

# Geoscience for America's Critical Needs

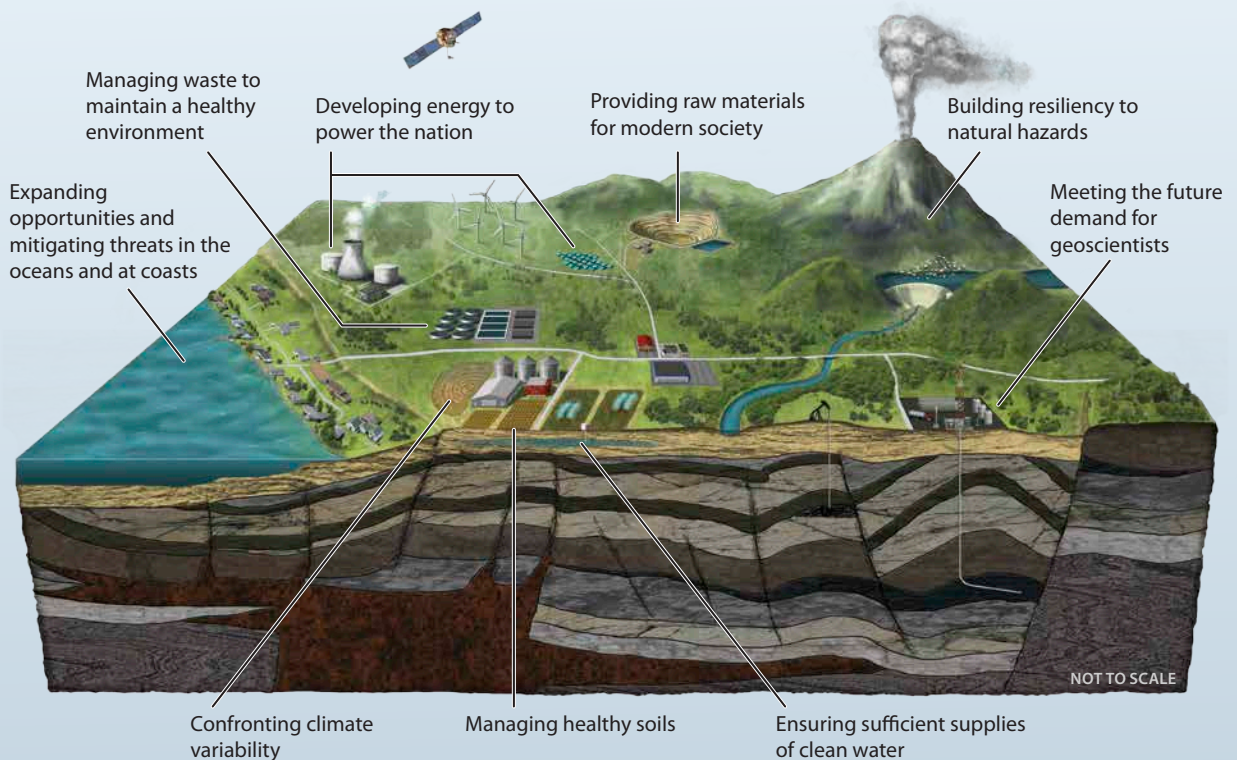


Invitation to  
a National  
Policy  
Dialogue



 **AGI** american  
geosciences  
institute  
connecting earth, science, and people  
2016

# Geoscience and Society



K. Cantner/AGI

This illustration shows some of the major contributions the geosciences make to society. Investments in geoscience information and research increase our ability to strengthen economies and protect public health and safety while living on Earth in a responsible and sustainable manner.

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# Invitation to a Dialogue

The geoscience community has the knowledge, experience, and ingenuity to address a wide range of societal needs. We study Earth's systems, the complex geologic, marine, atmospheric, and hydrologic processes that sustain life and the economy. Geoscience expertise allows us to better understand and predict the interactions between people and Earth's systems; such expertise is essential to developing solutions to critical economic, environmental, health, and safety challenges.

As you develop policy, we in the geoscience community offer to share our scientific expertise and perspectives on topics such as:

- Ensuring sufficient supplies of clean water
- Developing energy to power the nation
- Building resiliency to natural hazards
- Managing healthy soils
- Providing raw materials for modern society
- Expanding opportunities and mitigating threats in the ocean and at coasts
- Confronting climate variability
- Managing waste to maintain a healthy environment
- Meeting the future demand for geoscientists

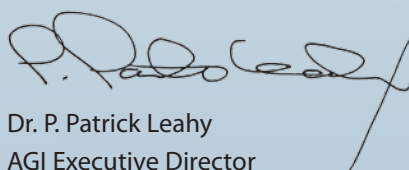
The American Geosciences Institute (AGI) connects Earth, science, and people by serving as a unifying force for the geoscience community. On behalf of the geoscientists represented by the 51 member societies of AGI, we invite you to join us in a dialogue on how to achieve our shared interests in meeting America's critical needs.

This document outlines high-level actions to address major policy issues where the geosciences play a significant role. We urge you to draw on the expertise of the geoscience community when crafting your policies. Together, we can achieve our nation's goals: a strong economy, thriving and resilient communities, and a healthy environment.

Sincerely,



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# Water

## Ensuring Sufficient Supplies of Clean Water

Clean water is fundamental to life and is essential for economic prosperity. However, the long-term security of water supplies is threatened by overuse, pollution, and climatic variability. Long-term planning and water management are critical for agriculture, electricity generation, fisheries, industry, transportation, recreation, municipal supplies, and healthy ecosystems.

Geoscientists provide the expertise necessary for effective water resource planning and management, and they conduct research to better understand and predict changes in the amount, quality, and location of water resources.

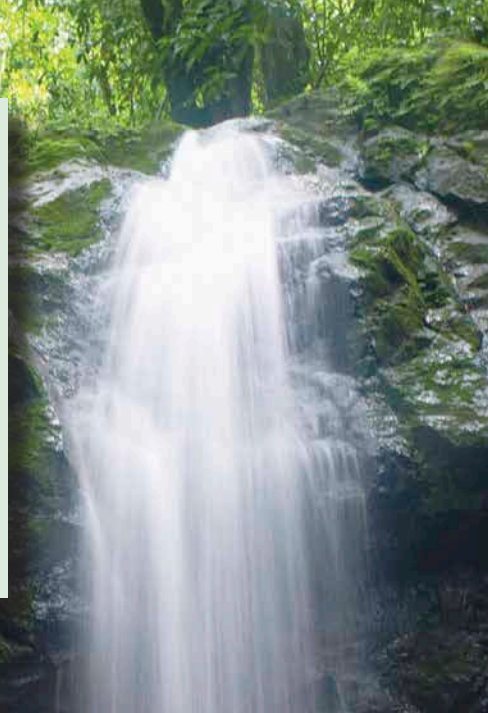


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### To optimize availability of clean water:

**Increase monitoring of both the quantity and quality of surface water and groundwater.** Knowledge of the state of water resources and how they are changing is critical for protecting, maintaining, and restoring the nation's water resources. It is important to collect and manage this information effectively and share it widely.

**Improve understanding of connections within the hydrologic cycle and between water resources and other critical issues.** We need to better understand the interaction between surface water and groundwater and integrate that knowledge into water and land management practices. Understanding links between water and other critical issues, including energy, agriculture, natural hazards, and waste disposal, will facilitate integrated planning and optimal decision making.

**Balance water use with ecosystem needs.** Healthy ecosystems purify water and air, mitigate floods, reduce erosion, and perform many other vital services, but ecosystem health depends on a sufficient water supply.

**Develop and maintain infrastructure to collect, treat, store, and deliver safe water and ensure sufficient capacity to meet changing needs.** The high costs of infrastructure development, maintenance, and replacement impose growing financial burdens and require long-term planning based on geoscience understanding and innovative engineering.

**Address persistent sources of contamination and identify threats to water quality in a timely manner.** Water quality is threatened by long-recognized contaminants, such as trace elements, pesticides, industrial spills, and excess salt and nutrients primarily from agricultural sources. Newly understood threats include naturally occurring contaminants, pharmaceuticals, and nanoparticles.



# Energy

## Developing Energy to Power the Nation

Energy supports economic growth, national security, and all the elements of daily life—food, water, transportation, communication, and entertainment. The United States' historically robust and secure energy systems have contributed to our high quality of life.

Geoscientists find and develop earth- and ocean-sourced energy, such as oil, natural gas, coal, uranium, and geothermal. They also find and develop the raw materials needed for renewable energy sources, such as cement and metals for dams, and rare earth elements for wind turbines and solar installations. In addition, geoscientists help determine suitable locations for energy infrastructure, including refineries, transmission lines, dams, and wind farms.

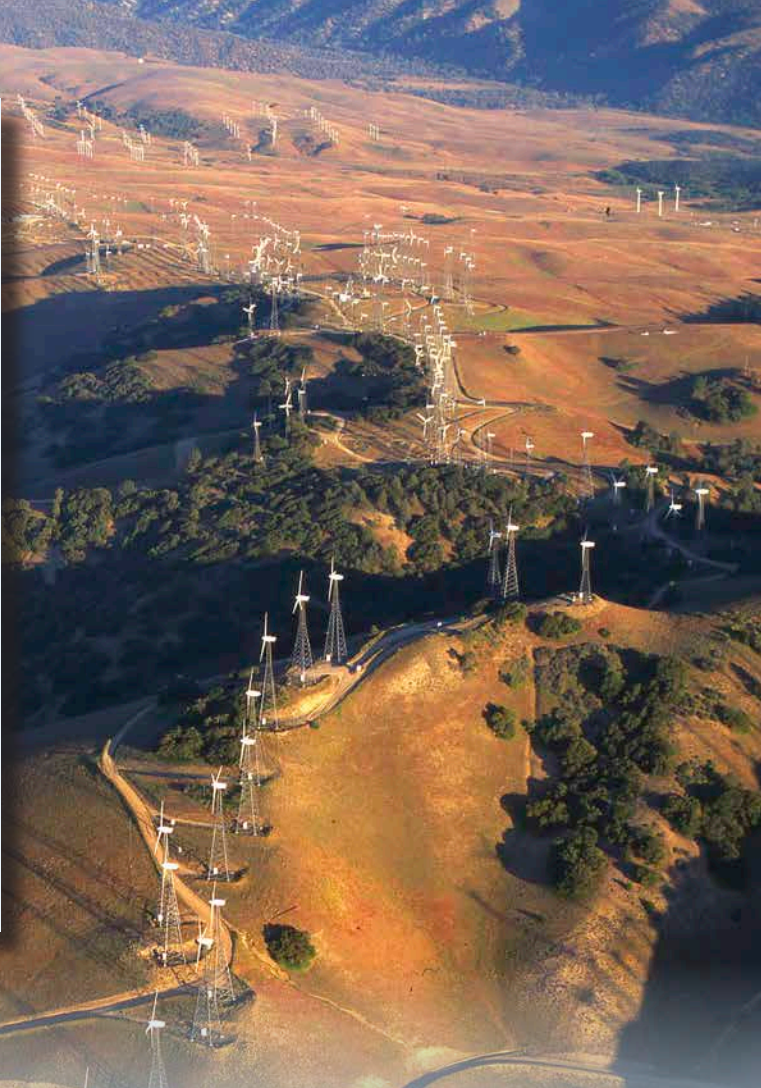


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### For an energy-secure nation:

**Assess the quantity and location of energy resources.** Geoscientists improve understanding of energy resources, helping decision makers to create robust energy policies and allowing energy producers to develop resources more efficiently.

**Develop the nation's diverse energy sources.** The United States relies on a variety of energy sources including petroleum, natural gas, coal, nuclear, hydroelectric, geothermal, and other renewables, like wind and solar. The continued responsible development of these resources, and the advancement of emerging energy sources, will ensure reliable supplies for the future.

**Study and develop solutions that reduce the environmental impacts of energy extraction and generation.** Geoscientists perform life-cycle analyses of the short- and long-term impacts of energy development, use, and waste disposal that help inform energy policy decisions.



# Natural Hazards

## Building Resiliency to Natural Hazards

Natural hazards affect every state in the nation. Earthquakes, volcanoes, landslides, sinkholes, wildfires, tornadoes, hurricanes, floods, extreme heat and cold, and drought, among others, result in billions of dollars in annualized losses to the United States. These hazards threaten lives and property, disrupt services, damage infrastructure, and weaken economies. A thriving nation requires resilient communities that help protect citizens from economic and social disruptions related to natural hazards.

Geoscientists help communities identify, mitigate, prepare for, respond to, and recover from natural disasters. In coordination with engineers, social scientists, public safety professionals, and emergency managers, geoscientists conduct natural hazards research, monitoring, training, education, and public outreach to create an integrated approach to developing resilient communities.



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## To minimize the potential impact of natural hazards:

**Encourage basic and applied research to strengthen community resilience.** Geoscientists study the links between natural hazards and Earth processes and the ways natural hazards impact society. They identify hazard-prone areas through geologic mapping, seismic monitoring, and other investigations.

**Prioritize natural hazard monitoring.** Geospatial tools such as satellites, lidar, seismic networks, and stream gauges help geoscientists collect data to assist in disaster assessment and response and develop better models, forecasts, and warnings.

**Support communication of the risks and vulnerabilities associated with natural hazards to the public.** Geoscientists translate technical data into actionable information, helping to include science in mitigation, preparedness, response, and recovery efforts.

**Mitigate hazard impacts on people, buildings, and infrastructure.** Geoscience research informs transportation planning, land-use practices, and building codes, leading to more resilient communities.



# Soils

## Managing Healthy Soils

The ability of soil to support plant life is vital to the food we eat and the air we breathe. Soils are primarily made of a complex and variable combination of minerals from rocks, organic matter from plants and animals, air, and water.

Geoscientists study the characteristics, history, and efficient management of soils to improve agricultural yields, purify water, treat waste, supply industrial and pharmaceutical goods, evaluate foundation stability for infrastructure, and reduce impacts from natural disasters.



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## To manage the nation's soils efficiently:

**Encourage monitoring of soil quality and moisture for optimal agricultural production.** Soil fertility and its ability to produce crops depend on the nutrients it contains. Better monitoring and management can improve crop yields and potentially reduce offsite contamination.

**Incorporate knowledge of soil characteristics and properties into the planning, design, construction, and modification of critical infrastructure.** Soil and rock provide the foundation for our nation's buildings, roads, bridges, water systems, and pipelines. Understanding soil properties and how they relate to the underlying geology can lead to more resilient infrastructure.

**Expand the use of soil as a filter to remove pollutants from water.** Environmental geoscientists use soil filtration as a natural and relatively inexpensive means to mitigate pollution and improve water quality, particularly for fertilizer application in agricultural settings.

**Characterize soil biodiversity and its relation to essential ecosystem functions.** Healthy soil supports a wealth of biotic diversity. Geoscientists help understand the link between soil microorganisms and the functions they provide to support plant growth, remediate contaminants, and contribute to a drought- and flood-resilient ecosystem.

**Improve soil characterization and geologic mapping to identify underlying hazards.** Earthquakes, landslides, wildfires, droughts, and floods all affect soil stability, occasionally leading to loss of life and property. Identifying and mitigating potential weaknesses in soil layers will benefit society by reducing the likelihood and impact of disasters.



# Mineral Resources

## Providing Raw Materials for Modern Society

Daily activities, national security, and the greater economy all depend on an abundant supply of minerals — from gold for cell phones, to potassium for crop fertilizers, to rare earth elements for missile guidance and clean energy technology, to crushed stone in concrete for buildings and roads.

Despite the pervasiveness of minerals in everyday life, the full extent and accessibility of the nation's mineral resources is not known; supplies of some critical minerals are vulnerable to disruption; and mineral extraction, use, and disposal have environmental impacts that should be better understood and mitigated.

Geoscientists locate and characterize mineral deposits and provide essential information for efficient resource extraction and effective environmental stewardship.



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## To support a secure supply of minerals:

**Assess the nature and distribution of domestic mineral resources.** This basic information on the nation's natural wealth is essential for government, industry, environmental, investment, and community decision making.

**Quantify domestic and global supply of, demand for, and flow of minerals.** Industry relies on a stable supply of raw materials. Understanding and predicting the market forces that impact mineral supply is essential to anticipate and avoid supply disruptions and to make well-informed financial and policy decisions.

**Support socially, economically, and environmentally responsible domestic mineral production.** The United States relies on imports for more than one-half of its apparent consumption<sup>1</sup> of 43 mineral commodities,<sup>2</sup> including several that are considered critical to the national interest, such as rare earth elements.

**Foster innovative solutions to lessen the environmental impact of mining and mineral use.** Recycling and substitution are increasing, but mining is, and will continue to be, the primary source for most materials. New approaches to mining, mineral use, and product disposal can mitigate the impacts of mineral production and consumption.

<sup>1</sup> Apparent consumption is usually defined as (production + imports) – exports.

<sup>2</sup> Mineral Commodity Summaries 2015. U.S. Geological Survey. <<http://minerals.usgs.gov/minerals/pubs/mcs/2015/mcs2015.pdf>>



# Ocean & Coasts

## Expanding Opportunities and Mitigating Threats

The United States depends on the ocean and the Great Lakes for food, national security, energy resources, transportation, recreation, and myriad other critical needs. More than half of the United States population lives in coastal watershed counties that generate 58 percent of the nation's gross domestic product.<sup>1</sup> The United States has jurisdiction over 3.4 million square miles of ocean, more than the land area of all 50 states combined. This vast marine area offers environmental resources and economic opportunities. However, coastal communities are also threatened by tsunamis, hurricanes, industrial accidents, and water-borne pathogens. A better understanding of our ocean and coastal areas will strengthen our economy and protect our people.

Geoscientists provide information about how our planet's coasts, ocean, and seafloor operate now and how they have functioned in the past. They conduct research on marine energy and mineral resources, natural hazards, rising seas, and ocean acidification.

<sup>1</sup> National Coastal Population Report: Population Trends from 1970 to 2020. National Oceanic and Atmospheric Administration. < <http://stateofthecoast.noaa.gov/features/coastal-population-report.pdf> >



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## To ensure the long-term sustainable use of our ocean and coastal resources:

**Support basic and applied research on ocean and coastal issues.** Better knowledge of the ocean and its role in global processes now and in the past allows scientists to forecast for the future. An improved understanding of ocean and coastal processes will reduce damage and promote responsible growth of coastal communities.

**Enhance ocean observations.** The ocean drives global water and weather systems by absorbing, holding, and moving vast amounts of the Earth's heat, water, and CO<sub>2</sub>. A resilient nation needs sustained ocean observations from space, from the ocean surface, and at depth.

**Monitor, research, and respond to sea-level rise.** Sea level is rising at an increasing rate, changing coastal ecosystems and making vital coastal communities vulnerable to erosion and flooding associated with storm surges and high tides.

**Assess marine energy and mineral resources, and their environmental context.** The ocean not only hosts energy and mineral resources but also is a source of energy itself. Most of the marine world remains unexplored, making informed policy a challenge.

# Climate Change

## Confronting Climate Variability

Decades of scientific research show that Earth's climate, the long-term seasonal averages of weather on a regional or global scale, changes as a result of both natural and human causes. Over the past century, global average temperatures have increased significantly.<sup>1</sup> These changes drive sea level rise and exacerbate ocean acidification. Climate change will likely lead to greater storm surges, droughts, heat waves, flooding, and other events that could cost the nation billions of dollars and affect domestic and global security.

Geoscientists use rock and ice cores to study records of past climate, satellites and weather stations to monitor current climate, and sophisticated computer models to project future conditions. This information supports decisions about agriculture, human health, and critical infrastructure.

<sup>1</sup> Temperature Anomalies Time Series, June 2015. National Oceanic and Atmospheric Administration. <<https://www.ncdc.noaa.gov/sotc/global/201506>>



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## To better equip society for a changing climate:

**Encourage research and improve models to understand the connection between Earth's systems, human activity, and climate change.** For more than four billion years, land, water, ice, and the ocean have helped shape, and have been shaped by, a changing climate. Understanding past climates through evidence preserved in the geologic record increases the accuracy of today's climate models and the ability to forecast how ecosystems will respond to climate change.

**Plan for the diverse and complex societal impacts of climate change.** Holistic plans consider not just single weather events but extended effects, such as drought, crop failures, emerging diseases, and damage to ecosystems, which carry the potential for long-term social and economic impact. Information from geoscientists, who are familiar with the interrelated processes that impact climate, strengthens climate-change adaptation plans.

**Evaluate strategies for limiting carbon in the atmosphere.** Scientific evidence indicates that carbon in the atmosphere is a key factor in rising global temperatures. Reducing carbon generation and storing it in geologic formations, also known as carbon capture and storage (CCS), are effective ways to limit atmospheric CO<sub>2</sub>.



# Waste Disposal

## Managing Waste to Maintain a Healthy Environment

Waste is an inevitable byproduct of society. Waste types are as varied as human activities themselves, and many waste products are toxic. Protection of human health and the environment often relies on geoscience knowledge to isolate waste materials from people and ecosystems.

Geoscientists translate their understanding of complex Earth systems into meaningful approaches for isolating waste streams and remediating waste sites.



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### To optimize the balance between resource use and a healthy society:

**Assess the safety of disposing of liquid waste in deep wells.** This method of disposal is commonly used today to dispose of treated wastewater, chemicals, and oil field brines, but it can potentially induce earthquakes or contaminate groundwater. Geoscience investigations can help make disposal safer.

**Understand and minimize impacts of energy production and usage.** Energy byproducts include solid wastes such as fly ash, thermal pollution of water from power plant cooling, liquid wastes, and gaseous byproducts such as CO<sub>2</sub>.

**Mitigate the high risk associated with nuclear waste.** Large volumes of spent nuclear fuel are currently stored at multiple temporary sites in the United States, and more such waste continues to be generated. A long-term disposal option is still needed for this toxic radioactive waste, and a geologic repository may provide a long-term solution. Geoscientists provide information to help assess site suitability and selection.

**Support cleanup of abandoned mines, brownfields, and Superfund sites.** Landfills, dumps, and spills can introduce a wide variety of toxic chemicals into the environment. Geoscience provides a basis for evaluating risks, setting priorities for remediation, and assuring that expenditures yield substantial benefits.

# Workforce & Education

## Meeting the Future Demand for Geoscientists

The 300,000 geoscientists<sup>1</sup> currently working in the U.S. private and public sectors help the nation ensure a clean and sustainable water supply; explore, access, and manage its energy and mineral resources both on land and under the sea; monitor, forecast, and mitigate terrestrial and marine natural hazards; support agricultural soil productivity; research land-sea-atmosphere interactions to understand the changing climate; and safely clean up environmental contamination and dispose of waste. By sharing their knowledge with students and the public, geoscientists help to create a society that understands Earth's processes and recognizes resource, hazard, and environmental issues.

The economic demand for geoscientists will continue to grow within the United States and worldwide, yet increasing numbers of U.S. geoscientists are reaching retirement age. AGI estimates a shortage of 135,000 geoscientists within the U.S. economy by 2022.<sup>2</sup> The nation's schools, colleges, and universities must be ready to educate and train this next generation of geoscientists.

<sup>1</sup> Wilson, C.E., The Status of the Geoscience Workforce 2014. Alexandria, VA: American Geosciences Institute, 2014. <[www.americangeosciences.org/workforce/reports/status-report-2014](http://www.americangeosciences.org/workforce/reports/status-report-2014)>

<sup>2</sup> Ibid.



Images all from AGI's 2014 Life in the Field contest. Photographers, top to bottom: Arnaud Mansat; Alisa Kotash; Judah Epstein; Rob Thomas.

## To develop a knowledgeable, experienced, and innovative geoscience workforce:

**Sustain and grow programs to educate a diverse group of students in science, technology, engineering, and math (STEM).** Geoscience educators ensure that students across the U.S. at all levels have opportunities to learn about the Earth. They recruit, teach, and retain talented students and encourage them to pursue careers in geoscience and related STEM disciplines.

**Support federal investments in basic and applied geoscience research.** Federally funded research leads to scientific discovery and provides critical educational opportunities for students pursuing geoscience careers.

**Encourage partnerships between industry, government, and universities and colleges.** Private-sector research and development is essential to maintaining America's globally competitive, knowledge-driven economy. Partnerships between government, industry, and higher education promote innovation while enhancing the educational environment and preparing students graduating from U.S. colleges and universities for the workforce.



# What do the Geosciences Include?

Water research to **ensure water quality and quantity**

Petroleum geology to **identify and recover energy resources**

Natural hazard science to **help ensure safer, more resilient communities**

Soil science to **monitor soil quality and health for agriculture and construction**

Environmental geology to **protect and provide a healthy environment**

Engineering geology to **build stable infrastructure**

Economic geology to **locate and extract mineral resources**

Coastal geology to **support sustainable use of coastlines**

Oceanography to **protect maritime productivity and ocean commerce**

Atmospheric research for **weather forecasting and climate modeling**

Planetary science to **better understand Earth and other planets**

Geoscience education to **cultivate a society that understands the Earth**

Image credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group; MODIS Science Data Support Team; MODIS Atmosphere Group; MODIS Ocean Group Additional data: USGS EROS Data Center (topography); USGS Terrestrial Remote Sensing Flagstaff Field Center (Antarctica); Defense Meteorological Satellite Program (city lights).

## About AGI

AGI connects Earth, science, and people by serving as a unifying force for the geoscience community. With a network of 51 member societies, AGI represents more than a quarter-million geoscientists with specialized knowledge of the Earth and its interactions.

AGI was founded in 1948, under a directive of the National Academy of Sciences, as a network of associations representing geoscientists with a diverse array of skills and knowledge of our planet. The Institute provides information services to geoscientists, serves as a voice of shared interests in our profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in society's use of resources, resilience to natural hazards, and the health of the environment.



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### AGI Programs

**EARTH magazine:** This monthly publication explores the science behind the headlines. EARTH magazine gives readers definitive coverage on topics from natural resources, energy, natural disasters and the environment to space exploration and paleontology and much more.

**Education and Outreach:** AGI Education offers products and services for K-12 educators, including NSF-funded curricula, high-definition videos, classroom activities, teacher professional development, and online resources.

**GeoRef:** GeoRef is a comprehensive, bibliographic database containing over 3.6 million references to geoscience journal articles, books, maps, conference papers, reports, and theses.

**Policy and Critical Issues:** Geoscience Policy works with AGI member societies and policy makers to provide a focused voice for the shared interests of the geoscience profession in the federal policy process. Critical Issues provides a portal to comprehensive, impartial geoscience information for decision makers.

**Workforce:** AGI Workforce studies the human resources of the geoscience community, produces the Directory of Geoscience Departments, collects data on the supply of and demand for geoscientists, and works to ensure that the health of the profession is understood and improved.

**Earth Science Week:** Reaching over 50 million people a year, Earth Science Week promotes awareness of Earth science and appreciation of the geosciences' role in society. This international public awareness campaign, organized each October by AGI, provides informational resources, educational materials, and a variety of events and activities for students, teachers, and others. Program partners in government, industry, and the nonprofit sector unite to advance these efforts and continue the solid track record of success of this nearly two-decade-old initiative ([www.earthsciweek.org](http://www.earthsciweek.org)).

**Center for Geoscience and Society:** The Center links geoscience information to diverse, non-specialist audiences, with a particular emphasis on communicating with decision makers at all levels and with educators in non-geoscience disciplines.

**AGI Foundation:** The Foundation is the principal source of U.S. tax-deductible endowment and programmatic contributions to the American Geosciences Institute from industry, private foundations, and individual donors.



# AGI Member Societies

AASP-The Palynological Society (AASP)  
American Association of Petroleum Geologists (AAPG)  
American Geophysical Union (AGU)  
American Institute of Hydrology (AIH)  
American Institute of Professional Geologists (AIPG)  
American Rock Mechanics Association (ARMA)  
Association for the Sciences of Limnology and Oceanography (ASLO)  
Association for Women Geoscientists (AWG)  
Association of American Geographers (AAG)  
Association of American State Geologists (AASG)  
Association of Earth Science Editors (AESE)  
Association of Environmental & Engineering Geologists (AEG)  
Clay Minerals Society (CMS)  
Council on Undergraduate Research, Geosciences Division (CUR)  
Environmental and Engineering Geophysical Society (EEGS)  
Friends of Mineralogy (FOM)  
The Geochemical Society (GS)  
Geo-Institute of the American Society of Civil Engineers (GI)  
Geological Association of Canada (GAC)  
Geological Society of America (GSA)  
The Geological Society of London (GSL)  
Geoscience Information Society (GSIS)  
History of Earth Sciences Society (HESS)  
International Association of Hydrogeologists/U.S. National Chapter (IAH)  
International Medical Geology Association (IMGA)  
Karst Waters Institute (KWI)  
Mineralogical Society of America (MSA)  
Mineralogical Society of Great Britain and Ireland (MSGBI)

National Association of Black Geoscientists (NABG)  
National Association of Geoscience Teachers (NAGT)  
National Association of State Boards of Geology (ASBOG)  
National Cave and Karst Research Institute (NCKRI)  
National Earth Science Teachers Association (NESTA)  
National Ground Water Association (NGWA)  
National Speleological Society (NSS)  
North American Commission on Stratigraphic Nomenclature (NACSN)  
Paleobotanical Section of the Botanical Society of America (PSBSA)  
Paleontological Research Institution (PRI)  
Paleontological Society (PS)  
Petroleum History Institute (PHI)  
Seismological Society of America (SSA)  
SEPM (Society for Sedimentary Geology) (SEPM)  
Society for Mining, Metallurgy, and Exploration, Inc. (SME)  
The Society for Organic Petrology (TSOP)  
Society of Economic Geologists (SEG)  
Society of Exploration Geophysicists (SEG)  
Society of Independent Professional Earth Scientists (SIPES)  
Society of Mineral Museum Professionals (SMMP)  
Society of Vertebrate Paleontology (SVP)  
Soil Science Society of America (SSSA)  
United States Permafrost Association (USPA)  
  
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Geological Society of Africa (GSAf)  
International Association for Promoting Geoethics (IAPG)  
YES Network

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