



## Containing the worst industrial waste

**S**toring industrial waste has never been a pretty job, and it's getting harder. New techniques for refining such metals as aluminum and vanadium, for example, also yield new by-products that have to be sealed away from human and environmental contact. And the practice of "scrubbing" the exhaust of coal-fired power plants keeps chemicals like sulfur dioxide from entering the air, but produces a more concentrated residue.

Now, many of these wastes are proving too acidic, basic or concentrated for commonly used storage materials. That's why UW-Madison researchers, partnering with scientists from CETCO of Hoffman Estates, Illinois, through the National Science Foundation's Grant Opportunities for Academic Liaison with Industry program, set out to reinforce those materials by fusing them with polymers.

Their starting point is sodium bentonite clay, which has proven reliable in a variety of environmental applications, essentially swelling up and forming a seal when exposed to water or other liquids. But the clay sometimes fails to swell up adequately when subjected to harsh conditions, such as the extreme pH levels of "red mud," the alkaline residue produced by aluminum extraction. "You have to be able to store the waste into perpetuity—hundreds of acres of this liquid," says Wisconsin Distinguished Professor Craig Benson. "Effective containment is part of the social contract these companies have with their community."



Benson



Edil



Likos

Benson, colleagues Tuncer Edil and William Likos, and former PhD student Joe Scalia have spent the past seven years working with CETCO scientists exploring how combining polymers with bentonite clay creates effective barriers. They eventually found that the best method was to let polymer molecules move around on the bentonite's surface, essentially finding their way into the flow paths of the liquid as the clay absorbs the leachate. The polymers then interact to form a blockage in the flow path, like a logjam in a river. The resulting material can withstand pH levels as low as 1 (highly acidic) and as high as 14 (highly basic), depending on the concentration of the substances involved.

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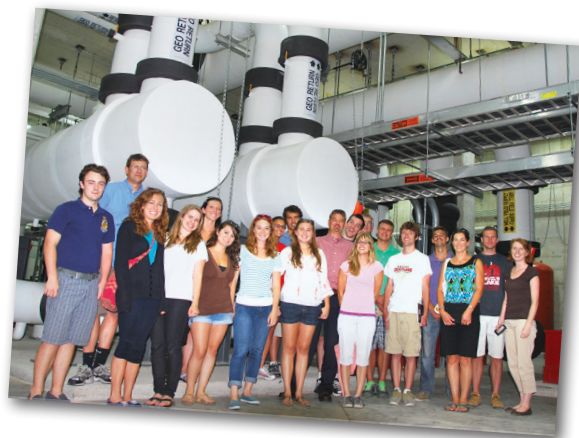
## Tinjum partners with EPIC on geothermal wells

**T**he campus of healthcare software giant EPIC Systems, located in Verona, Wisconsin, is well known for its fun, architecturally distinct features: its farm-themed buildings, its slide between floors, and its futuristic conference room. The corporate culture at EPIC, which employs more than 8,000 people, is distinct as well. Team meetings often take place in EPIC's spacious tree house and it's perfectly acceptable to do work-related reading while sitting on the campus dock with toes soaking in the pond.

Fewer people are aware, however, of EPIC's unique commitment to renewable sources of power, which includes installations of solar panels, ground-source heat pump systems, and off-site wind turbines. In fact, EPIC currently produces enough energy to power about 2,500 homes and could soon produce roughly as much energy as it consumes.

Associate Professor James Tinjum, is part of a research team currently installing 13 performance-monitoring wells in a field of 2,500 ground-source heat exchangers on the EPIC campus. "EPIC's commitment to the development of geothermal exchange, as well as its large and unique site, provides a really great opportunity for research teams like ours," Tinjum says.

Geothermal exchange fields are designed to take advantage of the relatively constant, year-round temperature of 50 degrees that exists just a few feet below the earth's surface. In the closed-loop system of an exchange field, water is cooled (or warmed, depending on the season) as it travels to a depth of about 500 feet in wells that are



situated vertically in the earth; the water from a large number of wells is then collected into larger pipes and used to dramatically reduce the work of the above-ground heat exchanger, contributing extra heat to the system in winter and extra cooling in summer.

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## CHAIR'S MESSAGE

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**G**reetings, friends and alumni of geological engineering! It is an exciting time in geological engineering (GLE) at UW-Madison. Enrollment is at an all-time high, with nearly 140 undergraduate students in the major or on track to join in their sophomore year, and our graduates have the highest starting salaries in the College of Engineering. Our initiative to

develop a strategic thrust in conventional and renewable energy has yielded partnerships that provide internships and full-time employment opportunities for our students (including with Apache and Schlumberger, as seen in this issue). GLE has also hired a new faculty member, Hiroke Sone, who completed his PhD at Stanford University and is currently on a postdoctoral assignment in Germany. Hiroke works in rock mechanics and rock physics with applications in the energy industry, and will join us in summer 2015.

I share some bittersweet news as well. I am in my final year as GLE chair, and will step down at the end of June 2015. I have thoroughly enjoyed leading GLE during

eight years of growth and success. Please join me in welcoming our incoming chair, Professor Bill Likos (likos@wisc.edu), an exceptional faculty member and leader who joined us in 2012.

During my tenure as chair, your support has been a key catalyst driving growth in GLE. As we wind down this calendar year, and head into the holiday season, I ask that you consider a gift to support GLE (gle.wisc.edu/support-gle). We will use your gifts wisely to continue providing exceptional student experiences.

**YOU SHARE Give Today**  
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## Geothermal (Continued from front page)

The EPIC campus is currently one of the largest cooling-dominated geothermal exchange sites in North America, with more than 3,500 exchange wells using 25 kilometers of underground piping and circulating 12 million liters of water.

"The wells we're installing now will use a number of innovative sensor technologies to measure ground temperatures around the buried wells," Tinjum says. "These sensors will provide the data we need to design more efficient ground-source heat pump systems."



**Tinjum**

Tinjum's research on geothermal systems is part of a UW-Madison initiative, the Geothermal and Energy Geotechnics Group (GEGG), a collaborative academia-industry network. This cross-disciplinary group of researchers is dedicated to the study of alternative geothermal exchange systems, heat transfer within the earth's near surface, and the performance and sustainability of geothermal-based heating and cooling systems.

Tinjum and his GEGG colleagues received a 2014 Wisconsin Energy Institute seed grant to fund their work at the EPIC site, and have also recently applied for a National Science Foundation grant that would allow them to continue in-depth, long-term data collection at the site as well as to analyze, interpret and model that data.

"We feel strongly that our work at EPIC will help build the scientific and engineering foundations necessary for creating new design, new methods, and new production of geothermal-based heating and cooling systems," Tinjum says.

**D**an Piette earned his undergraduate degree from the UW-Madison mining program in 1980 and has since gone on to a long career in the energy industry in Houston. He may not be the first person you'd expect to meet in the startup community, but he's found his energy background comes in handy when he meets inventors trying to get new companies off the ground as a judge in the Rice Business Plan Competition (RBPC).



Piette is a board member of Petroleum Geo-Services and Headwave, consults for several startup companies, and also serves on the UW-Madison geological engineering board of visitors. He says that his UW-Madison curriculum in mining, energy, geology and computing taught him the importance of being able to see things with a new eye.

"You're always adapting what you've learned to a new circumstance, and that's probably the best training you can get to go into the startup world," Piette says.

## The intersection of energy and entrepreneurship

RBPC began in 2000, and Piette started getting involved about five years later. He's been active in the competition, serving as a judge and seeing both the competitors grow more professional and the RBPC become the richest such competition in the world. In 2014, the judges awarded more than \$3 million in prize money.

Even those who don't win top awards at the competition can walk away with sizeable deals and helpful contacts. In 2014, Microbe Detectives, owned by civil and environmental engineering PhD candidate Trevor Ghylin, won a total of \$26,000 at RBPC.

Like many entrepreneurship and invention competitions, RBPC challenges people with technical backgrounds to get a better grasp of business matters and presentation. Even though the competition only considers very new companies that include at least two students, those students are rising to the challenge, Piette says.

"They're much more professional than they were 10 years ago," he says. "You see people take it much more seriously. There are medical companies who are well on their way to FDA approval, whereas 10 years ago you just didn't have that level of sophistication on the teams."

Still, Piette says, what makes RBPC valuable is that it gives young inventors and entrepreneurs a low-risk way to learn some lessons about the skills and persistence the startup world demands. "Getting involved in a start-up is really hard," Piette says. "You fail a lot, so it's nice to know that just because this one idea you had didn't work out, it's not the end of the world. I'm a huge proponent of these little companies. You have to have that ability to bounce back after hearing no so many times."



## GLE alum honored at **ENGINEERS' DAY 2014**

**R**yan Bennett (BSGLE and Mathematics '90) received a Distinguished Achievement Award during the 2014 ENGINEERS' DAY celebration on Oct. 24 on the UW-Madison campus.

A member of the first-ever class to graduate with a UW-Madison geological engineering degree, Ryan Bennett has gone on to experience the mining industry from both the technical side and the investment side.

After earning his UW-Madison bachelor's degree in 1990, Bennett, a Sun Prairie native, moved to Denver, where he worked as a mining engineering consultant for Caterpillar and a geologist for the United States Bureau of Mines. He soon shifted his focus to the business aspects of the industry, joining the banking group NM Rothschild & Sons. He spent six years there in various executive roles, including a stint in the company's Sydney, Australia, office.

In 1998, Bennett joined at its inception, Denver-based private-equity firm Resource Capital Funds, where he still works and is currently a senior partner. His proudest

professional accomplishment, he says, was serving on a team that built up a \$2.04 billion fund for the firm. The firm invests heavily in mining companies, and Bennett's technical background still comes in handy.

"GLE provided me with a diverse set of skills that I still use today," he says.

Bennett continued that technical education even after he joined Resource Capital Funds, earning a master's degree in mining and earth systems engineering from the Colorado School of Mines. Even though he's spent so many years on the investment side, a knowledge of and passion for the science of mining itself remains crucial to Bennett's career. To ensure success for all stakeholders in a mining project, investment firms rely on understanding the challenges and potential rewards of extracting specific kinds of minerals in all manner of different geographic locations.



The firsthand experience of team members like Bennett, then, is a big part of what enables Resource Capital Funds to attract new limited partners.

Bennett serves on the boards of several mining companies and is a member of the American Society of Civil Engineers; the Society for Mining, Metallurgy, and Exploration; the Society for Geology Applied to Mineral Deposits; and several other professional organizations. He also is a member of the Board of Visitors for GLE and the Industry Advisory Committee for the Colorado School of Mines Mining Engineering Department.

His hobbies include fishing, hunting, mining history and large-format photography. He lives in Cherry Hills Village, Colorado, with his wife, Jennifer, and their sons, Jonathan and Tye. His father, Philip Bennett, was a professor in the Department of Engineering Professional Development for 34 years.

## Dynamic Badger GLEs thrive at Schlumberger

**T**he energy industry took Malcolm Theobald from Madison to Houston, but in between it also took him to such disparate locales as Louisiana and the North Sea. Since earning his UW-Madison degree in mining engineering in 1983, Theobald has served in a variety of engineering and executive capacities at Schlumberger, one of the major suppliers of technical services in the oil and gas industry.

"It was a pretty heavy dose of technology and a lot of responsibility dumped on me at a very young age," Theobald says of his early career. "Suddenly six months after graduating from college, you're managing a couple or three operators on location."

That life suited Theobald, who wanted to be physically active and work in a number of different environments. From Louisiana to rigs off the coast of Scotland, he drew on his education's combination of geology and technological problem-solving. "I had to tap into the geology and subsurface classes I had in college to understand what was happening in the subsurface and how that tied into the data we were acquiring," he says.

GLE, which grew out of the mining engineering program, continues to produce students who intern and take jobs with Schlumberger. Adam Luepke, a GLE senior who interned with the company last summer, shares Theobald's spirit of adventure. Luepke spent his summer in New Mexico, running well-control software at hydraulic fracturing sites.

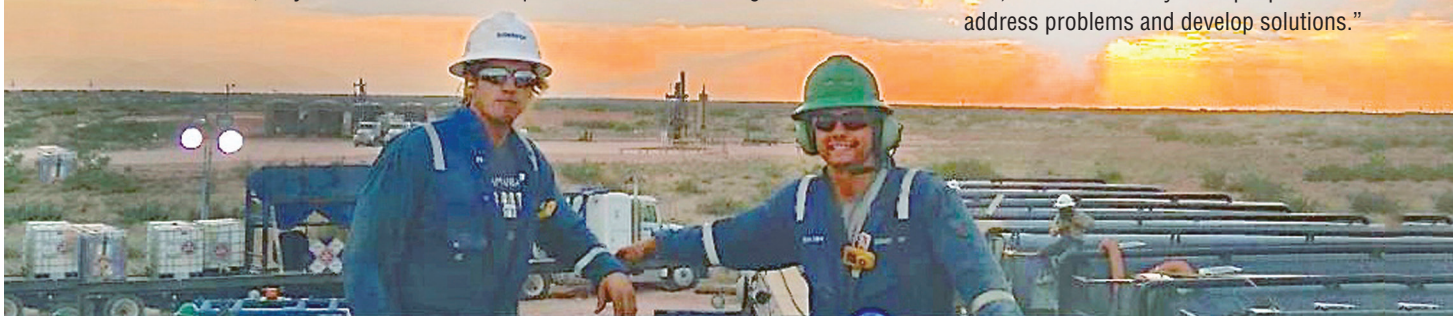
"They put me in a responsible role and didn't hold my hand, so I had to ask questions and make that step forward and learn as fast as I could," Luepke says. "You can't be shy, you have to be a go-getter and you have to understand it and learn it. You're in a high-stress environment, so you can't ask the same question over and over again."

In addition to testing his technical skills and endurance, Luepke says, the internship improved his interpersonal skills on the job. "I learned how to run a team, how to tell people what to do who are twice your age, but without being condescending," he says.

Theobald says that the company's interns and new hires come in with a good foundation and receive extensive training. "It seems like the GLE program is very well suited to this type of an environment, and I'd like to see how we can leverage that," he says.

Theobald and Luepke's experiences, of course, aren't the only ones the company offers. Even if they're not bound for far-flung places, geological engineers must be open-minded about how they apply their skills.

"You have to have a spirit of adventure and accept change, and it can happen quite rapidly in terms of progression and opportunity," Theobald says. "You also have to be very open to the cultural diversity that you run into, and different ways that people will address problems and develop solutions."





## Industrial waste *(Continued from front page)*

UW-Madison and CETCO researchers are working on how to adapt these materials to commercial uses. Chris Athanassopoulos, former technical services manager in CETCO's suburban Chicago office and now a professor at Harper College, says the involvement of UW-Madison engineers made it much easier to get people in industry interested in the new product. "When you're talking with a design engineer or a regulator, unfortunately they have lots of experience talking to salespeople, or people who promise the world to them without backing it up with good technical information," he says. "The fact that we were able to have data from Craig's lab over the long term, with some of these materials, was probably the biggest benefit in terms of getting acceptance."

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—Wisconsin Distinguished Professor  
Craig Benson

Athanassopoulos and former colleague Mike Donovan, R&D director for CETCO, have commercialized the product as Resistex GCL, and have developed an even more robust version, Resistex Plus. So far, the products have been accepted by one of the world's largest producers of aluminum, which recently used the material to line one of its storage facilities for aluminum tailings.

To build on this success, Benson plans to focus on understanding the chemistry of how the material works, and eventually build off the material's design to create a suite of different materials tailored to contain different kinds of extreme chemistries.

Beyond industrial waste storage, Benson sees potential for this research in applications as diverse as plugging wells and building containment walls that seal off contaminated groundwater areas from the rest of the water supply. And as UW-Madison researchers and CETCO scientists learn more about the science of extremely resilient environmental materials, CETCO is exploring how to adapt its manufacturing processes to spread the benefit of these materials.

"Craig and his team are always asking questions and developing tests," Athanassopoulos says. "We've learned a lot from them."



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## Apache looks to UW-Madison for future energy explorers

**G**eological engineering at UW-Madison boasts a remarkable record of high employment among its graduates, and there are many clues to why in the Apache Corporation's recruitment of Badger GLE alums.

In recent years, Apache, which explores and extracts oil and gas in operations around the world, has become a regular presence at recruiting events on campus, and has given many GLE students internships and their first post-graduation jobs. Gifts from Apache, totaling \$37,500 between 2013 and 2014,

also have supported undergraduate research scholarships, including four awarded in fall 2014, and an undergraduate research program that solicits proposals from students to participate in hands-on experiential learning through research in geological engineering.

"These gifts help GLE develop greater student engagement and participation in the energy industry and energy-related issues," says Wisconsin Distinguished Professor and GLE chair Craig Benson. "Apache has also been providing summer internships each year where students have hands-on experiential learning on real projects, including steering of full-scale horizontal drilling operations for enhanced oil and gas recovery."

The GLE program's technical excellence is one explanation for the company's support, but Apache senior HR manager Emily McClung says that cultural factors also make UW-Madison stand out among the schools from which Apache recruits. "We recruit from some of the core that you'd expect us to look at, but then when we went to Wisconsin, for me, the students just have a really strong work ethic, and it's definitely more pronounced than we might find in some of the other large schools that are more heavily recruited at," McClung says. "They take it seriously and they just are very engaged and hungry for an opportunity. When we say the majority of GLE internships are going to be in Tulsa, Oklahoma, or Midland, Texas, they're happy to go wherever the work takes them."

McClung says UW-Madison GLE students tend to go out of their way to show their interest, dressing professionally and showing a willingness to take on change and responsibility. "We're looking for someone who wants to take ownership of something. We're looking for students who are motivated," McClung adds. "We're looking for students who are inquisitive, who don't just do what everybody else does."



**The Apache scholarship recipients: Bharat Madras Natarajan, Spencer Sellner and Paul Fredrickson. (Not pictured, Joshua Cook.)**