



# EARTH SCIENCES: CORE SCIENCE PROGRAMS

## Foundations for Innovation

In addition to participating in NSF-wide initiatives and special programs, the Division of Earth Sciences consists of core scientific programs that fund both large- and small-scale projects. These core programs support cutting-edge research that advances scientific understanding, and help to address pressing global issues, including the provision of clean water, the prediction of natural disasters, understanding human impacts on our environment and resource management.

**The core programs within the Division of Earth Sciences support innovative research that forms the pillars of the broader cross-cutting research encouraged by NSF-wide initiatives**

The core programs are devoted to supporting fundamental and focused science that is not driven by a specific mission or directive. This allows for free-flowing creativity that can lead to the innovation necessary for great advances. Furthermore, this core understanding is the key enabler of broader-scale interdisciplinary research. Core scientific knowledge fuels interdisciplinary advances.



### **Research funded by the core programs can be interdisciplinary**

The work funded by these programs is often highly interdisciplinary. When projects span multiple disciplines, they require cross-foundational partnering in their review and support. This work engages existing Geoscience programs as well as other NSF directorates that support physics, chemistry, biology, engineering, computer science and polar science.

### **Core programs adapt and respond to the needs of the scientific community**

Core programs nurture and support the latest advances in science. Program directors solicit input from the scientific community through townhall meetings and workshops, and by commissioning reports from impartial and respected entities such as the National Research Council. These reports have led to the reorganization of the Division of Earth Sciences and initiation of new core programs to better respond to evolving needs of the scientific community. By listening to the scientific community consensus expressed in these reports and discussions, as well as by regularly attending key scientific meetings, core program staff are well positioned to support the most transformative and novel research.

*“Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science.”*

**Vannevar Bush**, Director of the Office of Scientific Research and Development  
in *Science the Endless Frontier, A Report to the President, July 1945*

### **Nurturing America’s next generation of scientific leaders**

Core programs enable new scientists to establish their careers by supporting projects that develop them intellectually and professionally. In the past five years, over one-fifth of the projects funded by the Division of Earth Sciences’ core programs were led by early-career scientists who were within seven years of receiving their doctorate. These scientists often go on to participate in larger-scale projects as part of broader NSF initiatives. And many of these scientists were guided towards this career path by participating in core program-supported projects as undergraduate and graduate students.

By supporting the pipeline of skilled Earth scientists, the Division of Earth Sciences contributes to America’s ability to address regional, national, and global issues critical to human and environmental well-being.

*“Without solid investment in science education and a fundamental science base, nations will not acquire the groundbreaking knowledge required to make discoveries and innovations that will shape their future.”*

**Ahmed Zewail**, Nobel Prize winner in Chemistry and member of President Barack Obama’s Council of Advisors on Science and Technology

### **The core scientific programs within the Division of Earth Sciences**

- EarthScope
- Education and Human Resources
- Geobiology and Low-Temperature Geochemistry
- Geomorphology and Land-Use Dynamics
- Geophysics
- Hydrologic Sciences
- Instrumentation and Facilities
- Integrated Earth Systems
- Petrology and Geochemistry
- Sedimentary Geology and Paleobiology
- Tectonics

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### **Core Contributions in Environmental Sustainability**

#### **Rapidly rising sea levels may impact half of the U.S. population.**



Understanding sea level rise is crucial for protecting coastal populations. *Credit: Thinkstock*

According to the National Oceanic and Atmospheric Administration, between 1980 and 2003, population in coastal counties increased by 33 million people, or 28%. This means that over half of the U.S. population (not including Alaska) now lives on our coasts.

For this reason, understanding the threats to coastal communities is now more important than ever. A project funded by the Geomorphology and Land-Use Dynamics program has shown that the rate of sea level rise along the U.S. Atlantic coast is greater now than at any time in the past 2,000 years. This research has also demonstrated a consistent link between changes in the average global temperature and sea level.

“Having a detailed picture of rates of sea level change over the past two millennia provides an important context for understanding current and potential future changes,” says Program Director Paul Cutler.

“It’s especially valuable for anticipating the evolution of coastal systems,” he says, “in which more than half the world’s population now lives.”

According to the study’s lead scientist, Andrew Kemp of Yale University, “Scenarios of future rise are dependent on understanding the response of sea level to climate changes. Accurate estimates of past sea level variability provide a context for such projections.” *Award: EAR-0829717*



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## Core Contributions in Public Safety

**Better understanding of the basic science behind volcanoes could help us better predict catastrophic eruptions.**



Volcanic eruption on Stromboli Island in Italy.  
*Credit: Thinkstock*

Understanding “volcanic plumbing” systems, or how magma (hot, liquid rock) moves beneath the Earth’s surface, could bring scientists closer to understanding plate ruptures and predicting eruptions. Volcanic ridges occur when tectonic plates pull apart.

This happens when magma is injected into weaknesses in the brittle upper crust, erupting as lava and forming new crust upon cooling. Studies of volcanic plumbing supported by the Geophysics program reveal new information about where magma is stored and how it moves through the geological plumbing network. *Award: EAR-0635789*

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## Core Contributions in Education and the Economy

**Research funded through the core programs supports the training of America’s next generation of earth scientists.**



CAREER award recipient Peter Reiners at the University of Arizona funded a summer program which teaches students geochronology through field and lab exercises. Above, students and instructors pose for a photo in the field. The award was funded through the Petrology and Geochemistry Program. *Credit: Peter Reiners, University of Arizona*

Society relies on a strong workforce of earth scientists and geoscientists, especially as we face growing environmental and energy challenges requiring the application of geoscience knowledge. According to a 2011 report by the American Geosciences Institute, a rapidly aging U.S. geoscience workforce combined with a shortage of talent relative to industry needs, will require the recruitment of scientists from other countries, unless more students in the U.S. are trained

in the field. The supply of newly trained geoscientists falls short of demand, even in oil and gas companies, which typically offer the highest salaries of all geoscience-employing industries. Due to the low market demand for geologists with bachelor’s degrees, the support of graduate students in the earth sciences is crucial for meeting this shortage. The core programs financially support students by assisting with funded research projects, creating a tech-

savvy and skilled workforce. Also, the core programs fund prestigious Faculty Early Career Development (CAREER) awards which support junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research. These faculty members work hard to train the next generation of America's scientists.

Award: EAR-0649707

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## Core Contributions in Health and the Environment

Research funded by multiple core programs looks at how water quality is impacted by natural disasters and human activities.



Research funded by the Geobiology and Low-Temperature Geochemistry Program looked at the water quality of the East Pearl River in Mississippi before, during and after Hurricane Katrina. The above picture was taken one month after the hurricane. Credit: Charlotte Brunner, University of Southern Mississippi.

to quantify the overall net threat of multiple stresses such as pollution, land use, and climate change on water resources. In a recent article in the scientific journal *Nature*, the team reports that 80 percent of the world's population is exposed to inadequate or unsafe water. The analysis framework may better enable policymakers to understand the options and trade-offs of strategies for improved water security.

Other recent work supported by the Geobiology and Low-Temperature Geochemistry Program has been important for assessing river water quality following the Hurricane Katrina disaster. Researchers found that the damage done to trees and vegetation had only a minimal effect upon water quality. Such findings have implications for environmental management strategies in the face of future natural disasters and weather fluctuations.

Award: EAR-0854957, EAR-0001049, EAR-0617607

Clean and adequate fresh water supplies, which are critical to all life, are a limited resource on the planet. Issues with water supply may have far-reaching implications for the U.S. and world economies, as well as for global security. The Division of Earth Sciences supports research that provides information critical for proper management of this resource.

A research team supported by the Hydrologic Sciences program has performed a global-scale analysis

“Earth Sciences: Core Science Programs” was produced and published by the National Science Foundation Office of Legislative and Public Affairs (OLPA).

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Earth Sciences is a Division of the National Science Foundation's Directorate for Geosciences (GEO). GEO-funded research increases scientific knowledge of Earth's environment—including natural resources such as water, energy, and minerals—as well as biological diversity and the interactions of human-environment systems. GEO-supported research also advances our ability to better understand natural phenomena such as climate change, weather, earthquakes, and droughts, all of which can have enormous and detrimental economic and human costs. GEO's research even extends to disruptive events in the solar-terrestrial environment, such as space weather and solar storms, which can disrupt global telecommunications. GEO also takes advantage of polar regions as unique platforms from which to explore fundamental questions including the origins of our universe.

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