

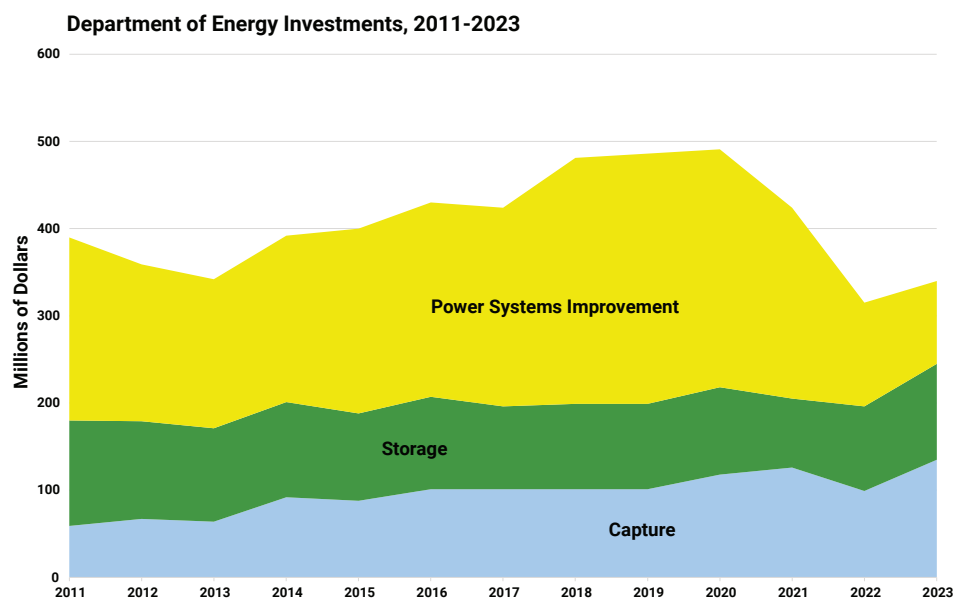
Geosciences Partnering in Innovating the Future



GEOSCIENCES IMPACT ON INNOVATION

Geoscientists and the geosciences contribute significantly to innovation, particularly in the United States, by driving advancements in critical sectors such as energy, raw materials, environmental management, and natural disaster preparedness. Through their work in understanding earth systems, geoscientists develop new methods for energy extraction and conservation, contributing to the sustainability and efficiency of resources like oil, natural gas, and renewables. Their research into geological formations and processes informs safer construction practices, mineral extraction, groundwater exploration, land-use

planning, and mitigating risks from earthquakes, landslides, and other geohazards. Additionally, geoscientists play a crucial role in addressing environmental challenges, pioneering techniques for carbon capture and storage, and improving water resource management. These innovations not only bolster the U.S. economy but also enhance its resilience against environmental and climatic shifts, making geosciences a vital field for policy and investment focus. It also offers a tangible pathway to bolster the STEM workforce through inspiring talent looking to improve how we live in the world through new technologies and methods.



The U.S. Department of Energy has been investing in technological approaches to reducing the carbon footprint of the U.S. economy. These approaches have included improving the carbon efficiency of power systems, and increasingly on capturing and permanently storing carbon before it enters the atmosphere.

Energy Exploration and Extraction

Geoscientists innovate in methods to locate and efficiently extract natural resources, including oil, gas, and geothermal energy, which are vital for the nation's energy independence.

Environmental Protection and Restoration

Geoscientists utilize geological knowledge to restore degraded landscapes, manage waste disposal, and rehabilitate ecosystems affected by industrial activities.

Water Resources Management

Hydrogeologists ensure secure and sustainable groundwater quantity, quality, and distribution, which are critical for agriculture, industry, drinking water, and urban development.

Advanced Material Development

Geoscientists discover and characterize new mineral deposits increasingly in extreme environments, that can be used in technology and manufacturing, driving technological advances. Geoscientists are particularly focused on extractive material processes which are central to utilizing new raw material sources and advanced recycling.

Hazard Assessment and Mitigation

Geologists and geophysicists develop predictive models and tools to assess and mitigate risks associated with natural disasters like earthquakes, volcanoes, and landslides, enhancing public safety and infrastructure resilience.

Climate Change Research

Geoscientists investigate the geological record to understand past climate changes and predict future trends, contributing to strategies for adaptation and mitigation.

Carbon Capture and Storage

Geologists and geochemists lead efforts in the geological sequestration of carbon dioxide to combat climate change and reduce greenhouse gas emissions and enhance the recovery of oil and natural gas and critical minerals.

Coastal and Marine Geosciences

Oceanographers and marine geologists enhance the understanding of coastal processes and marine ecosystems, important for managing coastal development, protecting marine biodiversity, and supporting fisheries. Advanced knowledge of marine geology is needed for anchoring renewable energy infrastructure, such as wind turbines.

EXEMPLARS OF IMPACTS OF GEOSCIENCE ON INNOVATION

Geoscientists use advanced geophysical and geochemical techniques to discover and evaluate mineral deposits essential for manufacturing, technology, and construction industries. Innovations in this field have led to more efficient extraction methods that are less invasive and more environmentally sensitive. Innovations in operating in extreme environments, whether in deep water, polar environments, or extreme depths into the crust, have opened new possibilities for accessing minerals and hydrocarbons located in previously untapped locations and doing so with modern, environmentally sustainable practices from the start. Hydraulic fracturing of low-permeability rock formations has led to a revolution in natural gas production, making the U.S. a world leader.

Geoscientists are at the forefront of exploring geoengineering solutions, such

as artificial enhancement of rock weathering or crustal injection, to remove carbon dioxide from the atmosphere and mitigate the effects of climate change. By mapping and analyzing the distribution and quality of natural resources, geoscientists develop sustainable management practices that minimize environmental impact

and help balance ecological needs with human usage. Geoscientists contribute to the renewable energy sector by assessing geothermal energy potential and improving the extraction and management of these resources. They also play a critical role in locating and evaluating sites suitable for wind and solar energy farms.





CASE STUDIES

In the past decade, geoscientists have driven innovations in hydraulic fracturing and horizontal drilling technologies. These advancements have unlocked vast reserves of shale gas, particularly in formations like the Marcellus Shale in Pennsylvania, significantly boosting the U.S. energy supply and reducing reliance on imported oil, while reducing net carbon emissions.

In the central U.S., geoscientists study the Ogallala Aquifer to implement sustainable water use strategies that address concerns over the rapid depletion of this critical water resource supporting one of the world's largest agricultural economies.

The Illinois Basin-Decatur Project captures CO₂ from ethanol production and stores it in saline aquifers. This project, supported by geoscientific research, showcases practical applications of carbon capture and storage technology.

Geoscientists have identified economically viable concentrations of rare earth elements in coal byproducts, leading to methods for extracting these critical materials used in high-tech devices, thus reducing dependency on imported materials.

In response to land loss and hurricane damage, geoscientists have developed models and techniques for coastal restoration in Louisiana, including river diversions to rebuild wetlands and barrier islands, crucial for protecting coastal communities and ecosystems.



EXAMPLES OF RELEVANT LEGISLATION AND POLICY

Executive Orders

- ▶ **14008:** Directive on climate change directly involves innovation in geosciences through its focus on clean energy technologies, sustainability, and environmental protection. It mandates significant investment in climate-related scientific research and the deployment of technologies that will leverage geoscientific knowledge.

Congressional Legislation

- ▶ **117th — S. 1260:** U.S. Innovation and Competition Act (USICA). While not enacted into law as a whole, various components of this comprehensive package were integrated into other legislation, including the CHIPS and Science Act. USICA originally included significant funding for basic and advanced research, enhancing America's competitiveness in science and technology, including environmental and earth sciences.
- ▶ **117th — H.R. 4521:** America COMPETES Act of 2022. This is another legislative effort, like USICA, aiming to significantly boost U.S. capabilities in technology and scientific research. It includes support for STEM education and workforce development, which would inherently support the geosciences sector.

Relevant Federal Agencies

- ▶ National Science Foundation
- ▶ U.S. Department of Energy
- ▶ National Institute of Standards and Technology

Related National Academy Reports

- ▶ Climate Intervention in an Earth Systems Science Framework: Proceedings of a Workshop-in Brief (2024)
- ▶ Foundational Research Gaps and Future Directions for Digital Twins (2024)
- ▶ Progress and Priorities in Ocean Drilling: In Search of Earth's Past and Future (2024)
- ▶ Supporting Black Students Through Their Science, Engineering, and Medicine Career Journeys: Proceedings of a Workshop (2024)
- ▶ Accelerating Decarbonization in the United States: Technology, Policy, and Societal Dimensions (2023)

Non-Partisan Non-Profit Expertise

- ▶ American Association of Petroleum Geologists
- ▶ American Institute of Hydrology
- ▶ American Institute of Professional Geologists
- ▶ Association of American State Geologists
- ▶ Association of Environmental and Engineering Geologists
- ▶ National Groundwater Association
- ▶ National Sand, Stone, and Gravel Association
- ▶ Society of Economic Geologists
- ▶ Society of Exploration Geophysicists
- ▶ Society for Mining, Metallurgy, and Exploration