Environmental Laboratory (INEEL), a U.S. Department of Energy (DOE) Office of Nuclear Energy, Science and Technology laboratory, and the Lawrence Berkeley National Laboratory (LBNL), a DOE Office of Science laboratory. The product of CORES will be a significantly funded, sustained, nationally integrated program of subsurface science research supported by the science and engineering community, industry, policy-makers, regulators, end users, and other stakeholders.

THE NEED TO ACCELERATE UNDERSTANDING OF THE SUBSURFACE

Development of a nuclear deterrence and the reliance upon fossil fuels have had dramatic, unforeseen impacts on our environment and economic security. The legacy of the nuclear weapons development program is a 300 to 600 billion dollar cleanup cost to remediate sites contaminated with radionuclides, metals, organics, and mixed wastes. The impact of relying on fossil energy is severely impacting our economy and environment. Access to affordable oil continues to shape our international policy. The long-term consequences and impacts of global warming on climate change are still being evaluated. Compounding these issues are anthropogenic impacts to the most valuable resource on our planet—water. As more demands are placed on our environment, safe supplies will be in jeopardy. Increased competition for

water resources among and within national and international sectors call for strategies that will help balance water use and protect our ecosystems.

A vital component to addressing these problems is understanding the dynamics of fluids within the earth. For almost all energy and environmental applications, the core of this science mission lies in the subsurface and its exchanges with the atmosphere and the oceans. Understanding and quantifying the amount of carbon sequestered by oceans and terrestrial sinks versus how much remains in the atmosphere is necessary to better predict the behavior of global sources and sinks affecting climate change. The interlinking issues of national energy and environmental security all require an underpinning of basic and applied research. For example, if we are to adapt to a hydrogen economy, we must develop energy sources to convert to hydrogen fuels. All known sources of energy generation in the amounts necessary to create and convert hydrogen are geoscience-based. Without a more complete understanding of the earth's subsurface, we may not achieve a hydrogen-based energy supply. Nanoscience and all of its promised achievements may be significantly accelerated by examining the earth's analog nano-processes and materials. Advances in the earth and life science are absolutely key to:

1. Protecting the world's aquifers from contamination
2. Safely managing hazardous materials in the subsurface
3. Sustaining a high level of agricultural productivity
4. Identifying, characterizing, and extracting energy and mineral resources
5. Mitigating global climate change
6. Addressing national security concerns.

CORES' MISSION

To adequately achieve energy security and environmental protection given the urgency of the times, the creation of fundamental knowledge must be accelerated and rapidly transitioned into practical results. The Consortium for Research on the Earth's Subsurface (CORES) is being formed to achieve timely solutions to critical national problems associated with the earth's subsurface. The mission of CORES is to ensure energy security and environmental protection by (a) improving our understanding of subsurface processes applicable to predicting the behavior and enabling cost-effective, safe management and treatment of contaminants in the subsurface, (b) exploring for and production of fossil fuels, (c) enabling more effective use of geothermal energy resources, (d) developing strategies for subsurface carbon sequestration, (e) predicting the subsurface fate of energy byproducts, (f) ensuring the reliable and safe disposal of spent nuclear fuel and nuclear waste, and (g) developing new energy resources (such as gas hydrates). To establish the consortium, we envision a multiyear effort—in the first year, defining the initiative, the participants, and establishing a steering committee; in the second (and most critical) year, defining the cross-cutting science behind the research agenda and writing proposals; and in the third year, commencing research. CORES will be jointly led and coordinated by the Idaho National Engineering and Environmental Laboratory (INEEL), a DOE Office of Nuclear Energy, Science and Technology laboratory, and the Lawrence Berkeley National Laboratory (LBNL), a U.S. Department of Energy (DOE) Office of Science laboratory. The product of CORES will be a significantly funded, sustained, nationally integrated program of subsurface science research supported by the science and engineering community, industry, policy-makers, regulators, end users, and other stakeholders.

CORES will redefine the ways that subsurface science research is conducted and, ultimately, how research leads to improvements in understanding and prediction. The research portfolio will be defined with an eye to identifying and addressing critical scientific gaps. The central theme of the research would center on removing scientific roadblocks that prevent us from having a more complete understanding of how fluids affect the physical, chemical, and biological dynamics in the earth and atmosphere, at a progression

of scales from the nano- to field scale. Researchers would be drawn from U.S. national laboratories, universities, and industry, and contribute a spectrum of interests and expertise.

An example of a CORES research area is the behavior of multiphase fluids in heterogeneous subsurface media. Fundamental to efficient and safe extraction and injection of fluids into the subsurface is accurate prediction not only of fluid phase, composition, and distribution, but also the knowledge of flow paths, permeability, and the interaction among the physical, chemical, and microbial processes and properties. To advance understanding of subsurface fluid flow and distribution, we anticipate that one component would be the development of advanced imaging methods. Advanced imaging will not only require better definition and fundamental understanding of how mechanical and electrical energy couples and interacts with earth materials, but will require new measurement technologies and computational methods to properly analyze and interpret the results, i.e., research in theory coupled with laboratory and field studies, supported by new measurement methods, adequately modeled and all leading to realistic imaging of the desired properties. Another research area to be addressed is multi-scale representation of ecosphere parameters and processes. This includes investigation of dominant processes and interactions between processes that occur at different spatial scales, and reconciling the different spatial scales associated with measurements, physical processes, and numerical models.

A RESULTS-DRIVEN APPROACH

Achieving the necessary understanding of the subsurface environment and developing predictive ability will require fundamental advances in basic and applied scientific knowledge, which can best be achieved through a consortium-based approach focused on the major environmental challenges facing the nation. Current research usually takes the form of individual projects or groups of projects focusing on an individual aspect of a particular problem. And crosscutting issues and approaches, such as scaling, heterogeneity, imaging, etc., while all address the problems, sometimes do so not only in an overlapping manner, but are duplicative and haphazard. Another shortcoming of the current approach is that research results are not systematically shared among individual projects, thus hindering progress on solving major roadblocks. Just as serious an issue, however, is how the products of the research or fundamental knowledge are transferred to actually solve a particular problem, i.e., it takes a long time for basic research results (if ever) to make an impact on solving a real-world problem and to be useful to the problem holder. Due to shrinking resources (time and budgets), we cannot afford to solely follow the current mode of research in the fundamental earth and environmental sciences. While there will always be a role for individual investigator-led research, we must have a component of research that is conducted in a more coordinated and integrated fashion, one that focuses on addressing the critical crosscutting issues that are preventing us from making rapid progress on energy supply and environmental matters.

A coordinated mix of developing theory, laboratory, field, modeling, processing, and interpretation methods is necessary to achieve transformational breakthroughs in the earth and life sciences. Integrating, coordinating, and linking field observations with scaling/integration/process studies and theoretical and modeling efforts over a variety of spatial and temporal scales and in different environments is necessary for improved understanding, prediction, and manipulation of the ecosphere. To transfer the technology as efficiently and effectively as possible, the research would be conducted at application field sites supported by appropriate-scale test facilities. The CORES endeavor will develop and discriminate three levels of end-state knowledge—fundamental science, enabling technology, and engineered systems. Features of the CORES approach include:

- A team approach with emphasis on critical bottlenecks
- Nested (i.e., multiple-scale) observatories in different (representative) environments

- Integrated theory, measurement, modeling, and interpretive studies
- Focus on end use of the research results.

PATH FORWARD

A report titled “Critical Choices: Science, Energy and Security” prepared by the Secretary of Energy Advisory Board’s Task Force on the Future of Scientific Programs at the DOE (October 13, 2003) points out that Congress has assigned DOE the stewardship to address those issues that will achieve energy and environmental security[1]. Implicit in this report is that time is of the essence. Critical research must be started in the next several years, and progress must be made on transferring the results to practice. Research and dissemination of the results to end users will be performed by a coalition of U.S. national laboratories, academic institutions, industry, and implementers of the technology.

An immediate first step is to assemble a nationally recognized core group of subject matter experts and leaders in the geoscience community to develop the national subsurface science research agenda. This will be accomplished through a series of workshops over the next year. A steering committee will be formed and a proposal written to accomplish the goals. It is envisioned that this will be accomplished in two five-year phases, moving from basic/fundamental research to application.

To date, INEEL and LBNL have sponsored two workshops on earth science issues in the CORES series. The *Coupled Processes Meeting* was held on July 30 and 31, 2003 at Lawrence Berkeley National Laboratory in Berkeley. The *Challenges in Subsurface Characterization, Imaging, and Monitoring Workshop* was held on September 24-26, 2003 in Salt Lake City. More information on CORES can be found at <http://www.inel.gov/cores>.

ACKNOWLEDGMENTS

This work is sponsored by the U.S. Department of Energy under DOE Contract Numbers DE-AC07-99ID13727 and DE-AC03-76SF0098.

REFERENCES

- 1 *Final Report of the Secretary of Energy Advisory Board’s Task Force on the Future of Science Programs at the Department of Energy, Critical Choices: Science, Energy, and Security, Final Draft*, October 13, 2003, Secretary of Energy Advisory Board, U.S. Department of Energy.