



Hiroki Sone still remembers his first encounter with the geosciences in elementary school in Houston, Texas—ground zero for the American oil and gas industry.

“Maybe it’s a Texas thing, but I remember in elementary school I learned what crude oil is,” Sone says. “Maybe that’s just because it was in Houston. But I also remember when I heard this word ‘sandstone’ in elementary school; it was weird because sand is sand and I wondered how it could be a stone. Somehow, I had this question when I was in elementary school, so probably I had interest in these things even then.”

Sone joined the college as an assistant professor of civil and environmental engineering and geological engineering in fall 2015 after a three-year postdoctoral appointment at the German Research Centre for Geosciences in Potsdam. It will be Sone’s first appointment in an engineering department, and he’s excited to bring his expertise in rock mechanics to UW-Madison.

Sone’s early interest in the geosciences wasn’t fully realized until his college years in Kyoto, Japan, where his pursuit of physics dovetailed with his interest in the physical world around him and the research of an early mentor.

While at Kyoto, where he completed bachelor’s and master’s degrees in geology and mineralogy, Sone studied the mechanics of a thrust fault in Taiwan linked to hazardous earthquakes. Later, at Stanford University, Sone continued his research on fault mechanics as a PhD student. But soon he and his advisor began focusing their research efforts elsewhere.

At Stanford, Sone began doing lab work on shale gas reservoir rocks. He characterized their basic qualities, in particular a quality called “creep deformation.”



Creep deformation is the very slow deformation of rocks such as shale when they are placed under a sustained load. Sone’s lab work on the shale gas reservoirs’ creep deformation characteristics helped identify reservoirs amenable to the extraction method of hydraulic fracturing, better known as “fracking.”

“Rocks flow to some extent,” Sone says. “When they flow, it changes the stress in the earth—stress being the force that’s inside the rocks. When that condition changes, sometimes it favors fracking, and sometimes it’s difficult to make fracking happen.”

Understanding how likely shale rocks are to flow gives researchers and companies an idea of what force or stress state a gas reservoir is in, which Sone says influences the outcome of fracking. “These are called ‘unconventional reservoirs’ because we knew that the gas was there, but we didn’t know how to get it out,” Sone says. “With conventional reservoirs, you poke a hole and oil just comes out, but that doesn’t happen with these shale gas reservoirs because the fluids don’t flow as freely as in conventional reservoirs.”

To make the fluid gas to flow, companies must fracture the shale that contains it. “I don’t think there is an alternative way,” Sone says. “It took the industry a while to figure out how to do that.”

Sone acknowledges the less-than-stellar reputation fracking has garnered in some circles over the last several years, with critics concerned about its environmental impacts.

“I’m not necessarily for or against fracking,” Sone says. “I just really want the discussion to be healthy. That’s one of the things I want to emphasize in the classes I’ll teach, so they can discuss this matter. Because energy problems are not just about the environment—they’re also economic and political. It’s just very important to be informed properly.” (Continued on next page)

Photo: Eleanor Bloom



Congratulations to our spring 2015 graduating class!
Student enrollment in GLE at UW-Madison is at an all-time high.

CHAIR'S MESSAGE



Bill Likos

Greetings! I am writing this as the new chair of GLE, a role I took over from Craig Benson in April of this year. I can confidently speak for our entire program when I say how grateful we are for Craig's outstanding leadership and contributions to our success. We wish him the very best as dean of Engineering and Applied Science at the University of Virginia.

It is an exciting time for GLE! We have more students than ever, energetic new faculty, and students and alumni who continue to make us proud. Undergraduate enrollment is at an all-time high. We now have 140 students, almost triple the number of students enrolled in our program when I joined it only three years ago. Each of these students is exposed to the huge variety of experiences characteristic of a truly interdisciplinary degree. Unprecedented growth in our program reflects exceptional demand for our graduates from a range of industries, highly competitive starting salaries, our continued efforts to recruit the best and brightest freshman, and concurrent growth in the broader world of geoscience education.



Our students continue to excel and to be recognized for their outstanding work. Chelsea Lancelle received the Outstanding Student Paper Award at the 2014 fall meeting of the American Geophysical Union for a presentation entitled, "Directivity and sensitivity of fiber-optic cable measuring ground motion using a distributed acoustic sensing array." Her work was co-authored with GLE Professors Herb Wang and Dante Fratta. Brigitte Brown received one of the very first scholarships awarded from the the American Coal Ash Association Educational Foundation for her research on beneficial use of coal combustion products. Kelly Del Ponte and Bharat Natarajan won the Barton A. Thomas Memorial Award for Best Technical Paper at the 2015 World of Coal Ash conference for their life cycle analysis research conducted with Geological Engineering Researcher and GLE alum Angela Pakes Ahlman (BS '96), and

Professor Emeritus Tuncer Edil. Former students Chris Bareither (MS '06, PhD '10) and Joe Scalia (MS '09, PhD '12) are now both faculty members in the Department of Civil and Environmental Engineering at Colorado State University. These two make a formidable academic duo to say the least.

In faculty news, Hiroki Sone joined GLE as a new assistant professor in July of this year. Hiroki brings expertise in experimental rock mechanics and geomechanics. Assistant Professor Matt Ginder-Vogel, who has held an appointment in civil and environmental engineering at UW-Madison since 2012, has also recently joined GLE. Matt brings new expertise in soil and environmental biogeochemistry to our faculty. We are very excited for the enthusiasm and energy that these two bring to our group and look forward to their success.

We could not do as much as we do without the generous support of our alumni and friends. Thank you for your gifts; we will use them wisely to continue providing exceptional student experiences.

William J. Likos, Chair
likos@wisc.edu
(608) 890-2662

New faculty: Hiroki Sone

(Continued from front page)

This fall, Sone is teaching *Geomechanics*, a graduate-level course on the mechanics of large-scale geophysical features. In spring 2016 he is offering an undergraduate course in rock mechanics, which applies similar concepts, but on a smaller scale limited to rocks.

And while Sone's research interests continue to include experimental rock mechanics and their application to both the understanding of earthquake-prone faults and of shale gas reservoirs, he is also beginning to explore engineering problems like those posed by nuclear waste disposal.

"When I study the slow deformation of shale rocks, which are clay-rich rocks, this directly applies to nuclear waste disposal," Sone says, "because governments, especially

in Europe, are thinking about building these repositories in clay-rich rock environments."

Some European governments have already selected target sites in such environments, Sone says. "I think in the U.S., since activity in the Yucca Mountain was slowed down, they're starting to look for other candidates," Sone says. "Shales are one of the types of rocks they're looking at. My research related to natural gas can actually be directly transferred to such settings."

Because clay-rich shales are less porous and have the ability to flow slightly, they have the ability to self-seal if fractured. Those same rocks also tend to adsorb excess moisture and contaminants that might otherwise leak through other rock types.

Sone also plans to be involved in European-led research on reducing fracking's environmental footprint. His experimental rock mechanics lab on campus will employ a postdoc and other graduate students. A large portion of the new lab's start-up funding was provided by a donor. Sone used the donation to purchase a new rock deformation apparatus.

"Modern rock mechanics equipment is quite expensive, but I felt the need to introduce one such piece of equipment because I needed to perform long, stable experiments to study creep behavior of rocks, and it also significantly reduces the time for students to learn how to use the specialized equipment," Sone says.

"I'm excited to be at UW-Madison," Sone says, "I'm among people and in an environment I was never exposed to before."



Alum honored at **ENGINEERS' DAY 2015**

Malcolm Theobald (BSMineEngr '83) received a Distinguished Achievement Award during the 2015 ENGINEERS' DAY celebration on October 16.

Theobald was one of the last people to earn a UW-Madison bachelor's degree in mining engineering before that program evolved into the Geological Engineering Program. But Theobald's career arc very much embodies the vision that today's GLE program has for its students and alumni.

After graduating in 1983, Theobald embarked on a long and diverse career with Schlumberger, one of the major suppliers of technical services in the oil and gas industry. In multiple roles as an engineer and manager with Schlumberger, he worked on projects in places spanning from Louisiana to Norway to the North Sea. These adventures required him to draw on skills ranging from data services to marketing.

Theobald says that his UW-Madison engineering education enabled him to keep pace with the geographical and technical whirlwind of his early post-college career. "Coming out of a respected engineering school positioned me to be hired then by a company that values technology as one of its main principles. People, profits and technology are what Schlumberger is all about," Theobald says. "A pretty heavy dose of technology and a lot of responsibility were dumped on me at a very young age. Suddenly, six months after graduating from college, I was managing a couple or three operators on location."

Since 2001, Theobald has been based at the company's Houston headquarters, where



he currently serves as president of its bits and advanced technologies division. In this capacity, he oversees more than 3,000 employees and the development of

sophisticated drilling technologies for some of the most challenging operations in the oil and gas industry. Before taking on his current role, Theobald managed the corporate relationship between Schlumberger and ExxonMobil, and served for nearly seven years as vice president of investor relations.

He has remained engaged with the highly successful GLE program of today, including serving as a member of the GLE board of visitors, and Schlumberger frequently recruits new GLE graduates for jobs and internships.

Theobald lives in Houston with his wife Janice. They have two sons, Jordan and Alex, and two daughters, Shannon and Taylor.

GEOLOGICAL ENGINEERING NEWS



Michael Cardiff

Congratulations to Geoscience Assistant Professor **Michael Cardiff**, who has been recognized for the 2015 Kohout Early Career Award. He is the fourth recipient of this award presented by the Geological Society of America to a distinguished early career scientist for their contribution to the field of hydrogeology through their research, service, and demonstrated potential for continued excellence throughout their career. Cardiff will be presented with the award at the 2015 GSA meeting this upcoming November in Baltimore. His exemplary publication record and dedication to the profession makes us proud to have him on our team here at the University of Wisconsin-Madison.



Friday morning coffee and donuts for GLE grad students (a tradition).



Brigitte Brown

Brigitte Brown has been selected to receive one of the very first scholarships awarded by the The American Coal Ash Association Educational Foundation (ACAAEF). The ACAAEF scholarship is award to students who have an interest in advancing the beneficial use of coal combustion products. The scholarship is awarded to individuals who stand out based on their essays, coursework, academic credentials, recommendations and a demonstrated interest in the use of coal combustion products.



GLE, CEE researchers win best paper award at coal ash conference

Geological Engineering Researcher **Angela Pakes Ahlman**, Civil and Environmental Engineering and Geological Engineering Professor Emeritus **Tuncer Edil**, geological engineering graduate student **Kelly Del Ponte** and geological engineering undergrad **Bharat Natarajan** won the Barton A. Thomas Memorial Award for Best Technical Paper at the 2015 World of Coal Ash conference, held in Nashville, May 4-7, 2015.

The researchers received the honor for their paper, "System-wide life cycle benefits of recycled materials," which Ahlman presented at the conference. The award is named in honor of a pioneer in the field of coal combustion by-product use, and each year's winner is chosen by a panel of judges at the conference.

To fully realize the potential of harnessing energy from the heat within the earth will require a far more detailed understanding of what's going on down there than scientists currently have. And beyond naturally occurring geothermal systems, man-made ones that emulate them could, by some conservative estimates, produce a total of 100 gigawatts of cost-competitive electricity over the next 50 years. But to get there, energy providers will need sophisticated systems for gathering and analyzing data about the rock mechanics and hydrology at work.

UW-Madison geoscientists and engineers are working with industry partners and the U.S. Department of Energy to integrate several data-gathering approaches into a highly detailed monitoring system for geothermal wells. A team that includes Geological Engineering and Geoscience Professor Kurt Feigl (*inset*) and Geological Engineering Associate Professor Dante Fratta, Geoscience Assistant Professor Mike Cardiff, Geoscience Professor Cliff Thurber, and Geoscience Professor Herb Wang, has converged on Brady Hot Springs in Nevada (*pictured*) with a combination of satellite imaging techniques and fiber-optic cable.

The researchers have turned this relatively small geothermal field into a proving ground for a system that ideally can be scaled up in wider and deeper fields.

Feigl says the project is the first in North America to use fiber-optic cables to measure rock properties in a geothermal field, though it's common for energy companies to use the technology in oil exploration. "Locating oil underground is tough, but in geothermal wells, the challenge is finding hot water," Feigl says.

What's changed over the past five or six years is that advances in fiber-optic cable now allow it to produce incredibly detailed seismic and temperature data. The cables produce new data about 500 times per second, yielding about a terabyte of data per day. "We have one channel every meter, whereas a typical seismic survey would have one channel every 30 or 40 meters," says Joe Greer, business development manager for Silixa, one of the industrial partners involved in the project.



College of Engineering
UNIVERSITY OF WISCONSIN-MADISON

Geological Engineering
1415 Engineering Drive
Madison, WI 53706



Nonprofit Org.
U.S. Postage
PAID
Madison, WI
Permit No. 658



Better data tools for a bigger geothermal future

The project's scope spans from fundamental geoscience to maximizing the production of electricity from geothermal wells. Feigl says there's still a great deal to learn about fractures and deformation in rocks. This information will in turn help DOE and industry partners Silixa and Ormat Technologies follow the hot water through a complex underground landscape—and pursue the long-term goal of commercializing EGS more broadly.

The information will also help industry develop enhanced geothermal systems (EGS), man-made geothermal wells created by injecting additional fluid into naturally heated rock areas that are not already saturated with fluid. This process opens up existing fractures in the rock, allowing the water to circulate through the area and transport the geothermal heat so that it can be converted into electricity.

"We have an opportunity to create better, more efficient reservoirs, and that could lead to the deployment of EGS on a broader scale," says Lauren Boyd, the EGS program manager for DOE. "We have to understand what our fracture network looks like before we try to create a reservoir."

Greer also points to the dynamic nature of EGS reservoirs and the need it creates for data-rich analysis. "There is one big advantage in fiber optics, and that is that if you want to go back and look at it again in a time-lapse survey, and re-image it and see what's changed, you can eliminate a lot of error," he says.

Boyd and her colleagues say that DOE chose to fund the project in part because of the UW-Madison team's unique combination of strengths in geoscience and data analysis.

"It was very clear that Kurt and his team have a really clear understanding of these challenges that we're facing, and it brings a creative approach to integrating technologies," Boyd says.