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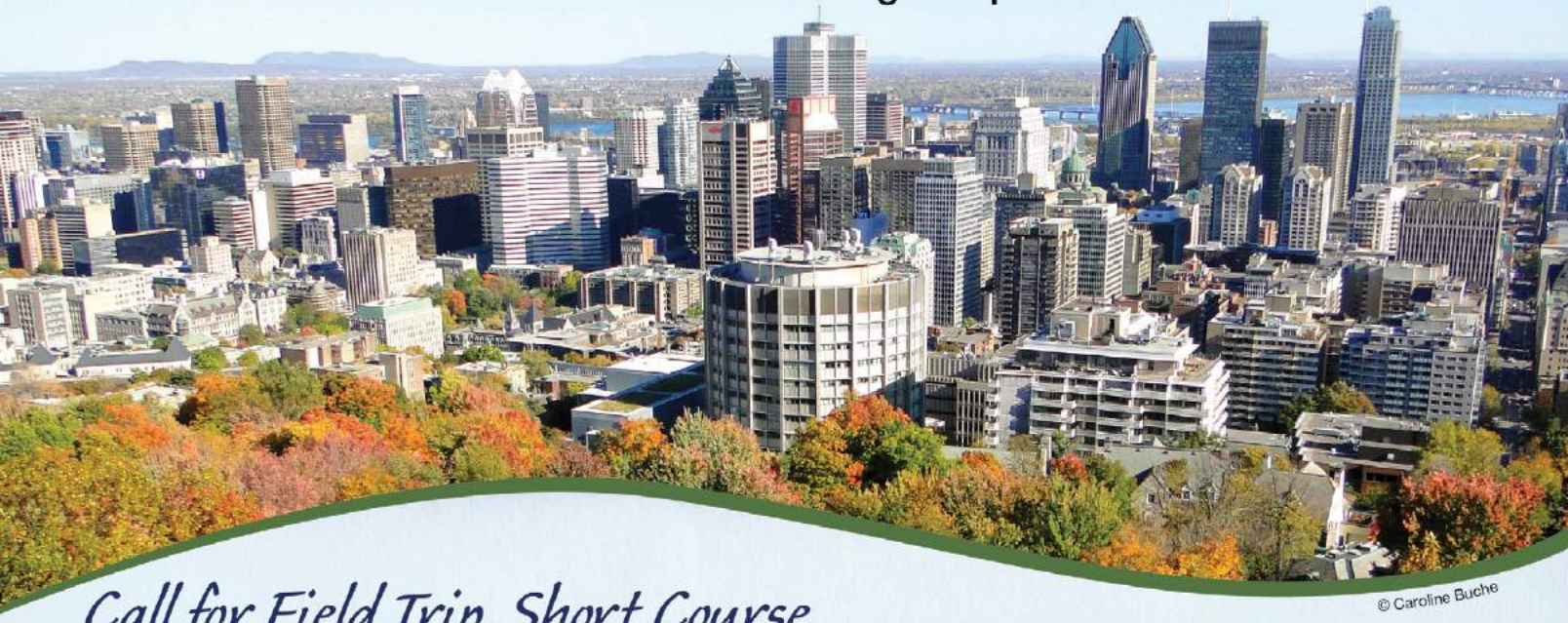
The Role of Introductory Geoscience Courses in Preparing Teachers—And All Students—For the Future: Are We Making the Grade?

25–28 October

GSA 2020

Montréal, Québec, Canada

GSA 2020 Annual Meeting & Exposition



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Call for Field Trip, Short Course, and Technical Session Proposals

It's time to plan for our 2020 Annual Meeting in Montréal, Québec, Canada. We look forward to highlighting the geology in the area. We challenge you to propose a field trip, short course, and/or a technical session that will teach your colleagues and promote discussion about the incredible regional geology.

Show the geology by leading a Field Trip.

Field Trip proposal deadline: 1 Dec. 2019

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Dear Colleagues,

GSA is committed to the ideal of scientific discovery, rigor, diversity, and integrity.

I invite you to prepare a proposal for a technical session for the 2020 Annual Meeting that reflects your expertise and research but also pushes the boundaries of the discipline. Without expanding our horizon, we will not move the geosciences forward and keep our relevance. I also challenge you to broaden your reach with whom you collaborate by including diversity in all ways—discipline, career progression, and individuals.

Thank you for considering sharing your science and work at the GSA Annual Meeting.

Vicki S. McConnell

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THE GEOLOGICAL SOCIETY OF AMERICA®

The Role of Introductory Geoscience Courses in Preparing Teachers—And All Students—For the Future: Are We Making the Grade?

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ABSTRACT

Introductory geoscience courses enroll hundreds of thousands of students a year, most of whom do not major in the geosciences. For many, including future K–12 teachers, an introductory course is the only place they will encounter Earth science at the college level. New standards for K–12 science education have profound implications for teacher preparation, particularly in Earth science. The new standards call for taking a systems approach, highlighting how humans interact with Earth, making use of science and engineering practices, and engaging students in discourse. Analysis of responses to the National Geoscience Faculty Survey (n = 813 in 2004; n = 994 in 2009; n = 972 in 2012; and n = 1074 in 2016) and data from 152 syllabi suggest that a systems approach is not widespread and human interactions with Earth are not emphasized, and that most instructors engage students in mostly low cognitive-level practices. While the use of discourse practices has increased over time, these and other active learning components are not yet widely included in students' grades. These results suggest that courses are not currently well-aligned with teacher needs. However, instructors have access to many research-based instructional resources to support them in making changes that will help *all* students—including future teachers.

INTRODUCTION

Several hundred thousand students enroll annually in introductory geoscience courses at institutes of higher education (Martinez and Baker, 2006). Fewer than 4000 students a year graduate with undergraduate degrees in geoscience (Wilson, 2016), however, which means that these courses serve a very large population of students that major in anything *other* than the geosciences. Few science majors require their students to take a geoscience course—it is not common for biology (Cheesman et al., 2007), nor recommended as a cognate for chemistry (ACS-CPT, 2015). In most cases, therefore, students enroll in geoscience courses to fulfill a general education requirement (Gilbert et al., 2012). Within this audience is a group of students that will become K–12 teachers, as most traditional teacher preparation programs do not include specific science content courses as part of their curricula (NRC, 2010). In the current teaching workforce, 64% of middle school teachers and 42% of high school teachers assigned to teach Earth science took no geoscience courses beyond introductory (Banilower et al., 2013). One critical purpose that introductory geoscience courses serve, therefore, is providing future teachers with their primary college-level Earth-science experience.

While it is easy to lament the numbers, teacher preparation is part of a complex system influenced by state certification, district needs and requirements, university degree requirements, and many other components (NRC, 2010). Within this complex system, disciplinary departments at institutes of higher education often play the role of content providers. Given this role, how well do introductory courses in the geosciences serve the population of future teachers?

BACKGROUND

Starting in 2007, communities of scientists developed consensus documents that define what every citizen should know about climate science (Climate Literacy Network, 2009), atmospheric science (UCAR, 2007), the oceans (Ocean Literacy Network, 2013), and Earth science (ESLI, 2010). A few years later, work began at the national level to develop a new set of science standards for grades K–12. An early step in that process was the publication of the *Framework for K–12 Science Education* (NRC, 2012b), which articulates three interconnected dimensions: science and engineering practices, cross-cutting concepts, and disciplinary core ideas. The disciplinary core ideas in the Earth and space sciences (Earth's place in the universe, Earth's systems, and Earth and human activity) emerged from the literacy documents, and thus represent a broad consensus of the scientific community (Wysession, 2012). The *Framework* provided guidance for the development of the Next Generation Science Standards (NGSS), which consist of a limited number of rigorous learning goals expressed as performance expectations (PEs) that integrate the three dimensions (see Table S1 in the GSA Data Repository[1]) (NGSS Lead States, 2013).

The vision for K–12 science education in the *Framework* and NGSS represents a significant shift conceptually and pedagogically, especially in Earth science. Conceptually, the NGSS take a systems approach, emphasizing the dynamic interactions between the atmosphere,

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[1]GSA Data Repository item 2019217, which includes methods, additional survey results, and selected components of the Next Generation Science Standards, is online at www.geosociety.org/datarepository/2019.

ocean, land, and life—an approach that has been advocated for more than 20 years (e.g., Ireton et al., 1996) but has been slow to be adopted. The system includes humans, too: no longer, for example, will it be sufficient for students to describe the global distribution of resources. In the new standards, the PEs ask students to tie that distribution to human activity and assess the impacts of resource extraction on the environment (Table S1 [see footnote 1]).

Pedagogically, integrating the three dimensions requires that "students actively engage in scientific and engineering practices in order to deepen their understanding of cross-cutting concepts and disciplinary core ideas" (NRC, 2012b, p. 217). The structure of this sentence is purposeful: active engagement in the practices comes *first* and leads to deeper understanding. The practices describe the use of data as the foundation for developing explanations that are modified and refined through active discourse (Table S2 [see footnote 1]). In Earth science, the PEs shift the focus from identification and description of Earth materials and landforms to analyzing geoscience data to construct explanations, make decisions, and evaluate solutions (Table S1 [see footnote 1]). Together, these changes led Wysession (2014) to assert that "the NGSS provide America's best opportunity yet in its almost 240-year history to educate its citizens about the complex and critical issues of Earth science."

This is an exciting development for the Earth-science community but one that will not be fully realized without deliberate effort from all components of the educational system. Because a powerful way that teachers learn to teach is by observation, mimicking the teaching strategies they have experienced as learners (Windschitl and Stroupe, 2017), one key leverage point for effecting change is the science courses that future teachers take. In the geosciences, we have two rich data sets that can be explored to assess the extent to which introductory geoscience courses align with the vision of the *Framework*. The National Geoscience Faculty Survey (NAGT, 2018) was administered in 2004, 2009, 2012, and 2016. The original survey was developed before the *Framework*, but is based on the same foundational documents. Over the four administrations, 3853 responses address introductory courses. A second data set comes from participants in professional development opportunities (PD) led by On the Cutting Edge (Manduca et al., 2010), who uploaded syllabi to a digital repository, where they are publicly available (SERC, 2002). The methods of analysis of these two data sets are described in the GSA Data Repository (see footnote 1).

RESULTS

Demographics

The number of respondents who completed the survey describing an introductory course they teach has been ~1000 for the past three administrations (Table S3 [see footnote 1]); responses come from all institution types, as do the 152 syllabi uploaded between 2002 and 2016 (Table S4 [see footnote 1]). Although the distribution across institution types differs somewhat, both fall within range of an earlier report on introductory courses (Martinez and Baker, 2006). Both data sets include courses that span the disciplines in the geosciences, with the largest combined numbers in Earth science, geology, and oceans (Table 1), which are among the courses current teachers most commonly report having taken as undergraduates (Banilower et al., 2013).

The total number of students enrolled in the introductory courses represented in the survey responses ranges from a low of 66,725 in 2004 to a high of 81,636 in 2009, followed by 68,170 in 2012 and 70,198 in 2016. This represents about a third of students counted through departmental responses to a survey describing 2004–2005 enrollments (Martinez and Baker, 2006), and perhaps 20%–25% of enrollment in 2016.

TABLE 1. COURSE DISCIPLINES

Broad discipline	Survey respondents	Total syllabi
Atmosphere	291	9
Earth science	218	12
Earth systems	74	3
Environmental	312	9
Geography	152	0
Geology	1375	77
Hazards	168	9
Historical	333	4
Oceans	294	25
Other	543	3

Survey Analysis

In all four survey administrations, respondents were asked how frequently they used specific teaching strategies in the "lecture" portion of their introductory course (Fig. 1). A large majority use traditional lecture in every class, but the proportion has decreased significantly over time. In parallel, the proportion of instructors using small-group discussions and in-class exercises—considered active-learning strategies—in every class and weekly has increased over time. Respondents employ these strategies regardless of the number of students in their classes (Tables S5 and S6).

A set of questions on the 2016 survey asked respondents to indicate the frequency with which their students engaged in particular practices (Fig. 2). "Three or

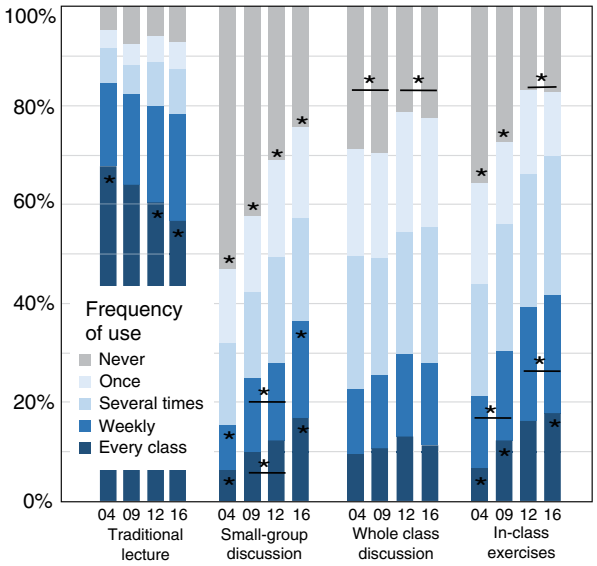

Figure 1. Histogram showing the frequency of use of teaching strategies over the four survey administrations. Asterisks indicate statistically significant differences in proportions ($p < 0.05$) between survey years; the significance is only shown for a particular frequency of use when there is a difference between multiple years. Asterisks with bars indicate that there is no significant difference between the two years connected by the bars, but there is a difference between those two years and the others.

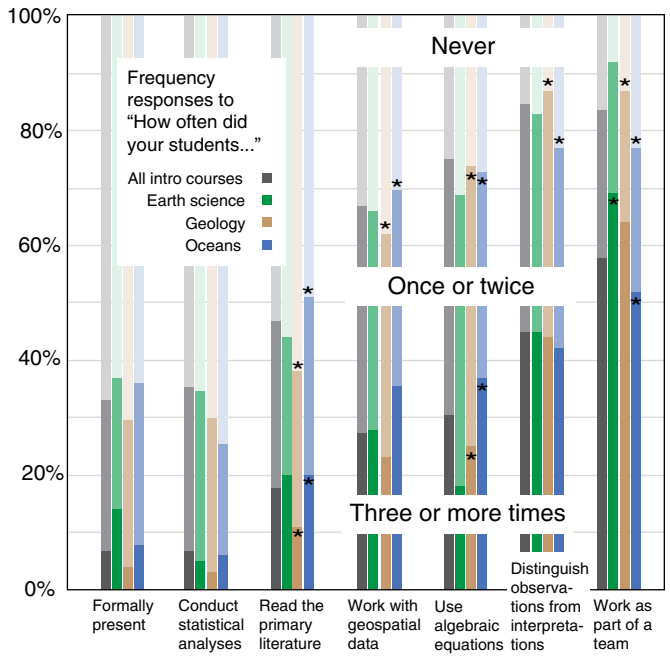

Figure 2. Histogram showing frequencies of use of practices for all introductory courses and for Earth science, geology, and oceans courses. Asterisks indicate statistically significant differences in proportions ($p < 0.05$) between discipline areas.

more times" can be considered the threshold for distributed practice, a strategy that has been shown to increase knowledge and skill acquisition and retention in a variety of fields (Benjamin and Tullis, 2010). About 45% of instructors engage students in distinguishing observations from interpretations three or more times, while few ask students to formally present their work or conduct statistical analyses. Respondents who teach oceans courses ask their students to read the primary literature, work with geospatial data, and use algebraic equations more frequently than respondents who teach geology courses. A majority ask students to work repeatedly in teams, with the greatest frequency reported by those who teach Earth science (Fig. 2).

Another set of questions asked instructors whether they make use of various activities (Fig. 3). Less than half responded that they engage students in collecting and analyzing their own data and/or addressing uncertainty, while just over half ask students to access and integrate information from different sources or describe quantitative evidence in support of an argument. Few engage students in working on local problems or environmental justice issues, but those who teach oceans and Earth science are more likely to do so than those who teach geology. While most ask students to address a problem of global or national interest, those who teach oceans are 15%–20% more likely to do so than those who teach geology (Fig. 3). Those who teach oceans courses are also significantly more likely to include aspects of systems thinking, such as analyzing feedback loops, discussing a change that has multiple effects throughout a system, and describing a system in terms of its parts and relationships. The overall likelihood of asking students to engage in high-level systems-thinking behavior, such as building predictive models, exploring systems behavior using computer models, and making systems visible through causal maps is low (Fig. 3).

Syllabus Analysis

The number of topics listed in course syllabi ranged from 10 to 30, with a mean of 17.5. When controlled for the number of weeks (10 weeks for quarters, 15 for semesters), courses averaged 1.2 topics per week. The most common topics are listed in Table 2 in order of popularity; within syllabi, the order and specific phrasing were highly correlated with the required textbook. Geology and Earth science topics overlap by two-thirds, while oceans courses are mostly different from both (Table 2). Systems are listed as a topic in six geology syllabi and none in either oceans or Earth science.

Learning outcomes were included in 78 syllabi. The number of learning outcomes ranged from three to 20 per course, and typically consisted of phrases that included one or more action verbs (e.g., "*describe* the processes and byproducts of weathering"). Instructors use lower cognitive-level (Krathwohl, 2002) action verbs most frequently, primarily *describe*, *identify*, and *explain* (Fig. 4). In comparison, the action verbs in the high school-level PEs (Table S1 [see footnote 1]) are more evenly distributed across all cognitive levels (Fig. 4). Nine syllabi included a learning outcome focused on systems (specifically an Earth system—not the solar system or ecosystem); ten included a learning outcome that referred to human activity and/or society. The majority of these use high cognitive-level action verbs like *evaluate* and *synthesize*.

Assessment

Of the 152 syllabi, 136 included information about the relative contribution of different types of student work to the final grade (Table 3); the proportions did not vary significantly between Earth science, geology, and oceans. Exams dominate the assessment strategies; exams and quizzes together contribute an average of 60% to a student's final grade (Table 3), though the variability is high, with a standard deviation of 20.7% and a range from 0% to 100%. In-class activities are included by about a third of instructors, and homework is factored in by about half, but both constitute a small proportion of the grade, generally less than 20%.

DISCUSSION

The surveyed population appears to represent a comprehensive and large subset of those teaching introductory geoscience courses in the United States based on the number of responses and the reported number of students enrolled. Though they consist of a much smaller set covering several years, syllabi appear to represent a reasonable subset of respondents due to the similarity in distribution by institution type (Table S4 [see footnote 1]) and course disciplines (Table 1).

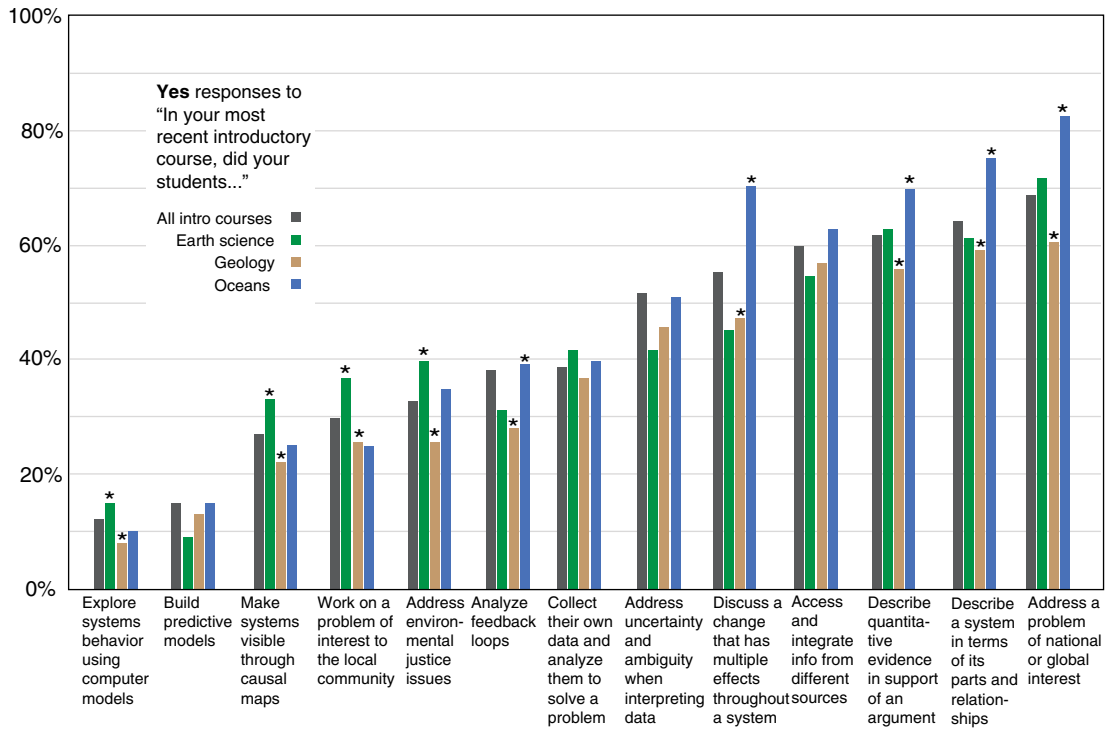

Figure 3. Histogram showing the use of aspects of scientific investigations for all introductory courses and for Earth science, geology, and oceans courses. Asterisks indicate proportions that are significantly different ($p < 0.05$) between discipline areas.

TABLE 2. FIFTEEN MOST COMMON TOPICS IN SYLLABI

Geology	Earth science	Oceans
Plate tectonics	Plate tectonics	Plate tectonics
Earthquakes	Earthquakes	Waves
Igneous rocks	Igneous rocks	Ocean sediments
Minerals	Minerals	Tides
Sedimentary rocks	Sedimentary rocks	History of oceanography
Metamorphic rocks	Oceans	Ocean circulation
Volcanoes	Weather	Coasts
Geologic time	Metamorphic rocks	Seawater
Streams	Volcanoes	Ocean life
Weathering	Geologic time	Seafloor
Deformation	Streams	Water
Glaciers	Groundwater	Ocean currents
Earth's interior	Solar system	Atmospheric circulation
Groundwater	Nature of science	Origin of the oceans
Resources	Atmosphere	Ocean pollution

Adequacy at Preparing Teachers

Earth-Systems Approach and Systems Thinking

Hallmarks of an Earth-systems approach in a learning environment include the use of real-world problems that integrate multiple disciplines (Holder et al., 2017), model-based reasoning by students (Pallant and Lee, 2017; Stillings, 2012), scaffolds that support students in developing their understanding of complex systems over time (Hmelo-Silver and Azevedo, 2006), and explicit instruction in complexity concepts such as feedback loops (Stillings, 2012) and systems dynamics (Pallant and Lee, 2017). High school teachers should be able to support students' progress toward the PE that reads "Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate" (NGSS Lead States, 2013).

In introductory geoscience courses, the results shown here suggest that a systems approach is not taken. "Earth system" and "systems" are rarely mentioned in syllabi, either as course topics or in learning outcomes; thus, these framing concepts are likely not apparent to students. While a majority of instructors indicate that they ask students to describe a system, only a small minority reach the higher-order skills such as analyzing feedback loops and using model-based experiments and reasoning, particularly in geology courses.

Systems thinking is an integral aspect of the NGSS, articulated in both the cross-cutting concepts and core ideas, but it is not fully realized in introductory geoscience courses, particularly geology. Fortunately, early admonishments to incorporate systems thinking have evolved into a strong literature base supporting specific practices that can build students' systems-thinking skills. Engaging with models helps students develop understanding of the complexity of systems (e.g., Wu, 2010). And even more recently, curricular materials developed through the InTeGrate project (InTeGrate, 2017) have been made widely available and shown to be effective at

developing students' systems-thinking skills in introductory courses (Gilbert et al., 2019; Iverson et al., 2019).

Human Interactions with Earth

Fully one-third of the PEs in the NGSS address human interactions with Earth (Table S1 [see footnote 1]). Even at the middle school level, students should be able to "construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems" (NGSS Lead States, 2013). In contrast, almost none of the top fifteen topics listed on syllabi in Earth science, geology, or oceans highlight connections to humans (Table 2): only resources (in geology) and ocean pollution (in oceans). Most instructors in geology and Earth science instead spend as much as a third of course time covering rocks and minerals, topics that are conspicuously absent from the PEs (Table S1 [see footnote 1]). Textbooks appear to be one of the primary determinants of topics, which may mean that, in order to address topics like hazard mitigation and managing natural resources, instructors need to change or supplement their required text.

There are other reasons to emphasize connections to individuals and societies in introductory courses. Investigating phenomena that connect to their lives and communities can provide students with motivation for learning (e.g., Glynn et al., 2009). But less than half of instructors engage students in investigations that emphasize connections to societal issues and disproportionately fewer geology instructors do so (Fig. 3).

Currently, human interactions with Earth are not emphasized in most introductory geoscience courses, leaving students ill-prepared to make personal, professional, and societal decisions about development, resource use, and many other issues. This is unfortunate for teachers, but the lack of connections to society (and thus perceived irrelevance of the discipline) can negatively impact recruitment and retention of students into the geosciences (e.g., Huntoon and Lane, 2007). The American Geosciences Institute defines nine "critical needs" where geoscience contributes to the development of solutions (AGI, 2016); these issues provide a framework for curricular materials that give students the opportunity to engage in data-rich, problem-solving activities (Egger et al., 2019). These and other resources can supplement or replace textbooks to emphasize human interactions with Earth and build relevance and motivation for students.

Using Practices to Engage with Data

The eight science and engineering practices of the *Framework* (NRC, 2012b) make components of authentic scientific investigation explicit (Table S2). The practices move instruction and learning away from the unrealistic conception of the linear scientific method and toward a more authentic view of what scientists and engineers really do (e.g., Schwartz et al., 2017).

While the PEs focus on using the practices to investigate phenomena, the learning outcomes in introductory courses emphasize content knowledge (Fig. 4). The large number of topics and learning outcomes addressed in courses may contribute to the paucity of higher-level learning outcomes, but engaging in high-level activities (while covering fewer topics) has been shown to increase learning gains for students (e.g., Freeman et al., 2014; NRC, 2015) and allows for more student-driven questioning that, like relevance, can motivate further investigation. In particular, instructors mostly do not engage students in developing and using models (SEP 2, Fig. 3). Most make very limited use of mathematical and computational thinking (SEP 5)—especially statistics (Fig. 2)—and obtaining, evaluating, and communicating information (SEP 8), since a minority ask students to read the primary literature or formally present (Fig. 2). In analyzing and interpreting data (SEP 4), nearly all instructors ask students to distinguish observations from interpretations (Fig. 2), but far fewer ask them to collect their own data and analyze them with all of the uncertainty and ambiguity inherent in that process (Fig. 3).

The emphasis on exams as a major component of final grades (Table 3) suggests that assessment is still heavily weighted toward content knowledge rather than engagement in the practices. While it is possible to design exams that assess skills rather than content (e.g., Jensen et al., 2014), many syllabi indicated that exams were multiple choice only and/or based solely on content in different portions of the course. As alternatives or in addition to exams, labs, homework, projects, and

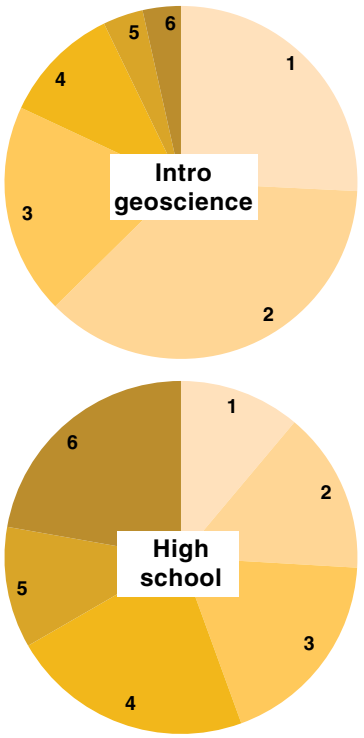

Figure 4. Frequency of use of action verbs at different Bloom's levels in learning outcomes and performance expectations. Note that more than one action verb may be included per learning outcome.

TABLE 3. FINAL GRADE COMPONENTS

Component	No. (%) of syllabi	Average contribution
Exams	126 (92%)	41.2%
Final exam	86 (63%)	22.7%
Lab	76 (56%)	27.9%
Homework	66 (49%)	19.8%
Quizzes	65 (48%)	16.0%
Project/report	53 (39%)	18.0%
In-class activities	48 (35%)	16.1%
Participation	28 (21%)	7.7%
Attendance	7 (5.1%)	8.9%
E + FE + Q*	134 (99%)	60.1%

*The sum of contributors to final grades for exams, final exams, and quizzes.

in-class activities can provide more frequent and better opportunities to assess the extent to which students are effectively making use of the practices.

Teamwork, Collaboration, and Discourse

Rearranging topics to take an Earth-systems approach, including more connections to human activity and society, and engaging students in working with data will not alone produce the kind of changes envisioned in the *Framework*. As noted by Windschitl and Calabrese Barton (2016), "It would be difficult to overstate the importance that discourse is now recognized to play in all aspects of science instruction" (p. 1128). Discourse involves eliciting student ideas, prompting students to talk with each other to compare their ideas and explain their reasoning, and situating the classroom as a community that is working together to make sense of the Earth system.

Since 2004, the use of small-group discussion such as think-pair-share has grown substantially in introductory geoscience courses (Fig. 1), with ~35% of instructors reporting in 2016 that they use the technique at least weekly. Whole-class discussion is used somewhat less frequently (Fig. 1), though this too is an important component of building the sense of community in the classroom (Kloser, 2014). Well over half of instructors have students work in teams three or more times throughout a course, and over 80% do so at least once (Fig. 2). Although both of the data sets examined in this study are self-reported, Teasdale et al. (2017) found a strong correlation between self-reports of the frequency of use of in-class exercises and observations of student-student interactions, group work, and discussion. The classrooms where these behaviors were observed were classified as "student-centered," which constituted 25% of the total they observed—a similar proportion to the proportion of instructors who reported using in-class exercises and/or small-group discussion in every class in 2016 (Fig. 1).

Several pedagogic strategies designed for the undergraduate classroom support the use of productive discourse, including lecture tutorials (Kortz et al., 2008), peer interactions and reflection (Mason and Singh, 2010), and two-stage (or collaborative) exams (Gilley and Clarkston, 2014), among many others. Providing students the opportunity to think and process new information in real time with their peers leads to better understanding and is worth the class time devoted to it.

CONCLUSIONS

The importance of Earth science to societal issues is embedded in the NGSS, which have been widely adopted across the United States, and the performance expectations set ambitious goals for students—and their teachers. As geoscientists, we teach students who go on to a variety of careers, including K–12 teaching, and we must adapt our courses to prepare them. Although our classes have become more active and student-centered over the past fifteen years, we have been slow to take a systems approach, make strong connections to human activity, and adopt research-based strategies that are shown to improve learning.

Now is the time to fulfill our "best opportunity yet … to educate [our] citizens about the complex and critical issues of Earth science" (Wysession, 2014, p. 299). We have a solid foundation of discipline-based educational research providing evidence for the practices that work in the classroom (McConnell et al., 2017; NRC, 2012a), new curricular materials that emphasize systems thinking and connections between Earth and human activity (InTeGrate, 2017), a thriving community of practice (Kastens and Manduca, 2017), and an imperative to prepare teachers who can engage students in the science and engineering practices and productive discourse (Windschitl and Stroupe, 2017). We can make use of these research results and resources to make improvements in our introductory courses to better reach *all* students. Looking to the future, as students emerge from K–12 systems built on the NGSS, they will enter our classrooms with high expectations for using the skills they've developed in middle and high school to conduct sophisticated analyses, address big problems, and make a difference in the world. We need to be ready for them.

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REFERENCES CITED

AGI, 2016, Geoscience for America's Critical Needs: Washington, D.C., American Geosciences Institute, https://www.americangeosciences.org/policy/critical-needs (last accessed 18 Apr. 2019).

American Chemical Society Committee on Professional Training (ACS-CPT), 2015, ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs: Washington, D.C., American Chemical Society, 38 p., https://www.acs.org/content/dam/acsorg/about/governance/committees/training/2015-acs-guidelines-for-bachelors-degree-programs.pdf (last accessed 18 Apr. 2019).

Banilower, E.R., Smith, P.S., Weiss, I.R., Malzahn, K.A., Campbell, K.M., and Weis, A.M., 2013, Report of the 2012 national survey of science and mathematics education: Horizon Research Inc., 309 p., http://horizon-research.com/NSSME/2012-nssme/research-products/reports/technical-report (last accessed 22 Apr. 2019).

Benjamin, A.S., and Tullis, J., 2010, What makes distributed practice effective?: Cognitive Psychology, v. 61, no. 3, p. 228–247, https://doi.org/10.1016/j.cogpsych.2010.05.004.

Cheesman, K., French, D., Cheesman, I., Swails, N., and Thomas, J., 2007, Is there any common curriculum for undergraduate biology majors in the 21st century?: Bioscience, v. 57, no. 6, p. 516–522, https://doi.org/10.1641/B570609.

Climate Literacy Network, 2009, Climate Literacy: The Essential Principles of Climate Science: Washington, D.C., U.S. Global Change Research Program/Climate Change Science Program, https://www.climate.gov/teaching/essential-principles-climate-literacy/essential-principles-climate-literacy (last accessed 22 Apr. 2019).

Earth Science Literacy Initiative (ESLI), 2010, Earth Science Literacy Principles: The Big Ideas and Supporting Concepts of Earth Science: Arlington, Virginia, National Science Foundation, 13 p.

Egger, A.E., Bruckner, M.Z., Birnbaum, S.J., and Gilbert, L.A., 2019, Facilitating the development of effective interdisciplinary curricular materials, *in* Gosselin, D.C., Egger, A.E., and Taber, J.J., eds., Interdisciplinary Teaching about Earth and the Environment for a Sustainable Future: Berlin, Springer, https://doi.org/10.1007/978-3-030-03273-9_3.

Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., and Wenderoth, M.P., 2014, Active learning increases student performance in science, engineering, and mathematics: Proceedings of the National Academy of Sciences of the United States of America, v. 111, https://doi.org/10.1073/pnas.1319030111.

Gilbert, L.A., Stempien, J., McConnell, D.A., Budd, D.A., van der Hoeven Kraft, K.J., Bykerk-Kauffman, A., Jones, M.H., Knight, C.C., Matheney, R.K., Perkins, D., and Wirth, K.R., 2012, Not just "rocks for jocks": Who are introductory geology students and why are they here?: Journal of Geoscience Education, v. 60, no. 4, p. 360–371, https://doi.org/10.5408/12-287.1.

Gilbert, L.A., Gross, D.S., and Kreutz, K.J., 2019, Developing undergraduate students' systems thinking skills with an InTeGrate module: Journal of Geoscience Education, v. 67, no. 1, p. 34–49, https://doi.org/10.1080/10899995.2018.1529469.

Gilley, B.H., and Clarkston, B., 2014, Collaborative testing: Evidence of learning in a controlled in-class study of undergraduate students: Journal of College Science Teaching, v. 43, no. 3, p. 83–91, https://doi.org/10.2505/4/jcst14_043_03_83.

Glynn, S.M., Taasoobshirazi, G., and Brickman, P., 2009, Science Motivation Questionnaire: Construct validation with nonscience majors: Journal of Research in Science Teaching, v. 46, no. 2, p. 127–146, https://doi.org/10.1002/tea.20267.

Hmelo-Silver, C.E., and Azevedo, R., 2006, Understanding complex systems: Some core challenges: Journal of the Learning Sciences, v. 15, no. 1, p. 53–61, https://doi.org/10.1207/s15327809jls1501_7.

Holder, L.N., Scherer, H.H., and Herbert, B.E., 2017, Student learning of complex earth systems: A model to guide development of student expertise in problem-solving: Journal of Geoscience Education, v. 65, no. 4, p. 490–505, https://doi.org/10.5408/17-261.1.

Huntoon, J.E., and Lane, M.J., 2007, Diversity in the geosciences and successful strategies for increasing diversity: Journal of Geoscience Education, v. 55, no. 6, p. 447–457, https://doi.org/10.5408/1089-9995-55.6.447.

InTeGrate, 2017, InTeGrate Teaching Materials: https://serc.carleton.edu/integrate/teaching_materials/index.html (last accessed 26 Sept. 2018).

Ireton, F., Mogk, D.W., and Manduca, C.A., 1996, Shaping the Future of Undergraduate Earth Science Education: Innovation and Change Using an Earth System Approach: https://serc.carleton.edu/shapingfuture/index.html (last accessed 18 Apr. 2019).

Iverson, E.R., Steer, D., Gilbert, L.A., Kastens, K.A., O'Connell, K., and Manduca, C.A., 2019, Measuring literacy, attitudes, and capacities to solve societal problems, *in* Gosselin, D.C., Egger, A.E., and Taber, J.J., eds., Interdisciplinary Teaching about Earth and the Environment for a Sustainable Future: Berlin, Springer, https://doi.org/10.1007/978-3-030-03273-9_5.

Jensen, J.L., McDaniel, M.A., Woodard, S.M., and Kummer, T.A., 2014, Teaching to the test … or testing to teach: Exams requiring higher order thinking skills encourage greater conceptual understanding: Educational Psychology Review, v. 26, no. 2, p. 307–329, https://doi.org/10.1007/s10648-013-9248-9.

Kastens, K., and Manduca, C., 2017, Leveraging the power of a community of practice to improve teaching and learning about the Earth: Change: The Magazine of Higher Learning, v. 49, no. 6, p. 14–22, https://doi.org/10.1080/00091383.2017.1398997.

Kloser, M., 2014, Identifying a core set of science teaching practices: A delphi expert panel approach: Journal of Research in Science Teaching, v. 51, no. 9, p. 1185–1217, https://doi.org/10.1002/tea.21171.

Kortz, K.M., Smay, J.J., and Murray, D.P., 2008, Increasing learning in introductory geoscience courses using lecture tutorials: Journal of Geoscience Education, v. 56, no. 3, p. 280–290, https://doi.org/10.5408/1089-9995-56.3.280.

Krathwohl, D.R., 2002, A revision of bloom's taxonomy: An overview: Theory into Practice, v. 41, no. 4, p. 212–218, https://doi.org/10.1207/s15430421tip4104_2.

Manduca, C.A., Mogk, D.W., Tewksbury, B., Macdonald, R.H., Fox, S.P., Iverson, E.R., Kirk, K., McDaris, J., Ormand, C., and Bruckner, M., 2010, On the Cutting Edge: Teaching help for geoscience faculty: Science, v. 327, no. 5969, p. 1095–1096, https://doi.org/10.1126/science.1183028.

Martinez, C., and Baker, M.A., 2006, Introductory Geoscience Enrollment in the United States: Academic Year 2004–2005: American Geological Institute, GW-06-001.

Mason, A., and Singh, C., 2010, Helping students learn effective problem solving strategies by reflecting with peers: American Journal of Physics, v. 78, no. 7, p. 748–754, https://doi.org/10.1119/1.3319652.

McConnell, D.A., Chapman, L., Czajka, C.D., Jones, J.P., Ryker, K.D., and Wiggen, J., 2017, Instructional utility and learning efficacy of common active learning strategies: Journal of Geoscience Education, v. 65, no. 4, p. 604–625, https://doi.org/10.5408/17-249.1.

NAGT, 2018, National Geoscience Faculty Survey: National Association of Geoscience Teachers, https://serc.carleton.edu/NAGTWorkshops/baseline_survey/survey_background (last accessed 26 Sept. 2018).

National Research Council (NRC), 2010, Preparing Teachers: Building Evidence for Sound Policy: Washington, D.C., The National Academies Press, 234 p.

National Research Council (NRC), 2012a, Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering: Washington, D.C., The National Academies Press, 282 p.

National Research Council (NRC), 2012b, A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas: Washington, D.C., The National Academies Press, 400 p.

National Research Council (NRC), 2015, Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering: Washington, D.C., The National Academies Press, 256 p.

NGSS Lead States, 2013, Next Generation Science Standards: For States, By States: Washington, D.C., The National Academies Press, 324 p.

Ocean Literacy Network, 2013, Ocean Literacy: The Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages: http://oceanliteracy.wp2.coexploration.org (last accessed 18 Apr. 2019).

Pallant, A., and Lee, H.-S., 2017, Teaching sustainability through system dynamics: Exploring stocks and flows embedded in dynamic computer models of an agricultural land management system: Journal of Geoscience Education, v. 65, no. 2, p. 146–157, https://doi.org/10.5408/16-169.1.

Schwartz, C.V., Passmore, C., and Reiser, B.J., 2017, Moving beyond "knowing about" science to making sense of the world, *in* Schwartz, C.V.P., Passmore, C., and Reiser, B.J., eds., Helping Students Make Sense of the World Using Next Generation Science and Engineering Practices: Alexandria, Virginia, NSTA Press, p. 3–21.

SERC, 2002, On the Cutting Edge: Strong undergraduate geoscience teaching: https://serc.carleton.edu/NAGTWorkshops/index.html (last accessed 28 Sept. 2018).

Stillings, N., 2012, Complex systems in the geosciences and in geoscience learning, *in* Kastens, K.A., and Manduca, C.A., eds., Earth and Mind II: A Synthesis of Research on Thinking and Learning in the Geosciences: Geological Society of America Special Paper 486, p. 97–111, https://doi.org/10.1130/2012.2486(17).

Teasdale, R., Viskupic, K., Bartley, J.K., McConnell, D., Manduca, C., Bruckner, M., Farthing, D., and Iverson, E., 2017, A multidimensional assessment of reformed teaching practice in geoscience classrooms: Geosphere, v. 13, no. 2, p. 608–627, https://doi.org/10.1130/GES01479.1.

University Consortium for Atmospheric Research (UCAR), 2007, Essential principles and fundamental concepts for atmospheric science literacy: Boulder, Colorado, National Science Foundation, https://scied.ucar.edu/atmospheric-science-literacy-framework (last accessed 22 Apr. 2019).

Wilson, C., 2016, Status of the Geoscience Workforce: American Geosciences Institute, 131 p.

Windschitl, M., and Calabrese Barton, A., 2016, Rigor and equity by design: Locating a set of core teaching practices for the science education community, *in* Gitomer, D.H., and Bell, C.A., eds., Handbook of Research on Teaching, Fifth Edition: Washington, D.C., American Educational Research Association, p. 1099–1158, https://doi.org/10.3102/978-0-935302-48-6_18.

Windschitl, M., and Stroupe, D., 2017, The Three-Story Challenge: Implications of the Next Generation Science Standards for teacher preparation: Journal of Teacher Education, v. 68, no. 3, p. 251–261, https://doi.org/10.1177/0022487117696278.

Wu, H.K., 2010, Modelling a complex system: Using novice-expert analysis for developing an effective technology-enhanced learning environment: International Journal of Science Education, v. 32, no. 2, p. 195–219, https://doi.org/10.1080/09500690802478077.

Wysession, M.E., 2012, Implications for Earth and Space in New K–12 Science Standards: Eos, v. 93, no. 46, p. 465–466, https://doi.org/10.1029/2012EO460001.

Wysession, M.E., 2014, The Next Generation Science Standards: A potential revolution for geoscience education: Earth's Future, v. 2, no. 5, p. 299–302, https://doi.org/10.1002/2014EF000237.

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Call for Nominations

2020 GSA Awards & Medals

Deadline: 1 Feb. 2020
www.geosociety.org/awards

Penrose Medal

The Penrose Medal was established in 1927 by R.A.F. Penrose Jr. to recognize eminent research in pure geology, for outstanding original contributions, or for achievements that mark a major advance in the science of geology. This award is made only at the discretion of the GSA Council, and nominees do not need to be members of the Society. Penrose's sole objective was to encourage original work in purely scientific geology, which is interpreted as applying to all scientific disciplines represented by GSA. Scientific achievements should be considered rather than contributions in teaching, administration, or service. Mid-career scientists who have already made exceptional contributions should be given full consideration for the award.

Day Medal

The Arthur L. Day Medal was established in 1948 through a donation by Arthur L. Day, founding director of the Geophysical Laboratory of the Carnegie Institution of Washington. It recognizes outstanding distinction in the application of physics and chemistry to the solution of geologic problems, with no restriction to the particular field of geologic research. It was Day's wish to provide an award to recognize outstanding achievement in research and to inspire further effort, rather than to reward a distinguished career, and so it has been the longstanding practice of the Society to award this medal to geoscientists actively pursuing a research career.

Young Scientist Award (Donath Medal)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 years or younger throughout the year in which the award is to be presented—*for 2020, only those candidates born* ***on or after 1 Jan. 1985*** *are eligible*) for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in the earth sciences. The award consists of a gold medal (the Donath Medal) and an honorarium.

How to Nominate

To ensure thorough consideration by the respective committees, please follow these nomination instructions carefully; additional information supplied will not enhance the nomination. For each candidate please submit the following:

1. Go to **https://rock.geosociety.org/forms/Awardform.asp** for the online form.
2. **Supporting documents** (submitted as email attachments or via post):
   - Curriculum vitae;
   - Summary (300 words or fewer) of the scientific contributions to geology that qualify the candidate for the award;
   - Selected bibliography of no more than 20 titles (for the Donath Medal, only 10 titles are required); and
   - Letters of support from five GSA Fellows or members *in addition to* the person making the nomination.

For the Day Medal only: Letters from five scientists with at least three of those being from GSA Fellows or members and up to two from fellows or members of the Mineralogical Society of America, Geochemical Society, or American Geophysical Union.

Florence Bascom Geologic Mapping Award

The Florence Bascom Geologic Mapping Award was approved by GSA Council in October 2013 and the first award was presented in 2015. This award acknowledges contributions in published high-quality geologic mapping that led the recipient to publish significant new scientific discoveries, to bring about greater understanding of fundamental geologic processes and concepts, and to contribute to the application of new knowledge to societal needs and opportunities in such areas as mineral resources, water resources, and the environment.

The recipient will have authored high-quality geologic maps, cross sections, and summary reports that have received scientific acclaim and are available to both peers and the public, through federal or state agencies or major scientific societies. In evaluating the merits of nominees for this award, scientific achievements should be considered rather than contributions in teaching, administration, or service. Nominees do not need to be members of the Society, and they may be from any nation.

Selection criteria: (A) excellence of the nominee's published geologic maps; (B) a clear record of greater understanding of fundamental geologic processes and/or concepts, and high-quality publication of same, emerging directly from the meritorious quality of the geologic mapping; and (C) peer acclaim of the practical usefulness of the geologic mapping and the new discoveries that emerged from the mapping.

How to Nominate

1. Go to **https://rock.geosociety.org/forms/Awardform.asp** for the online form.
2. **Supporting documents** (submitted as email attachments or via post):
   - Curriculum vitae
   - Letter of nomination (300 words or fewer) addressing the evaluation criteria;
   - Selected bibliography of geologic maps (20 titles or fewer);

- Selected bibliography of peer-reviewed publications (20 titles or fewer);
- PDFs or website links to several key geologic maps authored by the nominee; and
- Letters of support from three scientists with at least two from GSA Fellows or members and one from a member of another professional geoscience organization. Diverse supporters (i.e., including individuals who are not currently/recently associated with the nominee's institution) are strongly encouraged.

The Bromery Award for Minorities

The Bromery Award for Minorities should be given to any minority, preferably African Americans, who qualify under at least one of these two categories:

1. Nominee has made significant contributions to research in the geological sciences, as exemplified by one or more of the following:
   - Publications that have had a measurable impact on the geosciences;
   - Outstanding original contributions or achievements that mark a major advance in the geosciences; and
   - An outstanding lifetime career that demonstrates leadership in geoscience research.
2. Nominee has been instrumental in opening the geoscience field to other minorities, as exemplified by one or more of the following:
   - Demonstrable contributions in teaching or mentoring that have enhanced the professional growth of minority geoscientists;
   - Outstanding lifetime career service in a role that has highlighted the contributions of minorities in advancing the geosciences; and
   - Authorship of educational materials of high scientific quality that have enjoyed widespread use and acclaim among educators or the general public.

How to Nominate

1. Go to **https://rock.geosociety.org/forms/Awardform.asp** for the online form.
2. **Supporting documents** (submitted as email attachments or via post):
   - Curriculum vitae;
   - Letter of nomination (300 words or fewer);
   - Letters of support from three scientists with at least two from GSA Fellows or members and one from a member of another professional geoscience organization; and
   - Optional selected bibliography of no more than 10 titles.

Doris M. Curtis Outstanding Woman in Science Award

The Doris M. Curtis Outstanding Woman in Science Award recognizes a woman who has had a major impact on the field of the geosciences based on her Ph.D. research. The generous support of the Doris M. Curtis Memorial Fund makes this award possible. GSA's 103rd president, Doris Curtis pioneered many new directions for geology, not the least of which was her tenure as GSA president after an unbroken chain of 102 men. Causes dear to her were women, public awareness, minorities, and education. Women are eligible for this award the first three years following their Ph.D. degree.

How to Nominate

1. Go to **https://rock.geosociety.org/forms/Awardform.asp** for the online form.
2. **Supporting documents** (submitted as email attachments or via post):
   - Curriculum vitae including dissertation title and abstract;
   - Letter of nomination that clearly states how the Ph.D. research has impacted the geosciences in a major way;
   - Letters of support from three scientists with at least two from GSA Fellows or members and one from a member of another professional geoscience organization; and
   - Selected bibliography of no more than 10 titles.

GSA Distinguished Service Award

GSA Council established the GSA Distinguished Service Award in 1988 to recognize individuals for their exceptional service to the Society. GSA members, Fellows, associates, and employees may be nominated for consideration, and any GSA member or employee may submit a nomination for the award. GSA's Executive Committee will select awardees, and GSA Council must ratify all selections. Awards may be made annually, or less frequently, at the discretion of Council.

How to Nominate

1. Go to **https://rock.geosociety.org/forms/Awardform.asp** for the online form.
2. **Supporting documents** (submitted as email attachments or via post):
   - Curriculum vitae;
   - Letter of nomination (300 words or fewer);
   - Brief biographical sketch that clearly demonstrates the applicability of the selection criteria; and
   - Optional selected bibliography of no more than 10 titles.

GSA Public Service Award

GSA Council established the GSA Public Service Award in 1998 in honor of Eugene and Carolyn Shoemaker. This annual award recognizes contributions that have materially enhanced the public's understanding of the earth sciences or have significantly served decision makers in the application of scientific and technical information to public affairs and earth science–related public policy. This may be accomplished by individual achievement in:

- Authorship of education materials of high scientific quality that have enjoyed widespread use and acclaim among educators or the general public;
- Acclaimed presentations (books and other publications, mass and electronic media, or public presentations, including lectures) that have expanded public awareness of the earth sciences;

- Authorship of technical publications that have significantly advanced scientific concepts or techniques applicable to the resolution of earth-resource or environmental issues of public concern; and/or
- Other individual accomplishments that have advanced the earth sciences in the public interest.

The award will normally go to a GSA member from any nation, with exceptions approved by Council, and may be presented posthumously to a descendant of the awardee.

How to Nominate

1. Go to **https://rock.geosociety.org/forms/Awardform.asp** for the online form.
2. **Supporting documents** (submitted as email attachments or via post):
   - Curriculum vitae;
   - Letter of nomination (300 words or fewer);
   - Brief biographical sketch that clearly demonstrates the applicability of the selection criteria; and
   - Selected bibliography of no more than 10 titles.

Honorary Fellow

Established by the GSA Council in 1909, Honorary Fellowship may be bestowed on individuals who have made outstanding and internationally recognized contributions to geoscience, or in rare circumstances, provided notable service to the Society. In practice, nearly all candidates are non–North Americans who live and work outside of North America. The most noteworthy exceptions were astronauts. The awardee does not have to be a member of the Society to receive the award. No more than two Honorary Fellows will be awarded annually. Honorary Fellows will be recognized during the GSA Annual Meeting and will receive complimentary lifetime membership in the Society.

How to Nominate

1. Go to **https://rock.geosociety.org/forms/Awardform.asp** for the online form.
2. **Supporting documents** (submitted as email attachments or via post):
   - Curriculum vitae;
   - Letter of nomination (300 words or fewer) that clearly demonstrates the applicability of the selection criteria;
   - Letters of support from three scientists with at least two from GSA Fellows and one from a GSA Fellow or a person of equivalent international stature; and
   - Selected bibliography of no more than 20 titles.

Candidates whose names are submitted by the respective award committees to GSA Council but who do not receive an award will remain under consideration by those committees for three years. For those still under consideration, it is recommended that an updated nomination letter be sent to GSA.

Nomination forms and submission instructions are online via link at **www.geosociety.org/awards.** Forms and instructions can also be obtained from GSA Grants and Awards, P.O. Box 9140, Boulder, CO 80301-9140, USA, +1-303-357-1028, awards@geosociety.org.

Call for Nominations

2020 GSA Awards & Medals

John C. Frye Environmental Geology Award

Deadline: 31 March 2020

In cooperation with the Association of American State Geologists (AASG), GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys.

Anyone can nominate a paper as long as it is selected from a GSA or state geological survey publication and published during the preceding three full calendar years. The nomination letter must include a paragraph stating the importance of the paper. Up to three letters from users of the publication can be included to support the nomination.

Each nominated paper will be judged on its uniqueness or significance as a model of its type of work and its overall worthiness for the award. The paper must (1) establish an environmental problem or need; (2) provide substantive information on the basic geology or geologic process pertinent to the problem; (3) relate the geology to the problem or need; (4) suggest solutions or provide appropriate land-use recommendations based on the geology; (5) present the information in a manner that is understandable and directly usable by geologists; and (6) address the environmental need or resolve the problem. It is preferred that the paper be directly applicable to informed laypersons (e.g., planners, engineers).

Please send your nominations to GSA Grants and Awards, P.O. Box 9140, Boulder, CO 80301-9140, USA. For more information, go to **www.stategeologists.org/awards_honors.php.**

2020 AGI Awards

AGI Medal in Memory of Ian Campbell

The AGI Medal in Memory of Ian Campbell recognizes singular performance in and contribution to the profession of geology. Candidates are measured against the distinguished career of Ian Campbell, whose service to the profession touched virtually every facet of the geosciences. Campbell was a most uncommon man of remarkable accomplishment and widespread influence, and in his career as a geologist, educator, administrator, and public servant, he was noted for his candor and integrity. To submit a nomination, go to **https://www.americangeosciences.org/awards.**

AGI Marcus Milling Legendary Geoscientist Medal

The Marcus Milling Legendary Geoscientist Medal is given to a recipient with consistent contributions of high-quality scientific achievements and service to the Earth sciences having lasting, historic value; who has been recognized for accomplishments in field(s) of expertise by professional societies, universities, or other organizations; and is a senior scientist nearing completion or has completed full-time regular employment. To submit a nomination, go to **https://www.americangeosciences.org/awards/legendarygeoscientist.**

In Memoriam

The Society notes with regret the deaths of the following members (notifications received 30 April–31 July 2019). Memorials to deceased members are published open access at **www.geosociety.org/memorials** Visit that page to learn about how to honor someone with a memorial.

Sam L. Agron
Verona, New Jersey, USA
Date of death: 12 Aug. 2018

Sam Boggs Jr.
Eugene, Oregon, USA
Date notified: 21 June 2019

Samuel A. Bowring
Cambridge, Massachusetts, USA
Date of death: 17 July 2019

Willi K. Braun
Warman, Saskatchewan, Canada
Date of death: 1 Jan. 2019

Severn P. Brown
Canton, New York, USA
Date of death: 4 May 2019

Eugene E. Brucker
St. Louis, Missouri, USA
Date of death: 10 May 2019

Jean F. Demouthe
San Francisco, California, USA
Date of death: 20 Oct. 2018

T. Randolph Gray Sr.
Birmingham, Alabama, USA
Date notified: 5 May 2019

Sherman Gromme
Palo Alto, California, USA
Date of death: 8 Aug. 2018

Gregg F. Gunnell
Durham, North Carolina, USA
Date of death: 20 Sept. 2017

Marvin L. Ivey
Largo, Florida, USA
Date of death: 5 Apr. 2019

Alfred Kroener
Mainz, Germany
Date of death: 22 May 2019

David B. MacKenzie
Denver, Colorado, USA
Date of death: 13 May 2019

Glenn M. Mason
New Albany, Indiana, USA
Date of death: 7 Nov. 2018

Lucian B. Platt
Gladwyne, Pennsylvania, USA
Date of death: 1 Jan. 2019

Jeremy P. Richards
Sudberry, Ontario, Canada
Date of death: 7 June 2019

Henry R. Schmoll
Denver, Colorado, USA
Date of death: 5 Dec. 2018

Robert E. Sloan
Winona, Minnesota, USA
Date of death: 17 June 2019

Jerry D. Vineyard
Ozark, Missouri, USA
Date notified: 15 May 2019

Rolf E. Westgard
Saint Paul, Minnesota, USA
Date of death: 20 May 2019

Change Coming to *Lithosphere*

GSA is participating in a new open-access, community-led journal being launched by GeoScienceWorld (GSW), a nonprofit collaborative and comprehensive resource for research and communications in the earth sciences. (GSA is a founding publisher of GeoScienceWorld, and its journals and books are hosted on the GSW platform.)

As part of GSA's commitment to this new publishing effort, the society has reached an agreement with GSW to have *Lithosphere* be the vehicle for the community journal. Because this does involve transferring ownership of *Lithosphere* to GSW, this is a big change.

This decision wasn't made lightly and was debated at length by GSA Council. "We welcome the expanded support GSW's involvement will bring to the journal," said GSA Executive Director Vicki McConnell. "GSA sees this partnership with GSW as a reflection of its mission to advance geoscience research and discovery and to allow *Lithosphere* to grow."

Why a New Journal?

GSW is looking for ways to help its member publishers deal with the changes brought by mandated open-access proposals, which are gaining ground around the world. While GSA made *Lithosphere* and *Geosphere* fully open access in 2018, other founding publishers of GSW have fewer open-access options.

The community journal will get papers in two ways: direct submissions and papers transferred from other GSW-participating societies. Transferred papers will be those that the society has determined are not right for its journal(s) but that still have merit and should be considered for publication. Examples include papers that: don't match the scope or size restrictions of a particular journal; deliver a nice compilation of data but no new insights or broader implications; show valuable confirmatory results that aren't always published (e.g., the second instance of a mineral discovery); or show null results (an experiment or model was tried but didn't work—of value to those pursuing the same line of thought).

Lithosphere will continue to publish under GSA for the rest of 2019. The journal will retain its impact factor, and all archival content published by GSA will continue to be open access and freely available just as it is today.

GSA 2019 Mentoring

Thank you to all the mentor volunteers who served at the GSA 2019 Annual Meeting!

Mentors are integral to GSA's meetings and are a source of motivation and support for students and early career professionals as they seek advice and information related to their academic and career pathways. Below are the programs mentor volunteers participated in and some comments from mentees:

- Drop-in Mentors
- On To the Future Mentors
- Résumé Mentors
- Networking Mentors
- Women in Geology Mentors
- GeoCareers Center Presenters

"My mentor was fantastic; he provided excellent advice about how to make effective and informative posters, how to meet new people and who to talk to, and introduced me to some of the students that he worked with in the past."
—On To the Future Mentorship

"I thought that the résumé mentor was very thoughtful and informative, and I appreciated all of his feedback."
—Résumé Mentorship

"I had a very good experience with my mentor. They were very insightful and thoughtful. When they couldn't answer my questions, they put me in contact with people who could."
—On To the Future Mentorship

Join us for GSA's next epoch of
DISCUSSION & DISCOVERY

THE GEOLOGICAL SOCIETY OF AMERICA®

Penrose CONFERENCE

Revitalize your geology at GSA's Penrose Conference, the premier small meeting for collaborative research around the world. Introducing a brand-new format and criteria for submission.

Streamlined Submission and Review Process Proposals will only be accepted 1 Nov. – 15 Dec. and acceptances will be announced in March.

Scientific Breadth within Earth and Planetary Science Each conference subject should be under current investigation and active discussion by researchers in the field and/or laboratory and may be wide ranging in the scope of research or topic. Proposals should work to bring together support from multiple divisions, organizations, and societies.

Diversity within the Science and the Community To ensure a broad-ranging stimulus, proposals should include balance with early to late career scientists from underrepresented groups and gender among the Conveners and participants.

Competitive Review Process Proposals will be evaluated on their scientific merit, scientific breadth, and diversity of participants, disciplines, and scope. Only one Penrose Conference will be selected per year.

Expanded Review Committee The Penrose Conference committee will be made up of seven (7) voting members including past Conveners of a Penrose Conference, past Leaders of a Thompson Field Forum, and Early Career Scientists.

Funding GSA and GSA Foundation have increased the funding to US$20,000 per Penrose Conference (one per year).

Proposal Submissions Accepted: 1 Nov. through 15 Dec. 2019 | Recipient Announced: March 2020

www.geosociety.org/Penrose

Questions: Becky Sundeen at bsundeen@geosociety.org

A new slate for
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Thompson FIELD FORUM

Revitalize your geology at GSA's Thompson Field Forum; trips that capture the essence of geologic discoveries or controversial topics. Introducing a brand-new format and criteria for submission.

Streamlined Submission and Review Process Proposals will only be accepted 1 Nov. – 15 Dec. and acceptances will be announced in March.

Scientific Breadth within Earth and Planetary Science Each field forum subject should be under current investigation and active discussion by researchers in the field and/or laboratory and may be wide ranging in the scope of research or topic. Proposals should work to bring together support from multiple divisions, organizations, and societies.

Diversity within the Science and the Community To ensure a broad-ranging stimulus, proposals should include balance with early to late career scientists from underrepresented groups and gender among the Conveners and participants.

Competitive Review Process Proposals will be evaluated on their scientific merit, scientific breadth, and diversity of participants, disciplines, and scope. Only one Thompson Field Forum will be selected per year.

Expanded Review Committee The Thompson Field Forum committee will be made up of seven (7) voting members including past Conveners of a Penrose Conference, past Leaders of a Thompson Field Forum, and Early Career Scientists.

Funding GSA and GSA Foundation have increased the funding to US$20,000 per Thompson Field Forum (one per year).

Proposal Submissions Accepted: 1 Nov. through 15 Dec. 2019 | Recipient Announced: March 2020

www.geosociety.org/Thompson

Questions: Becky Sundeen at bsundeen@geosociety.org

Gain Valuable Career Experience with GeoCorps™ America

GSA's GeoCorps America program provides rewarding opportunities on public lands for geoscience education and career development. The program is a partnership between GSA, governmental agencies, and other organizations committed to science and stewardship.

Participant Story

GeoCorps participant Pablo Juarbe-Martinez provided geospatial support to the National Forests in Alabama in the 2018 fall/winter season of the program. He created new and updated motorized vehicle–use maps, maintenance maps, and landline delineations for Forest Service districts for his project. He also gained field experience with land-surveying techniques.

"In my case, I have gained so many new skills in geographic information systems (GIS) and all of the different platforms where I can create all of these informative maps. I have a better understanding of the structure of the federal government and how it works. I learned valuable fieldwork experience that will greatly help me in the future. I was able to meet a lot of people in my field of interest and learn from them first hand." —Pablo Juarbe-Martinez

Since participating in GeoCorps America, Juarbe-Martinez continues to collaborate with the U.S. Forest Service in on GIS-related projects in Florida.

To get involved, go to **www.geosociety.org/geocorps.**

Above: Juarbe-Martinez discussing data and work plans with a forest land surveyor. Left: Juarbe-Martinez measuring tree circumference as part of an ecological survey in Tuskegee National Forest.

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GEOCORPS™ AMERICA — The Geological Society of America®

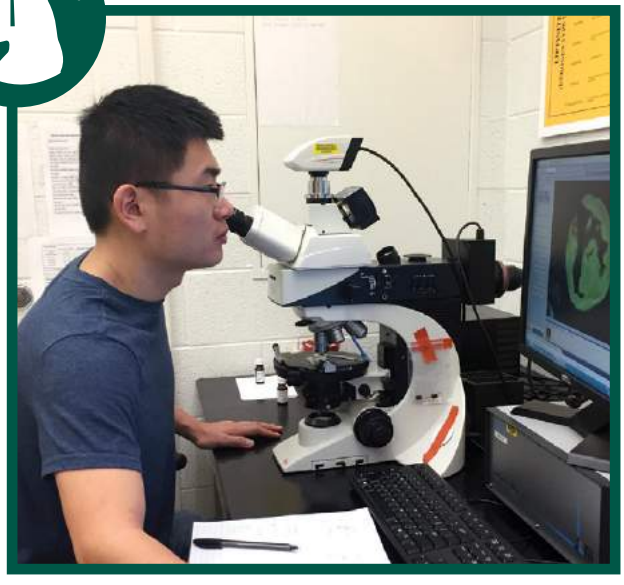
Aerotek — Our People Are Everything™

Aerotek

Bureau of Land Management (BLM)

Forest Service
Department of Agriculture

2019–2029 Strategic Plan



THE GEOLOGICAL SOCIETY OF AMERICA®

About GSA

Mission

To advance geoscience research and discovery, service to society, stewardship of Earth, and the geosciences profession.

Vision

To be the premier geological society supporting the global community in scientific discovery, communication, and application of geoscience knowledge.

The Geological Society of America (GSA), founded in 1888, is a global scientific society with more than 22,000 members from academia, government, and industry in more than 100 countries. Through its meetings, publications, and programs, GSA enhances the professional growth of earth scientists at all career levels; encourages cooperative research among earth, life, planetary, and social scientists; fosters public dialogue on geoscience issues; and promotes the geosciences in the service of humankind. GSA is headquartered in Boulder, Colorado, USA.

GSA will…

"continue to seek ways to engage and involve diverse people in the GSA family and in the geosciences."

Note: quotes taken from survey responses during the Strategic Plan input gathering process.

Jumping the Curve

Over time, organizations evolve through various stages of development, from inception to learning, growth, maturity, and decline. As a mature organization, GSA must avoid decline by "jumping the curve" back to learning and growth. GSA has jumped the curve several times throughout our history (see timeline), and it is clear the time has come again for GSA to undertake transformational change. As the geosciences profession evolves, GSA must adapt to the changing needs of our members and carefully prioritize programs and services in order to remain relevant and sustainable well into the future.

Defining GSA's path for the next decade

GSA has conducted business using a strategic plan for decades. The 2019–2029 strategic plan will serve as a guide for GSA to support a strong, diverse membership through advancing science, providing professional development opportunities, and promoting stewardship of the Earth, and to ensure that GSA maintains a fiscally responsible and technologically sound infrastructure.

GSA will… "maintain a proactive stance in promoting high standards for ethics in geosciences."

GSA JUMPS THE CURVE

1888 American Geological Society founded for the purpose of "the promotion of the science of geology by the issuance of scholarly publications, the holding of meetings, the provision of assistance to research, and other appropriate means"

1890 First issue of the *Bulletin of the Geological Society of America* published

1929 GSA was legally incorporated

1931 (31 July) R.A.F. Penrose Jr. passed away, leaving GSA half his fortune

1932 GSA moved into its first "permanent" office at 419 W. 117th Street, New York

1948 GSA opened membership to anyone with a degree in geology or related science

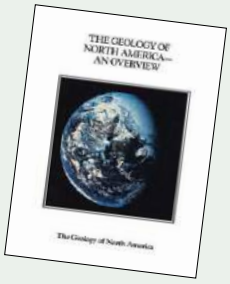
1963 GSA headquarters moved to 231 East 46th Street, New York, and adopted a new constitution and bylaws

1971 GSA opened membership to students in geology

1972

GSA moved into its current headquarters at 3300 Penrose Place, Boulder, Colorado

1973 First issue of *Geology* published



1980 GSA Foundation formed

1985 First *Decade of North American Geology* volume published

1991 Doris Malkin Curtis was the first woman to serve as GSA president

1997 GeoCorps™ America program launched

2007 GSA opened Washington, D.C., office focused on public policy and the geosciences

2010 66-kilowatt solar-panel system installed at GSA Headquarters

2019 Decadal Strategic Plan adopted

Process Overview

Input Gathering

In May 2019, GSA Council approved the Decadal Strategic Plan, a satisfying result of months of effort. This process began in August 2017 with gathering thoughts, desires, creative ideas, and other valuable input from members—young and old, student and emeritus, industry and academic, government and independent, managers, deans, associated societies, donors, and staff. The goal was for GSA to be proactive and intentional about our future.

Compiling

After surveying members, nonmember geoscientists, donors, and many other important demographics, a strategic planning team, together with an outside facilitator, compiled and consolidated this input. The consensus was that GSA did not need to update its mission or vision. Instead, **five strategic aspirations** emerged:

Advance Scientific Discovery, Rigor, and Integrity

Support Early Career Professionals and Students

Host Premier Conferences and Meetings

Influence Geoscience Policy and Link Geoscience to Society

Provide a Sense of Community and Venues for Networking

Task Forces

A larger planning team composed of more than 60 GSA members, plus many staffers from headquarters, was then engaged and divided into Program, Finance, and Development Task Forces. Each task force was charged with sorting through the ideas to modify and enhance existing, or develop new, GSA activities and set priorities.

The **Program Task Force** looked at current programs and future initiatives through the lens of the five GSA aspirations, resulting in 77 new or revised initiatives that they prioritized.

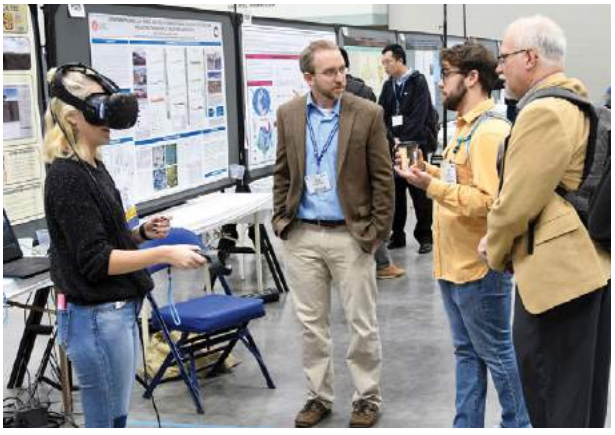
The Program Task Force results were reviewed by the **Finance Task Force**. This group identified the resources required to implement the program planning and proposed allocation of GSA's internal capital and capacity to fund new initiatives and/or modify programs or to recommend suspension of programs or initiatives.

The **Development Task Force** evaluated existing fundraising capacity and translated the plan into a prospectus for future investment and support.

After **Council approved the plan** in May 2019, **GSA staff began developing tactical plans** to turn these aspirational and strategic goals into operational realities—reorganizing within headquarters as needed and engaging feasibility consultants where required. GSA leadership has committed to participate in outreach, ad hoc committees, and review panels to reach its goals.

GSA will…

"increase emphasis on interdisciplinary and cross-disciplinary topics."



Strategic Plan Aspirations

Advance Scientific Discovery, Rigor, and Integrity

As a diverse, global geoscience organization, GSA will advance scientific discovery, rigor, and integrity to solve Earth's challenges by connecting the vibrant, comprehensive, and integrated geoscience community.

Objective 1 Enhance and expand cutting-edge geoscience and widely communicate those findings and knowledge.

Objective 2 Increase the multidisciplinary nature of the science offered through GSA programs.

Objective 3 Bolster scientific offerings by working toward greater inclusivity.

Objective 4 Lead the geosciences in building a culture of professional ethics, rigor, and integrity.

Support Early Career Professionals and Students

As a society committed to the next generation, GSA will invest in research, education, and professional opportunities for students and early career professionals worldwide, providing them with tools to meet the challenges of the future and find success on their chosen career paths.

Objective 1 Expand opportunities for students and early career professionals (ECPs) to communicate their science.

Objective 2 Promote a leadership culture through increased organizational engagement and student-led networks.

Objective 3 Strengthen the tools and support available for students/ECPs to build the knowledge and skills for professional goals through all stages of their careers.

Host Premier Conferences and Meetings

As a globally recognized geoscience organization, GSA will host conferences and meetings, serving as premier venues to attract and engage the global scientific community to share cutting-edge research, discover a compelling diversity of science, and identify and solve broad scientific questions and issues.

Objective 1 Design GSA meetings as the place to expand knowledge and share groundbreaking, multidisciplinary science.

Objective 2 Utilize the latest technologies to make meetings more effective, creative, and accessible to a larger, more diverse audience.

Objective 3 Cultivate and expand member opportunities for mentoring, networking, and career development.

Influence Geoscience Policy and Link Geoscience to Society

As the primary communicator of global geological events, GSA will engage and promote the global geoscience community in advocacy to influence geoscience policy, inform and educate the public, and propel scientific discovery to solve pressing earth and environmental challenges that impact people and societies.

Objective 1 Expand opportunities and resources for GSA members to effectively engage in policy at local, national, and international scales.

Objective 2 Develop and deliver products to convey geoscience knowledge to policymakers and the public.

Objective 3 Foster a group of advocates who will have a leadership role in driving geoscientific solutions to societal challenges.

Provide a Sense of Community and Venues for Networking

As the leading global geoscience community, GSA will connect the worldwide geoscience community, providing resources, venues, and opportunities to advance careers and foster relationships across the geosciences.

Objective 1 Lead efforts to provide a safe and inclusive culture for members worldwide to participate, contribute, and feel a sense of belonging to the profession.

Objective 2 Make GSA an essential and rewarding professional home for members from the undergraduate level through retirement.

Objective 3 Forge greater connections throughout the geoscience community across all levels and locales.

Implementation and Outcomes

The five 2019 aspirations are much the same as the first aspirations of GSA in 1888, when the *American Geological Society* was formed for "the promotion of the science of geology by the issuance of scholarly publications, the holding of meetings, the provision of assistance to research, and other appropriate means."

To promote the science of geology, two ideals must be achieved—the advancement of the geosciences (its worth to society and the world, its milestones, and its integration with other sciences) and the advancement of geoscientists (their study, careers, opportunities, and professional excellence). The best way to honor the aspirations and achieve these ideals is to organize GSA around two centers for excellence.

The **GSA Center for Geoscience Discovery** will include programs and initiatives surrounding geoscience field experiences, innovation and incubation of multidisciplinary research, new and revised publications, revamped meetings and conferences, and other means of advancing the geosciences for members and the geoscience community.

The **GSA Center for Professional Excellence** will address the professional development needs of all our members, including, but not limited to, student and early career programs, service to non-academic members, expanded research grants, mentoring, professional ethics, and diversity initiatives. GSA aims to serve the professional needs of its members from their first student presentation at a GSA Section Meeting until they receive the Penrose Medal and beyond.

GSA will organize its operations to streamline our services and communications to fit within the centers for excellence. There are multiple steps and tasks along the way, and we are presently working to develop realistic action plans that include timelines and measures of success. Progress on the strategic plan will be evaluated against benchmarks and reported regularly to GSA leaders and members. Members are encouraged to participate and keep GSA on the right track with sound programmatic and financial decisions going forward.

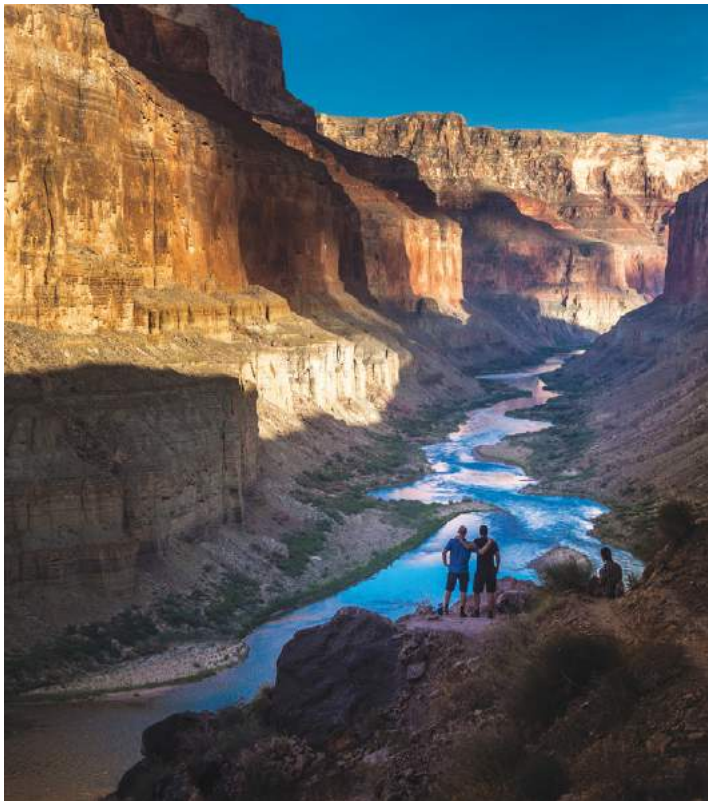
GSA will…

"keep supporting students... As long as GSA serves students, it serves me."

Call to Action

GSA Council, leaders, and staff join together in inviting all members to engage with the Society on this exciting journey to make GSA all that it can be over the next ten years.

Whatever your career stage, however much time or money you have to contribute, your participation will make all the difference. In large and small ways, each geoscientist adds to the fabric of our community and makes it richer and stronger with their presence.



GSA will… "increase support of geoscientists who want to advocate for the importance of science."

10 WAYS TO MAKE A DIFFERENCE

1. Keep current with your membership and recruit new members. Dues enable essential programs.
2. Read *GSA Today* and "GSA Connection," open your email, and stay informed about GSA's accomplishments. Tell your friends and colleagues.

3. Attend and participate in meetings. Bring your research; mentor a geoscience student or early career professional.
4. Donate through the GSA Foundation to support the next generation of geoscientists and large initiatives that benefit our profession.
5. Publish your research with GSA, serve as a peer reviewer, and shop in the GSA store.
6. Serve in a leadership capacity, and nominate another from our diverse community to do the same.
7. Attend a Congressional Visits Day and lend your voice to conversations about science in Washington, D.C., and in your own community.

8. Volunteer in local schools to excite children about geoscience and to help teachers with geoscience training. Volunteer to assist with media interviews in your areas of expertise.
9. Become a GSA ambassador when traveling, working, or researching outside North America.
10. Add your voice to the online Member Community to answer a question or provide a needed resource. Fill out your profile in the member directory and make connections with other GSA members.

Like most everything in life, you will receive as much from this professional association as you put into it. GSA stands ready to serve and assist all of you in the geoscience community, as we have done for over 130 years. We look forward to meeting the challenges of our shared aspirations and moving forward together into the next decade.

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250 Million Years of Earth History in Central Italy

Celebrating 25 Years of the Geological Observatory of Coldigioco

Edited by Christian Koeberl and David M. Bice

Central Italy has been a cradle of geology for centuries. For more than 100 years, studies at the Umbria and Marche Apennines have led to new ideas and a better understanding of the past, such as the Cretaceous–Paleogene (K-Pg) boundary event, or the events across the Eocene–Oligocene transition from a greenhouse to an icehouse world. The Umbria-Marche Apennines are entirely made of marine sedimentary rocks, representing a continuous record of the geotectonic evolution of an epeiric sea from the Early Triassic to the Pleistocene. The book includes reviews and original research works accomplished with the support of the Geological Observatory of Coldigioco, an independent research and educational center, which was founded in an abandoned medieval hamlet near Apiro in 1992.

SPE542, 532 p., ISBN 9780813725420 | list price $120.00 | **member price $84.00**

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Ads (or cancellations) must reach the GSA advertising office no later than the first of the month, one month prior to the issue in which they are to be published. (Note: Combined March/April issue releases on March schedule.) Print ads will also appear on the Geoscience Job Board to coincide with the month of print issue. **Contact: advertising@geosociety.org**, +1-800-472-1988 ext. 1053, or +1-303-357-1053. Email correspondence should include complete contact information (including phone and mailing address). Rates are in U.S. dollars.

Classification	Per Line for 1st month	Per line each addt'l month (same ad)
Positions Open	$9.35	$9.30
Fellowship Opportunities	$9.35	$9.30
Opportunities for Students		
First 25 lines	FREE	$5.00
Additional lines	$5.00	$5.00

POSITIONS OPEN

Planetary Geology/Geophysics, Western Washington University

The Geology Dept. and the Dept. of Physics & Astronomy at Western Washington University (WWU) invite applications for a tenure-track, assistant professor position with specialty in Planetary Geology/Geophysics, to begin Sept 16, 2020. We seek individuals who are enthusiastic about teaching, who will establish a vigorous research program, and who will involve undergraduate and Masters-level students in their research. Teaching assignments will be focused in Geophysics (https://www.wwu.edu/majors/geophysics-bs), a program shared between the departments.

The ideal candidate will enhance our existing strengths in remote sensing, planetary geology, seismology, magnetism, tectonics and stellar astrophysics by developing new courses and research avenues in planetary geology and/or geophysics. Areas of interest include the role of physical processes in topics such as planet formation and evolution, planetary interiors, surfaces, or potential fields, small bodies, solar system dynamics, or related areas.

For details about the position, application information and instructions, go to the WWU Employment website 497337: https://employment.wwu.edu/cw/en-us/job/497337/assistant-professor-of-planetary-geologygeophysics. Review of applications begins December 20, 2019, and will continue until the position is filled. Questions about the position should be directed to the search committee chair, Jackie Caplan-Auerbach. (caplanj@wwu.edu, +1-360-650-4153).

Assistant Professor, Geochemistry, San Diego State University

The Dept. of Geological Sciences and the Environmental Sciences Program at SDSU invites applications for a tenure-track Assistant Professor position in geochemistry and environmental sciences. The preferred start date of the appointment is August 2020. The full advertisement and directions for application are posted at http://apply.interfolio.com/67212. Review of applications will begin on 21 October 2019 and continue until the position is filled. For questions or more information please contact Dr. David L. Kimbrough, Search Committee Chair at dkimbrough@sdsu.edu. SDSU is an equal opportunity/Title IX employer.

Assistant Professor (Tenure Track), Structural/Tectonic Geology, San Diego State University

The San Diego State University Dept. of Geological Sciences invites applications for a tenure-track position in STRUCTURAL GEOLOGY/TECTONICS at the Assistant Professor level. We seek to hire a candidate who uses field-based and/or computational models to address questions related to structural deformation in regions of active tectonics. Specific areas of research might include any aspects of structural geology and/or active tectonics through the use of field studies, applied geophysics, computational techniques and/or models. The successful candidate will be expected to develop a vigorous, externally-funded, independent research program with student participation. Contribution to the Dept. of Geological Sciences teaching mission and participation in University and/or community service is also expected. Candidates should have a Ph.D. in Geology or related field, relevant postdoctoral experience, a strong record of research accomplishments, external funding and a demonstrated capacity for teaching.

Additional information and application procedures are available at Https://apply.interfolio.com/67226. Review of applications will begin on 21 October 2019 and continue until the position is filled. Please direct questions about the position to the search committee chair, Dr. Allen Gontz, agontz@sdsu.edu.

SDSU is a Title IX, equal opportunity employer.

Tenure-Track Assistant Professor, University of Illinois at Chicago

The Dept. of Earth and Environmental Sciences in the College of Liberal Arts and Sciences at the University of Illinois at Chicago (UIC) invites applications for a tenure-track Assistant Professor who pursues fundamental research in climate science with an emphasis on surface processes. The applicant's research should involve more than one approach (e.g., observational, modeling, experimental) and may address topics that include, but are not limited to, the effects of climate change on biogeochemical cycling and the role of climate in landscape evolution. The successful candidate is expected to establish an innovative and productive program of scientific research that complements department strengths in ecohydrology, planetary science, and biogeochemistry, and can contribute to university strengths in areas such as public health. The candidate will teach graduate and undergraduate courses, advise graduate students (MS and Ph.D.), and mentor undergraduate students in research projects. Applicants must have a Ph.D. in Earth Sciences or a related field, and a record of research accomplishments; postdoctoral experience is preferred.

The Earth and Environmental Sciences Dept. (https://eaes.uic.edu/) has extensive laboratory and computing facilities, and is expanding collaborations with other campus units including chemistry, health sciences, and biological sciences. The department serves a growing body of majors, the majority of whom are underrepresented in STEM. UIC is a public R1 institution and one of the most ethnically and culturally diverse universities in the country. It is the largest institution of higher education in the Chicago area with over 30,000 undergraduate, graduate, and professional students. To apply, please complete the online application providing contact information and three professional references at https://jobs.uic.edu (click on the Job Board and then on the position link) and upload a cover letter, curriculum vitae, and statements of research and teaching plans. For fullest consideration, please apply by October 21, 2019. Final authorization of the position is subject to availability of funding. The University of Illinois at Chicago is an affirmative action, equal opportunity employer, dedicated to the goal of building a culturally diverse and pluralistic faculty and staff committed to teaching and working in a multicultural environment. We strongly encourage applications from women, minorities, individuals with disabilities and covered veterans. The University of Illinois may conduct background checks on all job candidates upon acceptance of a contingent offer. Background checks will be performed in compliance with the Fair Credit Reporting Act.

Faculty Position in Crust/Lithosphere Evolution, University of California, Davis

Next review date: Oct. 20, 2019. Apply by this date to ensure full consideration by the committee. Final date: Dec. 31, 2019. Applications will continue to be accepted until this date, but those received after the review date will only be considered if the position has not yet been filled.

The Dept. of Earth and Planetary Sciences at the University of California, Davis seeks a geologist who investigates the generation, evolution, and deformation of Earth's crust and lithosphere. For this tenure-track faculty position, we seek candidates whose research is anchored in the rock record and addresses fundamental problems related to the Earth's physical and chemical evolution over geologic time. The ideal candidate will employ creative, interdisciplinary, and process-focused research that integrates observations with laboratory or computational methods, and/or integrates two or more subdisciplines within Earth science, such as petrology, rock mechanics, seismology, geochemistry, geochronology, structural geology, or tectonics. We are particularly interested in applicants who will expand our current research programs and have the potential to build new connections between areas of current research expertise in the department and across the UC Davis campus. The department's current research programs and experimental, analytical and computational facilities are described at https://geology.ucdavis.edu/research. See https://www.ucdavis.edu/academics/colleges-schools/ for more information about UC Davis.

Appointment will be at the Assistant Professor rank. Candidates must possess a Ph.D. or equivalent in geoscience or a related field by the time of appointment. The appointee is expected to develop and maintain a vigorous externally funded research program and to teach at the undergraduate and graduate levels. Supervision of graduate students and service to the department, university, and

broader discipline are expected. The average teaching load is 3 quarter-length courses per year.

Candidates should submit a cover letter, CV, publication list, statements of research plans, teaching interests, and contributions to diversity, and contact information of four references by October 20, 2019 to ensure full consideration by the committee. Review of applications will begin immediately and will continue until a suitable candidate is identified or the final search date of Dec. 31, 2019 is reached. Guidance for diversity statements may be found at http://academicaffairs.ucdavis.edu/diversity/equity_inclusion. Applications should be submitted online via the job listing #JPF03025 at https://recruit.ucdavis.edu/JPF03025 Inquiries may be addressed to the Search Committee Chair at eps-search@ucdavis.edu.

Assistant Professor in Hydrology & Water Sustainability, University of Pittsburgh

The Dept. of Geology and Environmental Science at the University of Pittsburgh invites applications for a tenure-track assistant professor position in Hydrology and Water Sustainability.

We are seeking a geoscientist who characterizes hydrologic change and evaluates adaptation strategies for sustainable adjustment to these changes. This colleague ideally uses combinations of field measurements and observations, modeling, and/or remote sensing to better understand water-climate-human interactions.

The successful candidate will establish an externally-funded, internationally recognized research program that complements existing department strengths. In particular, the department hosts the Collaboratory for Water Research, Education, and Outreach (https://www.water.pitt.edu) and the University Climate and Global Change Center (https://www.climatecenter.pitt.edu/), both platforms for cutting edge, interdisciplinary water science. Teaching duties include undergraduate and graduate courses in the candidate's area of expertise.

Review of applicants will begin on October 15, 2019 and continue until the position is filled. A Ph.D. is required at the time of appointment, with the position scheduled to begin in Fall 2020, subject to budgetary approval. Please apply online to: https://facultysearch.as.pitt.edu/apply/index/MjY4. Applications should include: 1) cover letter; 2) CV; 3) research statement; 4) research statement; 5) diversity statement; 6) four references; and 7) copies of three relevant publications. Please direct questions to the Search Committee Chair, Dr. Daniel Bain, dbain@pitt.edu, 412-624-8766.

Information about the University of Pittsburgh can be found at https://www.hr.pitt.edu/why-work-pitt. For information on the University of Pittsburgh's generous package of benefits, visit http://www.hr.pitt.edu/benefits.

Pitt is an EEO/AA/M/F/Vets/Disabled employer. Full advertisement: https://www.geology.pitt.edu/news/assistant-professor-hydrology-water-sustainability.

Assistant Professor of Geosciences Smith College

The Dept. of Geosciences at Smith College invites applications for a tenure-track position at the rank of Assistant Professor, to begin July 1, 2020. We seek a geologist with expertise in the broad field of climate science, and we are especially interested in applicants with expertise in and/or who can teach courses in climate change and surface processes, and other courses in support of majors in Geosciences and the Environmental Science and Policy Program. Faculty members at Smith teach an equivalent of 4 courses a year and are expected to establish an active research program that engages undergraduate students in their scholarship. Candidates must have a Ph.D. in geosciences at the time of appointment, and members of groups underrepresented in STEM are strongly encouraged to apply. Details about the Dept. of Geosciences may be found at http://www.smith.edu/geosciences. For more information and to apply, visit https://apply.interfolio.com/66800. Review of applications will begin on November 1. EO/AA/Vet/Disability Employer.

Director, Oklahoma Geological Survey, University of Oklahoma

Applications are being solicited for the position of Director, Oklahoma Geological Survey (OGS). The OGS is located on the University of Oklahoma campus in Norman, Oklahoma, and is under the direction and supervision of the Board of Regents of the University of Oklahoma. Organizationally, the OGS is located within the Mewbourne College of Earth & Energy, which also includes the School of Geology & Geophysics and the Mewbourne School of Petroleum & Geological Engineering. The Director of the OGS reports administratively to the Dean, Mewbourne College of Earth & Energy. If appropriate, the successful candidate may hold a dual appointment as a faculty member within the College as an Associate or Full Professor. Candidates should hold a doctorate or have the equivalent experience in geology, geophysics or a closely related field. Prior experience with a public agency, such as the OGS, would be beneficial.

The objectives and duties of the Oklahoma Geological Survey include the following:

- A study of the geological formations of the state with special reference to its natural resources, including coal, oil, gas, asphalt, gypsum, salt, cement, stone, clay, lead, zinc, iron, sand, road building material, water resources and all other mineral resources.
- Management of the Oklahoma seismic recording network, and the reporting and analysis of earthquake activity in the state.
- The preparation and publication of bulletins and reports, accompanied with necessary illustrations and maps, including both general and detailed descriptions of the geological structure and mineral resources of the state.
- The consideration of such other related scientific and economic questions that shall be deemed of value to the people of Oklahoma.

The Director of the OGS has the responsibility of overseeing activities related to geological and geophysical studies of Oklahoma and adjacent areas, preparation of reports documenting the findings of these studies, and communication of these results to individuals, agencies and the general public as appropriate and/or required.

The position requires supervision and administration of an organization of approximately 50 staff and associated facilities including offices, labs and the Oklahoma Petroleum Information Center (OPIC), which contains an extensive collection of rock cores and samples, other well information and selected facilities for the examination of these cores and samples. It is anticipated that the Director of the OGS will work with Oklahoma universities, state and federal agencies, industry and other entities to conduct research in areas of public interest, as well as providing advice and service in the areas of geology, geophysics and natural resources. One particular area of current high interest is the recent, significant increase in Oklahoma earthquake activity.

The successful candidate will have the demonstrated experience and ability to oversee these activities. Areas of experience that could be considered include an appropriate background with state or national surveys, administration in academia, experience in industry or research, or other related areas.

Review of candidates will begin May 1, 2019 and continue until the position is filled. The anticipated starting date is January 1, 2020. Applicants are requested to submit a complete resume, statement of relevant experience and a list of five references who can be contacted, including names, phone numbers, e-mail addresses and complete mailing addresses. Questions or requests for additional information may be addressed to J. Mike Stice, Dean of the Mewbourne College of Earth & Energy, and Chair of the OGS Director Search Committee, at (405) 325-3821, or mstice@ou.edu. Applications and nominations should be submitted on-line at: http://apply.interfolio.com/61740.

The University of Oklahoma is an Affirmative Action, Equal Opportunity Employer. Women and Minorities are encouraged to apply.

Department Chair, Dept. of Geological Sciences, California State University, San Bernardino CSUSB

The Dept. of Geological Sciences at California State University, San Bernardino invites applications for a Department Chair. The position will be a tenured faculty position at the rank of Professor with half-time allocated for Department Chair and half-time for faculty responsibilities. The position will begin August 2020. CSUSB is designated as a Hispanic Serving Institution and is committed to building a diverse and inclusive faculty. Applicants with a commitment to serving a diverse student population in an equitable and inclusive fashion are strongly encouraged to apply. We strive for excellence, enhance diversity and foster harmony. For a full position description, go to https://cns.csusb.edu/geology and select New Position Open: Geological Science Dept. Chair.

Assistant or Associate Professor of Geology, Colorado College

The Dept. of Geology at Colorado College announces a tenure-track faculty position in igneous petrology/ high temperature processes, to begin in August 2020. Applicants must have completed or be scheduled to complete a Ph.D. in Petrology

or a closely related field, and must be able to demonstrate depth and breadth across the disciplines of earth sciences. Possible areas of active study of Earth's crust could include fluid/rock interactions, economic geology, volcanology, and/or geohazards, among others, together with their connections to human society. The successful applicant should demonstrate innovative teaching methods, including the use of instrumentation, software, and/or analytical approaches. Experiences with and a future plan for the mentoring of undergraduates are essential. Experience with Rocky Mountain/western United States geology and acquaintance with the geologic evolution of the Colorado region, are valued, as are research and teaching interests that strengthen existing, or introduce new, departmental connections with other science programs at Colorado College (e.g., Environmental Science, Biology, Chemistry, Mathematics, and Physics). Appointment can be made at the rank of Assistant or Associate Professor, consistent with the current experience and rank of the candidate.

Colorado College is a leading national liberal arts college with a distinctive academic calendar called the Block Plan, in which students take, and professors teach, one course at a time. Maximum class size is 25 or fewer students. Our residential campus is located in Colorado Springs, in a varied geologic, geographic and cultural landscape at the base of Pikes Peak. The successful applicant should demonstrate enthusiasm and intention for teaching highly motivated undergraduate students in this environment, making maximal use opportunities for laboratory-, field-, or inquiry-based teaching afforded by the Block Plan.

Colorado College is dedicated to the development of faculty and staff who are committed to inclusive practices in teaching, learning, and working, and strives to increase the diversity of the college community. Candidates who can contribute to these goals are particularly encouraged to apply. The College's position on these practices can be found at: https://www.coloradocollege.edu/basics/welcome/diversity/commitment.html.

The college supports active scholarship via a generous sabbatical program, travel to conferences, and internal grant opportunities.

Please apply at: http://employment.coloradocollege.edu/postings/4081. For more information, direct questions to geology@coloradocollege.edu.

EQUAL OPPORTUNITY EMPLOYER: Colorado College is an equal opportunity employer committed to increasing the diversity of its community. We do not discriminate on the basis of race, color, national origin, gender, age, religion, gender identity or expression, disability, or sexual orientation in our educational programs and activities or our employment practices.

Department of Earth & Environmental Sciences, Tulane University

Tulane University's Dept. of Earth & Environmental Sciences seeks to fill a Professor of Practice position to begin in July 2020. The position is a non-tenured, full-time academic year (nine month) teaching position with renewable 3-year appointments. The responsibilities of this position include teaching courses related to the department's GIS Certificate Program, teaching courses in the applicant's area of specialization, and service to the educational mission of the department and university. Opportunities exist for advising undergraduate research and development of service-learning courses. A doctoral degree in an environmental science or related field is required. Applicants will be expected to teach introductory and advanced GIS courses.

Applications are due November 1 and the position will remain open until it is filled. Applicants should submit a cover letter, CV, statement of teaching philosophy, any previous teaching evaluations or other evidence of teaching excellence, and contact information for three references familiar with the applicant's teaching abilities. Please submit applications to apply.interfolio.com/64259. Questions regarding the position can be addressed to Dr. Nancye Dawers (ndawers@tulane.edu).

Tulane University is a member of the Association of American Universities (AAU). Tulane is an Equal Opportunity/Affirmative Action/ADA Employer and encourages minority applicants to apply.

Assistant Professor (Tenure Track) in Sedimentary Geology or Structural Geology, California State University Long Beach (CSULB)

The Dept. of Geological Sciences, California State University Long Beach (CSULB) invites applications for a tenure-track Assistant Professor with expertise in any aspect of Sedimentary Geology or Structural Geology to start Fall 2020. A qualified candidate should be dedicated to teaching at the undergraduate and Masters levels and committed to developing an externally funded research program that will involve students. As a campus that serves a very diverse community, the Dept. of Geological Sciences seeks candidates who, through previous experience supporting diverse students or their own lived experience, will be committed to the successful teaching and mentoring of all students.

Southern California abounds with world-class geologic exposures for teaching and research in the mountains, deserts, coast and ocean all within a few hours' drive. CSULB is located in the vibrant Los Angeles-Long Beach-Orange County metropolitan area, rich with universities and colleges, government agencies and local industry that provide many opportunities for collaboration.

Please follow this link for a detailed position description, list of required and preferred qualifications, and explanation of the application procedure. Review of applications will begin October 14, 2019. https://www.csulb.edu/academic-affairs/faculty-affairs/assistant-professor-of-geological-sciences-2556.

Igneous Petrology, Western Washington University

The Geology Dept. at Western Washington University (WWU) invites applications for a tenure-track, assistant professor position with specialty in Igneous Petrology to begin Sept 16, 2020. We seek individuals who are enthusiastic about teaching and who will establish a vigorous research program, and are particularly interested in those who will combine field and analytical, experimental or modeling approaches in their research, and who will involve undergraduate and Masters-level students in their research.

The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in igneous petrology. Broad areas of interest include, but are not limited to, the timescales of magmatic processes, the evolution of the continental crust, mantle, oceanic lithosphere/ocean island/mid-ocean ridge processes, the recycling of elements and volatiles within arc magmas and subduction systems, and links between tectonic and magmatic processes.

For details about the position, application information and instructions, go to the WWU Employment website http://employment.wwu.edu/cw/en-us/job/497184/assistant-professor-of-igneous-petrology.

Review of applications begins December 15, 2019 and continues until position is filled. Please contact the search committee chair, Susan DeBari (debari@wwu.edu) for questions about this position.

Assistant Professor, Geology- Marine and Coastal Science, Western Washington University

The Geology Dept. and the Marine and Coastal Science (MACS) program at Western Washington University (WWU) invite applications for two tenure-track, assistant professor positions with specialties in one of three fields:

Coastal Geomorphology/Coastal Geohazards. The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in coastal geomorphology, coastal tectonics and geohazards. Broad areas of interest include, but are not limited to, coastal erosion and sediment transport, delta evolution, beach/tidal morphodynamics, marine geohazards, and tectonic processes that impact coastal zones, including uplift, subsidence, and tsunami generation and impacts.

Paleoceanography/Paleoclimate. The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in paleoceanography/paleoclimatology. Broad areas of interest include, but are not limited to, oceanic circulation and heat transport, micropaleontology/paleoecology, the carbon cycle, and geochemical processes that are related to climate variations on geological timescales. Tools and techniques used to address these problems can include geochemical or sedimentological proxies of climate variations, paleontological proxies/indicators of climate variations, physical oceanographic data, or other appropriate techniques.

Marine Geologist. The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in marine geology with a focus on crustal/lithospheric evolution and/or tectonic processes. Broad areas of interest include, but are not limited to, formation of the oceanic lithosphere and

crustal evolution, geodynamics of the ocean basins, hydrothermal circulation at mid-ocean ridges, geochemistry of rock-water interactions, submarine volcanic systems, or tectonic processes associated with oceanic plate boundaries. Tools and techniques used to address these problems can include geochemical analyses, geophysical methods, geospatial analysis, textural rock analysis, numerical models, or other appropriate techniques.

These positions will begin Sept 16, 2020. As members of the group of initial faculty hires into the MACS program, the successful applicant will foster an interdisciplinary approach to teaching and research in geology and marine science. We seek individuals who are enthusiastic about teaching and who will establish a vigorous research program, and are particularly interested in those who will combine field, experimental, and/or modeling approaches in their research program, and who will involve undergraduate and Masters-level students in their research.

To apply, and for further details regarding qualifications and position responsibilities, please see http://employment.wwu.edu/cw/en-us/job/497185/assistant-professor-geology-marine-and-coastal-science.

Please contact the search committee chair, Bernie Housen (bernieh@wwu.edu) for questions about these positions. Review of applications begins October 14, 2019 and continues until the positions are filled.

Geoscience Education, California State University, Fullerton

The Dept. of Geological Sciences invites applications for a tenure-track Assistant Professorship beginning August 2020. CSUF is a minority-serving institution, and an affirmative action and equal opportunity employer with a strong commitment to increasing campus diversity. We seek a geoscience educator who develops, applies, and evaluates new geoscience teaching innovations and curricula, as well as develops and tests geoscience education research questions and hypotheses. We expect candidates to show evidence of an existing or developing active, externally funded student-centered research program. We seek a scholar who demonstrates interest and ability to teach courses in general geology and geoscience education at various levels including: general education, lower- and upper-division undergraduate, and graduate courses. The successful candidate shall: (1) coordinate geoscience education courses; (2) help facilitate the integration of teacher preparation; and (3) be involved in program-level assessment for our department. Applicants should submit a cover letter containing past and/or potential contributions to diversity through research, teaching, and or service, CV, research statement, teaching statement, and a list of three individuals who will provide letters of reference. Submit materials online at: https://apps.fullerton.edu/facultyrecruitment. Questions concerning the application or receipt of application materials should be sent to: Dr. Nicole Bonuso Geoscience-ed-search@fullerton.edu

Bruce D. Benson Endowed Chair in Petroleum Geology, University of Colorado Boulder

The Dept. of Geological Sciences at the University of Colorado Boulder invites applications for the Bruce D. Benson Endowed Chair in Petroleum Geology. We seek an outstanding scientist who has a demonstrable record for excellence in teaching and a strong scholarly record in the broad field of petroleum geosciences. Candidates with an ability to integrate multiple specialties to solve difficult technical questions are desired. The focus of teaching and research can be in any aspect of petroleum geology, such as reservoir characterization, structure and geomechanics, reflection seismology, petroleum geochemistry, or petroleum systems modeling.

The successful candidate is expected to bridge to wider faculty interests, build collaborations with existing faculty, and complement our strengths in petroleum geology, sedimentology, stratigraphy, geophysics, paleontology, structure and tectonics, geochemistry, geohydrology, paleoclimatology, geomorphology, and geobiology. The successful candidate will need to: develop an externally funded, innovative and impactful research program (preferably with industry participation); supervise independent student research at both graduate and undergraduate levels; contribute to departmental teaching at all levels; and provide applied training and guidance for students interested in a career in the energy sector.

This academic-year, open rank, tenure-track position has a start date as early as January 1, 2020. A Ph.D. in Geological Sciences or a related field is required, and we especially encourage applications from candidates with prior industry, research, and/or faculty experience. The Dept. of Geological Sciences is affiliated with several research centers and institutes (EMARC, INSTAAR, CSDMS, CIRES, LASP) and offers a diverse set of resources for teaching and research. Visit http://www.colorado.edu/geologicalsciences to learn more about the department, these affiliations, and resources.

For consideration, applications must be submitted through https://jobs.colorado.edu/jobs/JobDetail/?jobId=19641.

Applications must include statements of research and teaching interests; a curriculum vita; reprints of three papers; and names and contact information of three individuals who can provide letters of recommendation.

Research statements should include a description of what the applicant considers to be the important problems in their field, and how their research contributes to these questions. Teaching statements should address goals and approaches to instruction.

Review of applications will begin on July 20, 2019 and full consideration will be given to applications received by September 1, 2019. Applications will be accepted until the position is filled.

The University of Colorado Boulder is committed to building a culturally diverse community of faculty, staff, and students dedicated to contributing to an inclusive campus environment. We are an Equal Opportunity employer, including veterans and individuals with disabilities.

Director, Electron Microbeam Laboratory, University of Wisconsin–Madison

The Dept. of Geoscience at the University of Wisconsin–Madison invites applications at the Assistant, Associate, or Senior Scientist level to fill the Director's position in the Eugene Cameron Electron Microprobe Laboratory (http://www.geology.wisc.edu/~johnf/sx51.html). This is a full-time, institutionally-supported position. The lab houses SX51 and SX5FE electron microprobes, a Hitachi S3400 VP scanning electron microscope, and a lab manager to assist with SEM maintenance and operations. The lab serves as a hub for interdisciplinary scientific inquiry, providing hands-on training of students from disciplines across campus. Additional departmental resources include two electronics engineers and a staffed thin-section lab.

Applicants should hold a Ph.D. in Earth Sciences, Chemistry, Physics, Material Science, or related fields at time of appointment. Demonstrated ability and experience in the use of electron beam instruments for high-quality, quantitative analyses is required. Two or more years of daily hands-on management of an electron microprobe lab is preferred, as is demonstrated ability to pursue fundable research using electron microbeam instrumentation.

Applicants should submit the following: (1) cover letter that includes your research statement, (2) curriculum vitae, and (3) the names and contact information for three referees. Please apply by October 15, 2019 to guarantee full consideration, although applications will continue to be accepted until the position is filled. For more information and to apply, go to: https://jobs.hr.wisc.edu/en-us/job/502003/epma-lab-director.

The University of Wisconsin-Madison is an Affirmative Action, Equal Opportunity Employer with a commitment to diversity at all levels.

Tenure Track Assistant Professor in Remote Sensing/Geospatial Technology, California State Polytechnic University, Pomona

The Geological Sciences Dept. at California State Polytechnic University, Pomona (Cal Poly Pomona) invites applications for a tenure-track, ASSISTANT PROFESSOR position, beginning in the 2020-2021 academic year. We invite applications from geoscientists whose research incorporates data from ground-based remote sensing or observations from unmanned aerial vehicles or satellites, and the position is open to a broad range of research specializations, such as natural hazards, active tectonics, environmental geoscience, and/or climate change. A Ph.D. in geology, geophysics, environmental geoscience or a directly related science or engineering discipline is required. The successful candidate will have the potential for excellence in undergraduate and graduate teaching, and for developing an externally-funded research program that will involve undergraduate and Master's students. Teaching responsibilities will typically include a mix of geoscience courses at the lower division, upper division, and graduate levels, and will incorporate classes in Geographic Information

Systems, Remote Sensing or other specialty courses in the candidate's area of expertise. Demonstrated experience with data collection and analysis using modern instrumentation is expected. Preferred qualifications include demonstrated success with external funding, established ties to research institutions, industry or government agencies and interest in developing intradepartmental and cross-campus collaborations. At Cal Poly Pomona we cultivate student and faculty success through a diverse culture of experiential learning, discovery, and innovation. Cal Poly Pomona is committed to being the model for an inclusive polytechnic university that inspires creativity and innovation, embraces local and global challenges, and transforms lives. The position is open until filled. First consideration will be given to completed applications received no later than December 30, 2019. Full position description and application procedure: http://www.cpp.edu/~faculty-affairs/open-positions/.

OPPORTUNITIES FOR STUDENTS

Graduate Student Opportunities at Case Western Reserve University. Students with backgrounds in geology, physics, chemistry, biology, engineering, and related fields are encouraged to apply for our Ph.D. and MS programs in Earth, Environmental, and Planetary Sciences. Areas of active research in the department include planetary geology and geodynamics, planetary materials, high-pressure mineral physics and geochemistry, core and mantle processes, environmental science, sedimentary geology, and sediment transport. For more information, please visit http://eeps.case.edu or write to eeps-gradinfo@case.edu. Financial assistance is available. Application deadline: 1/15/2020.

Statement of Ownership, Management, and Circulation

(Required by Title 39 U.S.C. 4369)

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This information taken from PS Form 3526, signed 20 August 2019 by the Publisher, Vicki S. McConnell, and filed with the United States Postal Service in Boulder, Colorado.

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15. Extent and Nature of Circulation		
a. Total number of copies (*net press run*)	11,891	18,600
b. Legitimate paid and/or requested distribution (*by mail and outside the mail*)	11,611	18,378
c. Total paid and/or requested circulation	11,611	18,378
d. Nonrequested distribution (*by mail and outside the mail*)	0	0
e. Total nonrequested distribution	0	0
f. Total distribution (*sum of c and e*)	11,611	18,378
g. Copies not distributed (*office use, leftovers, spoiled*)	280	222
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John W. (Jack) Hess, *GSA Foundation President*

You Make On To the Future's Mentor-Mentee Relationships Possible

Do you remember your first GSA Annual Meeting? Even for those of us who have been coming for years, it can be an overwhelming experience. For students attending their first professional conference, it can be daunting. The On To the Future (OTF) initiative provides one year of membership, meeting registration, and travel scholarships to students from underrepresented groups in the geosciences to attend their first annual meeting. The key to the program's success is GSA members and donors like you, whose gifts of time and resources enable the mentor-mentee relationships that provide support and inspiration during the meeting.

This was the case for 2018 OTF participant Afiqah Ahmad Rafi, a student at the University of Wisconsin–Madison. When Afiqah first learned about the OTF program, she recognized it as an important opportunity to meet colleagues who shared her academic interests and to enter into the professional geoscience community. After being accepted into the program, Afiqah's next step was to select a mentor utilizing GSA's student-driven platform—a recent innovation to the program. Individuals registered for the annual meeting who want to support OTF students can access the mentor platform to create a profile. In turn, students search the list of available mentors to find one whose experience and background best fits their needs and interests, creating a deeper investment in the program and further enriching the mentorship relationship.

It was through this platform that Afiqah choose Joan Fryxell, a GSA Councilor and professor at California State University San Bernardino. Joan is a long-time mentor for the program, whose enthusiasm for OTF stemmed from witnessing the enthusiastic interactions between mentors and mentees at past meetings. More importantly, however, she was inspired by a desire to help first-time student attendees: "My students expressed much interest in having mentors to help guide them through their first meetings, which are otherwise pretty overwhelming, and somewhat intimidating."

Throughout the 2018 GSA Annual Meeting in Indianapolis, Indiana, USA, Joan and Afiqah checked in regularly. Joan was impressed with Afiqah, noting that, "She didn't need much mentoring, although she thought she did. In our conversations, she clearly had good perceptions about the profession and possibilities she could pursue, and was enthusiastically excited about the geosciences. I think my main contribution was to validate her already good ideas and direction." For Afiqah, Joan not only provided validation, but was a warm-hearted, considerate presence who, as a woman in the geosciences, was an inspiration. "Women especially are underrepresented in many industries, and I want this trend to change. I want Muslim women to have the same experience as any other geoscientist, and I believe that geology is now ready to leave gender division behind. Joan's passion, love, and sincerity definitely inspired me to grow and hopefully be an inspiration to future generations too."

You make these mentor-mentee relationships possible. Your generosity has made On To the Future a critical program that facilitates greater student success at our annual meeting and beyond, and with your help, even more students and mentors can benefit from this experience. If you would like to support the OTF program, please contact Clifton Cullen at +1-303-357-1007 or via email at ccullen@geosociety.org.

Joan Fryxell and Afiqah Ahmad Rafi taking the opportunity to catch-up during the GSA 2018 Annual Meeting.

2020 GSA Section Meetings

THE GEOLOGICAL SOCIETY OF AMERICA®

South-Central

9–10 March
Fort Worth, Texas, USA
Chairs: Omar Harvey, omar.harvey@tcu.edu; Arne Winguth, awinguth@uta.edu
www.geosociety.org/sc-mtg

Fort Worth Stockyards. Photo by Visit Fort Worth.

Joint Southeastern–Northeastern

20–22 March
Reston, Virginia, USA
Chairs: Arthur Merschat, amerschat@usgs.gov; Patrick Burkhart, patrick.burkhart@sru.edu
www.geosociety.org/se-mtg

Great Falls Park. Photo by Visit Fairfax.

Rocky Mountain

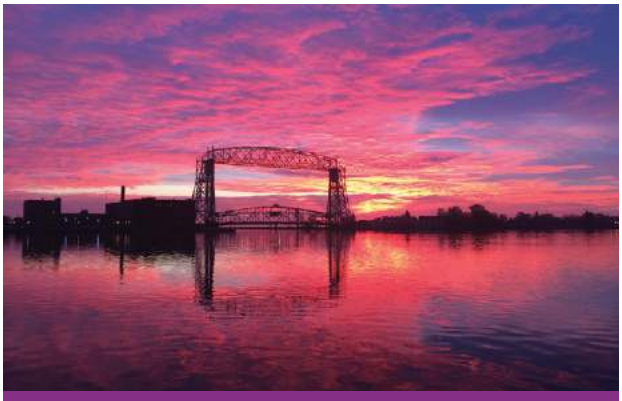
4–5 May
Provo, Utah, USA
Chair: Daniel Horn, hornsda@uvu.edu
www.geosociety.org/rm-mtg

Mount Timpanogos. Photo by Hike395 via Wikimedia Commons.

Cordilleran

12–14 May
Pasadena, California, USA
Chair: Doug Yule, doug.yule@csun.edu
www.geosociety.org/cd-mtg

City Hall. Photo by Pasadena Convention & Visitors Bureau.



North-Central

18–19 May
Duluth, Minnesota, USA
Chair: Karen Gran, kgran@d.umn.edu
www.geosociety.org/nc-mtg

Aerial Lift Bridge at sunrise. Photo by Visit Duluth.