GEOInnovation and Entrepreneurship: Accelerating Geoscience Impact to Society and the Economy

Presented by the Geological Society of America

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The Geological Society of America engaged the greater geoscience community around the subject of geoinnovation and entrepreneurship via a crowdsourcing effort. Responses indicate that while there is indeed a disconnect between geoscientists and an entrepreneurial mindset, this is not due to lack of interest in the geoscience community. There is recognition within the community that society faces challenges in the areas of climate change, energy resources, water, and mineral resources, among others, but that geoscientists are insufficiently represented in the efforts to find marketable solutions to these problems.

We collected information via crowdsourcing, specifically using an online survey containing four questions regarding innovation and entrepreneurship in the geosciences:

1. **What stands in the way of geoscientists becoming entrepreneurs and company founders? What resources, incentives, training, facilities, or changes in mindset are needed to overcome these barriers?**

2. **What ideas or suggested mechanisms might change the status quo and foster a thriving geoinnovation and entrepreneurial ecosystem focused on delivering results to society and the economy?**

3. **Which existing models, partnerships, programs, or projects constitute promising approaches to encouraging innovation and entrepreneurship in the geoscience community?**

4. **Where can the biggest and fastest gains be made?**

We advertised this survey extensively using direct engagement with the community at in-person events, social media channels, and direct emails to the GSA community. GSA is grateful to its members, meeting attendees, and the larger geoscience community for their engagement and contributions to this effort. Here we summarize the responses and recommendations, provide a brief summary of methods, and give an overview of response rates and demographics of participants.

A review of the survey responses reveals a great deal of overlap in the answers provided to the four survey questions. Several themes emerged from the data: geoscientists need more training and education in business skills, and this need is not recognized by traditional “academic mindsets”; a desire for opportunities for networking and collaborating with successful entrepreneurs and innovators including those in businesses, government entities, and academia; a need to develop supportive infrastructures including venture capital opportunities, geoscience business incubators and accelerators, and training opportunities; the acknowledgment that the public’s perception of geoscience often undervalues the work that geoscientists contribute to society while also addressing that geoscientists need to more greatly value the role of social responsibility; a focus on broadening participation, thus diversifying the perspectives and approaches of these endeavors; and a discipline-specific focus on the role of energy production balanced with sustainability.

QUESTION 1

What stands in the way of geoscientists becoming entrepreneurs and company founders? What resources, incentives, training, facilities, or changes in mindset are needed to overcome these barriers?

QUESTION 2

What ideas or suggested mechanisms might change the status quo and foster a thriving geoinnovation and entrepreneurial ecosystem focused on delivering results to society and the economy?

The responses to these first two questions lay out a series of clear challenges and actionable solutions.

LACK OF BUSINESS KNOWLEDGE

Most respondents discussed lack of business knowledge as the primary barrier to more geoscientists becoming entrepreneurs. This gap in knowledge is attributed to a general lack of business education and training within traditional geoscience degrees. This omission may also prevent some business-minded students from pursuing a geoscience degree, exacerbating a bias through self selection. However, gaps in the current geoscience curricula could be bridged with more targeted training. There are numerous examples of courses in physics, chemistry, and engineering departments—and in the few geoscience departments that have courses or professional master's offerings—that provide models for the geosciences. Two examples are Stanford's joint MD/MBA program and Rice University's Professional Science Master's Program, which focuses on business skills coupled with geoscience education (but not on original research or entrepreneurship).

ACADEMIC MINDSET VS. ENTREPRENEURIAL MINDSET

The development of an "entrepreneurial mindset" was also mentioned as a key need, suggesting that geoscientists could be encouraged to take risks and innovate. Interestingly, an academic mindset was frequently mentioned as the converse. Broadly speaking, faculty are encouraged to publish (not seek patents or start companies), while students are trained to be skilled workers and encouraged to pursue academic careers. These cultural aspects of a university education create additional selection bias and may help explain why some faculty do not see a benefit in encouraging an entrepreneurial mindset among their students. Without fostering an environment that supports geoinnovation and entrepreneurship, budding entrepreneurs will have difficulty finding a home within the geosciences. Other science and engineering fields have made changes to the tenure process—for example, giving credit for patents alongside academic publications—and have built technology transfer infrastructure to help turn scientific discoveries into commercial applications.

LACK OF BUSINESS NETWORKS AND INTERDISCIPLINARY COLLABORATION

In addition to formal training that comes from courses, workshops, and degree programs, less structured mentoring and networking is a building block to creating a vibrant, effective entrepreneurial ecosystem. There is a lack of understanding that a scientist or innovator in entrepreneurship does not necessarily have to become a founder. Identifying a problem, a solution, or a need are all ways that a geoscientist can contribute to an entrepreneurial endeavor. Thus, having the opportunity to be part of an interdisciplinary team with different skill sets is critical for geoscientists to understand what unique value they can bring to a practical challenge. And being exposed to geoscientists engaged in business, including mentors, is valuable for geoscientists to gain insights and connections that could lead to entrepreneurial success.

ACCESS TO RESOURCES

Access to various resources, including start-up capital, is a concern, indicating that geoscientists require more support to start and run a business. Given the broad set of fields in which geoscience knowledge and skills may have value, there is a potential need for targeted grants or venture capital to help commercialize promising ideas from geoscientists. The creation of a supportive ecosystem, including geoscience-focused incubators and accelerators, is seen as crucial for providing resources and mentorship. More interaction with business-minded partners (e.g., founders, capital providers, and interdisciplinary networks) will help geoscientists identify opportunities where they can bring the most value.

Collectively, these themes suggest that improving educational opportunities in entrepreneurship, providing financial resources, enhancing collaboration and networking opportunities, facilitating technology transfer, and building supportive infrastructures are vital to changing the status quo and fostering a thriving geoinnovation ecosystem.

QUESTION 3

Which existing models, partnerships, programs, or projects constitute promising approaches to encouraging innovation and entrepreneurship in the geoscience community?

The responses to this question echo the responses to questions 1 and 2, with a strong focus on business education and geoscience focused grants and venture capital. However, there were a few additional approaches that were suggested.

PUBLIC AWARENESS

One popular belief is that the geosciences are exclusively a field-based observational science. This belief restricts the ways in which the public, funders, and potential partners understand the full value of geoscientists. The collective training that geoscientists have spans the natural sciences (chemistry, engineering, math, ecology, etc.) and includes many disparate skills (applied math, AI, programming, chemical analysis, mineralogy, modeling, etc.). Moreover, the public is unaware that geoscientists are responsible for much of the knowledge that informs the public's understanding of many of the earth's major challenges (climate change, natural hazards, energy transition, GHG mitigation, etc.) Increasing visibility of geoscience and geoscientists will increase the public's understanding of the value and role of the geosciences.

GOVERNMENT SUPPORT

A number of respondents called for more collaboration among "governments, scientific institutions, enterprises and academia," recognizing the need for multiple perspectives, financial support, and joint research in order to develop new products and processes. There was also a call for expanded state-level support, such as cooperative extension to include the geosciences. There is also acknowledgement that some barriers, such as access to healthcare as an early-stage entrepreneur or funding applied research, are shared by other disciplines beyond the earth sciences.

SOCIAL RESPONSIBILITY

Many respondents directly or indirectly noted the importance of social responsibility at the intersection of the geosciences and entrepreneurship. Some noted it as an asset, because geoscientists have knowledge that can help identify marketable solutions to climate mitigation and adaptation. Others observed that the association of the geosciences with natural resource extraction and fossil fuels presented a public perception challenge and a motivation to pursue discoveries that would help ensure the future habitability of Earth.

These themes and specific mentions suggest a consensus among the respondents on the importance of collaborative efforts, educational and training programs, financial backing, and structured support systems in promoting innovation and entrepreneurship within the geosciences.

QUESTION 4

Where can the biggest and fastest gains be made?

Responses to this question included some of the ideas mentioned previously, such as increased business education, mentoring from successful entrepreneurs, support for incubators, dedicated funding, partnerships with engineers, increased public awareness, changes university curricula, and support for new discovery and patents. Respondents also recognized the potential of the immense amount of data within the geosciences. However, many responses related to the energy transition and sustainability highlighted some inherent tensions within the geoscience community.

ENERGY TRANSITION AND SUSTAINABILITY

Many respondents suggested that the geosciences can play a major role in the energy transition through mineral exploration (either on Earth or other planetary bodies) and by leveraging knowledge of petroleum exploration to support the development of geothermal energy and carbon capture. There was an equally large number of responses that promoted non-extractive solutions to sustainability and planetary stewardship, including recycling mine tailings, soil and water conservation/revitalization, and environmental protection. The tension between these two perspectives illustrates both the diversity of the geosciences and some of the challenges for the field in how to position the geosciences for greater public awareness.

BROADENING PARTICIPATION

Many respondents focused on broadening participation as a route to useful innovation. By increasing representation in emerging markets, developing economies, and traditionally underrepresented groups, the geoscience community overall will generate more innovative solutions because of a greater diversity of needs, skills, and perspectives.

Methods

We created a four-question survey using Survey Monkey and made it accessible via web link and a linked QR code. The survey was opened to respondents on 3 October 2023 and closed on 31 October 2023. The survey was advertised via the Geological Society of America's website, social media channels (X, Facebook, LinkedIn), targeted emails to members, emails to attendees of GSA Connects (GSA's annual meeting), and in person at the National Association of Black Geoscientists meeting, GSA Connects, and the Society for the Advancement of Chicanos and Native Americans in Science National Diversity in STEM meeting. Respondents were asked to answer a series of questions, described below. After each question, in parentheses, we denote the number of respondents followed by the number of respondents who declined to answer that question. Specific to innovation in the geosciences, we asked the following four questions:

1. **What stands in the way of geoscientists becoming entrepreneurs and company founders? What resources, incentives, training, facilities, or changes in mindset are needed to overcome these barriers? (109, 323)**

2. **What ideas or suggested mechanisms might change the status quo and foster a thriving geoinnovation and entrepreneurial ecosystem focused on delivering results to society and the economy? (109, 323)**

3. **Which existing models, partnerships, programs, or projects constitute promising approaches to encouraging innovation and entrepreneurship in the geoscience community? (106, 326)**

4. **Where can the biggest and fastest gains be made? (104, 328)**

Responses were collected in a short-answer style with no character limit, although respondents were asked to limit responses to 250 words. Survey respondents were also asked to answer seven optional questions describing demographics. Response options are indicated in italics:

5. **Which of the following best describes your career stage?**
   ***Undergraduate Student; Graduate Student; Early Career Professional; Professional; Retired* (422, 10)**

6. **What is your ethnicity? (Check all that apply):**
   ***American Indian or Alaska Native; Asian; Black or African American; Hispanic or Latinx; Native Hawaiian or Pacific Islander; White/Caucasian; Middle Eastern or North African; Prefer not to answer* (421, 11)**

7. **What is your gender?**
   ***Man; Woman; Non-binary; Prefer not to answer* (420, 12)**

8. **What is your primary professional interest?**
   ***Archaeological Geology; Biogeosciences; Climatology/Meteorology; Economic Geology; Engineering Geology; Environmental Science; Geography; Geoinformatics; Geology and Health; Geophysics/Tectonophysics; Geoscience Education; Geothermal; History/Philosophy of Geology; Hydrogeology/Hydrology; Karst; Limnogeology; Marine and Coastal Geoscience; Mineral Geochemistry, Petrology, and Volcanology; Organic Geochemistry; Paleo Sciences; Paleoecology; Planetary/Space Science; Policy/Regulatory; Quaternary Geology/Geomorphology; Seismology; Soil Science; Stratigraphy/Sedimentology; Structural Geology/Tectonics; Other* (420, 12)**

9. **What industry do you work in?**
   ***Administrative; Elementary; Secondary; Two-Year College; Four-Year University/College; Energy; Hydro; Museum/Science Tech Center; Minerals; Engineering; Environmental; Oil/Gas; Self-Employed/Consultant; City/County; State/Province; Federal; Student; Retired; Unemployed; Other* (415, 17)**

10. **What geographic location do you live in?**
    ***Africa; Asia; Australia; Europe; North America; South America* (412, 20)**

11. **If you live in the United States, which state or territory do you live in?**
    ***Alabama; Alaska; American Samoa; Arizona; Arkansas; California; Colorado; Connecticut; Delaware; District of Columbia; Florida; Georgia; Guam; Hawaii; Idaho; Illinois; Indiana; Kowa; Kansas; Kentucky; Louisiana; Maine; Maryland; Massachusetts; Michigan; Minnesota; Mississippi; Missouri; Montana; Nebraska; Nevada; New Hampshire; New Jersey; New Mexico; New York; North Carolina; North Dakota; Northern Marianas Islands; Ohio; Oklahoma; Oregon; Pennsylvania; Puerto Rico; Rhode Island; South Carolina; South Dakota; Tennessee; Texas; Utah; Vermont; Virginia; Virgin Islands; Washington; West Virginia; Wisconsin; Wyoming; Other* (386, 46)**