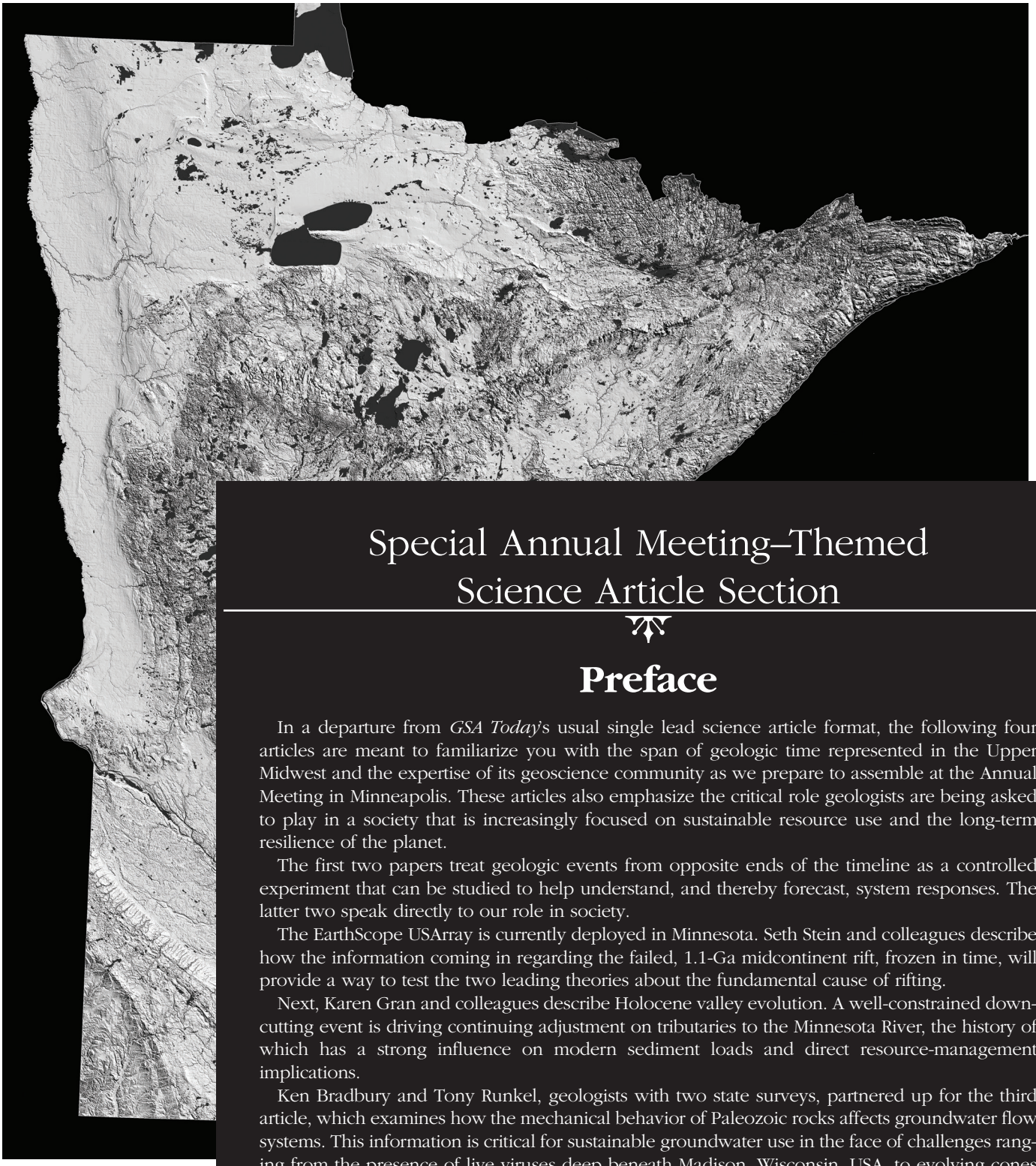

Special Annual Meeting–Themed Science Article Section

Preface

In a departure from *GSA Today*'s usual single lead science article format, the following four articles are meant to familiarize you with the span of geologic time represented in the Upper Midwest and the expertise of its geoscience community as we prepare to assemble at the Annual Meeting in Minneapolis. These articles also emphasize the critical role geologists are being asked to play in a society that is increasingly focused on sustainable resource use and the long-term resilience of the planet.

The first two papers treat geologic events from opposite ends of the timeline as a controlled experiment that can be studied to help understand, and thereby forecast, system responses. The latter two speak directly to our role in society.

The EarthScope USArray is currently deployed in Minnesota. Seth Stein and colleagues describe how the information coming in regarding the failed, 1.1-Ga midcontinent rift, frozen in time, will provide a way to test the two leading theories about the fundamental cause of rifting.

Next, Karen Gran and colleagues describe Holocene valley evolution. A well-constrained down-cutting event is driving continuing adjustment on tributaries to the Minnesota River, the history of which has a strong influence on modern sediment loads and direct resource-management implications.

Ken Bradbury and Tony Runkel, geologists with two state surveys, partnered up for the third article, which examines how the mechanical behavior of Paleozoic rocks affects groundwater flow systems. This information is critical for sustainable groundwater use in the face of challenges ranging from the presence of live viruses deep beneath Madison, Wisconsin, USA, to evolving cones of depression that change hydraulic gradients.

Finally, Cathy Manduca introduces readers to the process of producing an educated citizenry (and a well-prepared geoscience community) that understands the ways that Earth and society are linked. The article also illustrates the need to act collectively to share experiences, develop them into classroom activities, and accurately diagnose student challenges.

Carrie Jennings, Minnesota Geological Survey
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Improving undergraduate geoscience education —A community endeavor

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ABSTRACT

Undergraduate geoscience education is centrally important to all geoscientists. We improve when we share our insights and successes, build on our collective experiences, and work together to find the most important, durable ideas. Such intentional reflection on geoscience education is becoming an important part of the work of the geoscience community facilitated by professional societies, professional development opportunities, and online resources.

WORKING TOGETHER TO IMPROVE TEACHING

Teaching is more than hard work. Teaching, like surgery, is a difficult, creative practice informed by research and improved through experience. Effective teaching requires knowledge of the subject, knowledge of educational methods, and skill in the classroom, the lab, and in utilizing office hours. Teaching can be accurately described as the work of guiding and promoting learning—the challenging part is that the learning itself must be done by the student. Thus, the teacher, like a coach, must develop experiences for the students that allow them to progress while diagnosing the students' specific challenges in learning and continuously adapting to their response to instruction. Because faculty often work with groups of more than 100 students at a time, they must respond in aggregate to the needs of each individual. And, of course, it is not easy to observe students learning, so teachers must devise mechanisms for deducing how this learning is proceeding. At the end of the day, the teacher is asked to ascertain each student's state of knowledge and assign a grade, further complicating the relationship between the student and the teacher. No wonder faculty find teaching to be both a source of inspiration and pleasure and of frustration.

All geoscientists understand the importance of undergraduate geoscience education. It is our opportunity to reach out to the world and improve society's understanding of Earth—the ways that it impacts people and the ways that people impact it. It is also an integral piece of the development of new geoscience professionals, those who will take our places in the geoscience workforce as we know it, and those who will fill new, as yet unimagined, jobs that will emerge as our large population strives to live successfully on the planet. How then as a community do we maximize our ability to do the important work of educating?

As scientists, we routinely address our challenges collectively. The communication, discussion, and synthesis of ideas at the community scale is one of the hallmarks of science. The work of individual researchers or research projects is informed by the community's collective prior work, and its results are fed back into and used by this community as it moves forward in addressing the problems at hand. The need for a similar community-scale approach in education has been widely discussed (PKAL, 2002, 2006) and underpins the current program design of the National Science Foundation's "Transforming Undergraduate Education in STEM" solicitation (NSF 10-544).

In the past decade, the geosciences have made substantial progress in developing a community-scale approach to addressing the challenges of undergraduate geoscience education (Manduca, 2008). The Geological Society of America meetings, like the meetings of other professional geoscience societies,

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play an important role in supporting this work. This year, as in the past, the program will be full of opportunities to learn about teaching, both in the traditional sense of working with undergraduate students and preparing future teachers, but also in the more general sense of bringing new understanding to the public through writing, public speaking, or participation in policy discussions. The meeting will also provide opportunities to meet new people whose work in research or education enhances our own ability to do this educational work.

Professional societies and their journals are the traditional mechanisms that we use to move information and knowledge through our community. Complementing these traditional mechanisms, the geosciences have pioneered an array of opportunities for sharing information about teaching, discussing and synthesizing our teaching experience, and learning from one another. These include the "On the Cutting Edge" program for faculty professional development (Macdonald et al., 2004) and its associated website (http://serc.carleton.edu/NAGTWorkshops/index.html; Manduca et al., 2010); the "Teach the Earth" portal (http://serc.carleton.edu/teachearth/index.html), which provides integrated access to information and products developed by individuals, departments, and projects across our community; and the "Starting Point" (http://serc.carleton.edu/introgeo/index.html) and "Pedagogies in Action" (http://serc.carleton.edu/sp/index.html) websites which describe teaching methods and provide examples of their use within the geosciences and beyond.

Roughly one-third of geoscience faculty in the United States now make use of these opportunities to learn about how their colleagues teach a particular topic, to find new ideas or materials, or to seek information that will help support changes in their teaching approach to a more student-centered and interactive style (McLaughlin and Iverson, 2009). In addition, workshop participants and website users report that these opportunities give them new inspiration and new confidence to change their teaching. For them, the hard work of being an excellent teacher is made easier by capitalizing on the experiences of their colleagues. They are learning from one another and collectively improving geoscience teaching. As a result, new ideas are moving out of individual classrooms and spreading across the nation.

COLLABORATING TO UNDERSTAND LEARNING

How do we know these ideas are improvements? As scientists, we are well-trained to be suspicious of our results and to think critically about our claims and the data that support them. This is no less true in education. How do we know that our students are achieving the desired learning? That new materials or methods are working as designed or desired? Not only do individual faculty members seek these answers in their daily work in the classroom, institutions are increasingly calling on geoscience departments to assess the learning taking place in their programs. These questions are hard to answer and take time to address thoroughly—precious time. Robust analysis can require techniques from educational research, cognitive science, and social science that are foreign to most of us.

Again, a community approach is helping us. A new cadre of geoscience education researchers is pursuing research on teaching and learning in the geosciences. Faculty can learn about this work, as well as relevant developments in educational research and cognitive science through professional development opportunities like the recent journal club on temporal learning offered by the On the Cutting Edge professional development program. (Look for papers associated with the upcoming GSA Annual Meeting session "Time, Events, and Places: Understanding Temporal and Spatial Learning in Geoscience Education" [T167].) They can also participate in community-wide research projects testing the effectiveness of teaching methods (e.g., McConnell et al., 2006) and exploring new approaches to improving learning (e.g., McConnell, 2011). Assessing the learning taking place in an individual classroom or by an individual student is a central aspect of teaching and will remain an important skill for every instructor; however, by working together, we can collectively test our methods and materials.

BEYOND THE INDIVIDUAL FACULTY MEMBER OR COURSE

While the individual faculty member and his or her effort in teaching is critical, there is more to strong undergraduate geoscience education. The department as a whole offers programs of study including both course work and other co-curricular learning experiences, and it is at the department level that a culture develops that can support learning, mentoring, and advising. Increasingly interdisciplinary programs that bring geoscience together with other sciences or social sciences are an important part of our educational work. Developing strong programs, strong departments, and strong interdisciplinary collaborations are also challenging tasks for which learning from the experience of other geoscientists can be valuable. To this end, GSA, The National Association of Geoscience Teachers (NAGT), the American Geophysical Union (AGU), and the American Geological Institute (AGI) have sponsored the Building Strong Geoscience Departments program (http://serc.carleton.edu/departments). This program brings together workshops, sessions at professional society meetings (including GSA), and a website to support sharing and discussion of the challenges departments face. The program complements and makes use of the ongoing efforts at AGI to describe the state of geoscience education and the geoscience workforce.

Like science, geoscience education is a community endeavor. We can be most effective if we share our insights and successes, build on our collective experiences, and work together to find the most important, durable ideas. Just as every mountain belt has a unique history, each academic department is unique—but geoscientists long ago discovered the power and fun of working together to understand them. The GSA meeting in Minneapolis will provide an opportunity for all of us to learn from each other about teaching.

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