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NEWS

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# James Gardiner Defends Dissertation, Researches Complex Geologic Systems

Tracking down the origin of substances like oil or carbon dioxide ($CO_2$) that enter complex geologic systems deep underground can be difficult. That's because complex geologic systems can be infiltrated in multiple ways, which is what sets them apart from *simple* geologic systems. **James Gardiner** is conducting research to help locate the sources of fluids and gases that penetrate these complex geologic systems. "If you're trying to pinpoint the source of water quality degradation or water impairment, it's good to know where it's actually coming from, instead of just drawing a question mark," says Gardiner, who is teaching in the University of Pittsburgh's (Pitt) Department of Geology and Planetary Sciences. By conducting laboratory experiments and running isotope models, Gardiner has worked to eliminate as many of those question marks as possible.

*Gardiner bails a well at the sampling site in Chimayó, New Mexico. Bailing is a process used to remove mineral buildup from a well and improve its production.*

Gardiner's investigations, funded by the Office of Fossil Energy (FE), have not been confined to laboratories. He traveled to New Mexico to collect well-water samples for laboratory testing, a task that involved collaborating with **Alexandra Hakala,** the Technical Coordinator for the National Energy Technology Laboratory - Regional University Alliance (NETL-RUA) Unconventional Energy Resources team. In West Texas, he worked with **Rodney Diehl** and **Dennis Stanko**, also NETL-RUA researchers, to collect samples of "produced" water that rises, along with oil, in oil wells. He also visited well pads in Greene County, PA, and studied core samples taken from the Marcellus Shale the pads overlie.

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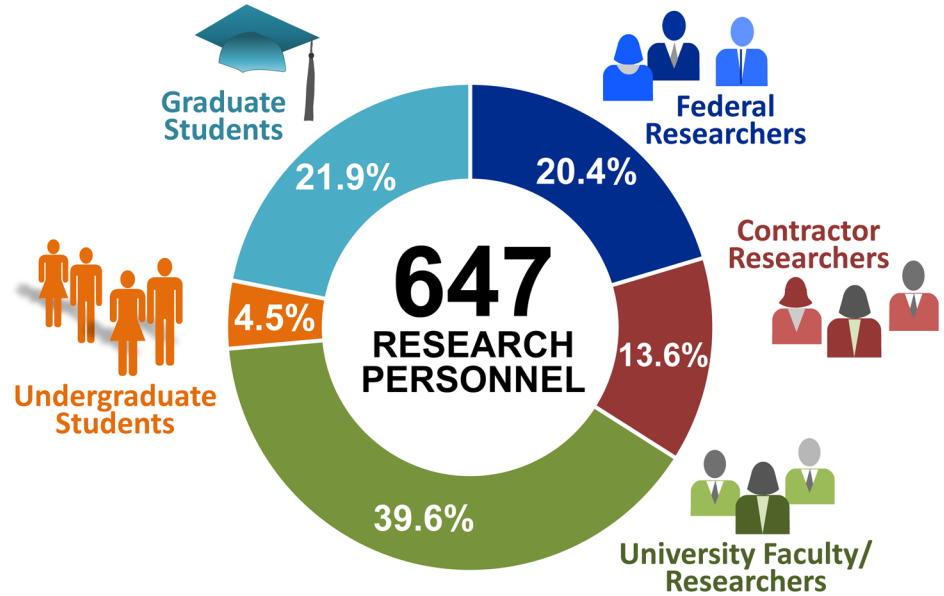


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The sites were wildly different, not just on the surface, but "when you get deeper, too," explains Gardiner. Regardless of the site, Gardiner and his research partners kept the same goal in mind: "applying geologic knowledge . . . and making good insights from our observations in the field."

This work led to his recent defense of his dissertation, entitled "Isotopic Investigation of Subsurface Rock and Fluid Interactions: Case Studies of $CO_2$ Sequestration and Gas-Bearing Shale Formations." Hakala, in particular, helped to guide the project, says Gardiner. Earlier, Gardiner had worked with her as an intern in the Oak Ridge Institute for Science and Education (ORISE) program. Hakala also sat on Gardiner's dissertation committee, as did NETL-RUA researchers **Rosemary Capo** (an associate professor of environmental geochemistry at Pitt), **Brian Stewart** (a Pitt associate professor of isotope geochemistry), **Dan Bain** (an assistant professor of catchment science at Pitt), and **Bill Harbert** (a Pitt geophysics professor).

*In West Texas, Gardiner fills a container with a sample of water collected from the well head of a producing oil well.*

Gardiner isn't backing off his research now that his dissertation is finished. In addition to teaching at Pitt, he returned to West Texas in January to collect more samples. "I'm excited about it," he says. "When I took samples before, it was before they started to inject $CO_2$ [underground], and now we'll take some samples after they've injected some." The results will help show the feasibility of $CO_2$-enhanced oil recovery and reveal the site's potential for carbon sequestration—the two most recent question marks Gardiner is helping to erase.

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## Innovation on the Rise: Corrosion Sensors Attract Interest of Oil and Gas Industry

When a new technology can slash maintenance costs for an industry, it's no surprise when corporations and trade groups rush in to help develop it. Such is the response that NETL research scientist **Margaret Ziomek-Moroz** and her research partner **Serguei Lvov**, director of The Pennsylvania State University's (Penn State) Electrochemical Technologies Program, expect to receive for their work on sensors that can detect minute amounts of corrosion on underwater pipelines. When developed, the sensors would be placed on oil and gas pipelines called risers, which are submerged in bodies of salt water. In that environment, corrosion is a menace, and the risers can become corroded both externally (from the seawater) and internally (from the production fluids the risers transport). Sensors currently in use cannot detect the initial stages of corrosion. In fact, operators may not even realize a riser has corroded until operations are shut down for routine maintenance. Instead, says Ziomek-Moroz, "we need to find the first stage of corrosion attack as soon as possible" to prevent catastrophic failures. The sensors she and Lvov are researching would provide such information far sooner than today's sensors because they could pinpoint the electrical-current changes generated by corrosion. "If [a change] like that happens," says Ziomek-Moroz, "within probably a day, that will be noticed by the operator."

Ziomek-Moroz at NETL and Lvov's group at Penn State have jointly made significant progress on identifying the right electrodes and materials for the sensors. The reference electrode, in particular, has been identified, which is a difficult task. NETL-RUA provides a key advantage when it comes to identifying electrodes and materials. The team of Ziomek-Moroz and Lvov can conduct the necessary electrochemical tests because of an autoclave equipped with electrochemical measuring devices that Lvov has access to at Penn State. "These autoclaves are absolutely unique," says Ziomek-Moroz. "We are aware that in the United States, nobody is able to do this type of electrochemical testing for high-pressure, high-temperature conditions." Equipment aside, Lvov's background in high-pressure and high-temperature studies bodes well for the project. Both he and Ziomek-Moroz have expertise in corrosion science and engineering, which includes mitigation of materials degradation caused by corrosion.

Once the NETL-Penn State research team has determined the proper materials to use for the sensors, they will design a probe for use in the field. The National Association of Corrosion Engineers has already expressed interest in helping them scale up the technology, and since the sensors stand to make it easier and cheaper to repair corrosion in risers, the team is optimistic that oil and gas companies will also take note.

## *Technology Spotlight*

# Every Drop Counts: Suite of Oil-Spill Modeling Tools Undergoes API Study

If a hurricane damages an offshore oil rig, where will the escaping oil travel? If an oil pipeline on the ocean floor springs a leak, how will the oil's chemical makeup change by the time it reaches land? And most importantly, how do we prevent these events and plan ahead of time to reduce their impacts on a variety of systems? NETL has developed a coupled suite of modeling tools—collectively known as the Blowout and Spill Occurrence Model (BLOSOM)—to answer these and similar questions. With its inclusion in a recent American Petroleum Institute (API) code comparison study, BLOSOM stands to become even more reliable.

BLOSOM simulates offshore oil spills in deepwater and ultra-deepwater settings. Funded by Section 999 of the Energy Policy Act of 2005 (EPAct) through FE, BLOSOM can reproduce the movement of an oil droplet through water and show how it can be chemically altered along the way, whether by oxidization, microbial influence, or breaking into smaller particles. For these reasons, BLOSOM helps NETL fulfill its obligations under EPAct. It is also an important tool that the NETL-RUA Ultra-Deepwater and Frontier Regions research team can use to predict impacts and help plan responses to harmful events in extreme offshore drilling and production.

API's comparative study will help vet the strengths and weaknesses of BLOSOM as well as those of the other modeling systems in the study. As Kelly Rose, BLOSOM's technical coordinator, explains, "[API] basically said, 'Here's a standard problem set. Everybody run it, and then we're going to compare results and try to understand if certain models seem to handle certain bits and pieces better than others.'"

BLOSOM is unique in that it is currently the only open-source, spill system model in the study. That's important because users can tailor it to account for new hydrocarbons, different ocean depths, or other variables as needed. "There are other models that can simulate different parts of a spill individually," says Rose, "but there just aren't many tools that follow the whole life cycle of the oil droplet." What's more, because students get the chance to work with BLOSOM themselves, the use of the modeling software helps prepare them for careers in energy research or industry—one of NETL-RUA's goals.

For more information please visit: http://www.netl.doe.gov/newsroom/labnotes/feb-2014/02-2014

# There Goes the Neighborhood: Kelley Rabjohns Studies Microbial Ecosystems at Carbon Capture, Utilization, and Sequestration Sites

The toughness of microbes is staggering. They "live in the deep subsurface, on the surface, in the oceans, in lakes, in rivers, in our guts, in high salinity, in low salinity, and in almost all climates from zero to 121 degrees Celsius," says **Kelley Rabjohns**, postgraduate ORISE intern who is mentored by **Circe Verba**, an NETL scientist involved in NETL-RUA research teams that are engaged in research supporting EPAct. Microbes' homes even include underground carbon capture, utilization, and sequestration (CCUS) sites. Until now, few publications have examined the microbial communities found in CCUS sites and how those communities respond when supercritical $CO_2$ invades their neighborhood. Rabjohns is looking to change that.

Rabjohns, who holds a master's degree in geological sciences from the University of Oregon, used data from NETL's CCUS database, NATCARB, to make a map that lays the temperatures of active CCUS sites over a geothermal heat flow map of the United States. She considered the temperatures and pressures found at the 94 active CCUS sites to determine which ones were likely hosts to microbes such as bacteria and archaea (microorganisms that look like bacteria but differ from them chemically, genetically, and in other ways). Only three sites—Jackson Dome in Mississippi, the Lawson Formation in Tampa, and the Wilmington Graben offshore of Los Angeles—had temperatures too high to be hospitable to microbes. The other 91 sites could suit a variety of microbes, and those microbes could have distinct effects on $CO_2$. Likewise, $CO_2$ could affect the microbial ecosystems. Rabjohns gives one example of how microbes and $CO_2$ can interact: archaea use inorganic carbon, such as $CO_2$, to produce organic compounds for biosynthesis; not only does this process cause the microbial community to grow, but it also helps keep sequestered $CO_2$ fixed in place.

It is these types of interactions that make Rabjohns' research so intriguing. Her work, funded by FE, affirms that species thriving under the surface of the earth can influence, and be influenced by, supercritical $CO_2$. "Microbes are an active part of the subsurface," says Rabjohns, "and should be considered when thinking about the effects of $CO_2$ sequestration."

## NETL Engineer Inducted as AIChE Fellow

**Isaac K. Gamwo**, PhD, an NETL research chemical engineer, was inducted as a Fellow of the American Institute of Chemical Engineers (AIChE) during the AIChE Annual Meeting in San Francisco, California, on November 5, 2013. Dr. Gamwo has been a member of AIChE since 1990 and a Senior Member since 1999.

The grade of Fellow is conferred on not more than 0.3 percent of all AIChE members in any given year. The induction is a special tribute for those who have made exceptional scientific contributions in engineering and services over several years, normally 25 years or more. AIChE, founded in 1908, is the world's leading organization for chemical engineering professionals, with more than 45,000 members from over 93 countries.

Dr. Gamwo was recognized for his research contributions in reactive multiphase flow modeling and his services to the chemical engineering community. He is currently leading the NETL-RUA project "Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature" as part of the Ultra-Deepwater and Frontier Regions research team.

*NETL Researcher and AIChE Fellow Dr. Isaac Gamwo*

## NETL-RUA Research Presented at 2013 AGU Fall Meeting

At the 2013 American Geophysical Union (AGU) Fall Meeting in San Francisco, faculty members and students from NETL-RUA member organizations joined NETL scientists to present the results of their research into the hydraulic fracturing of shale resources for natural gas extraction. The presentations supported NETL-RUA's Unconventional Energy Resources initiative, which helps NETL fulfill its obligations under the Energy Policy Act of 2005. **Athanasios Karamalidis**—an assistant research professor at Carnegie Mellon University (CMU) and an NETL-RUA researcher—was part of the committee that organized the session, entitled "Exploring Environmental Impacts of Hydraulic Fracturing in the Subsurface." NETL scientist Alexandra Hakala and **Andrew Wall**, an ORISE postdoc stationed at Pitt, gave invited oral presentations. Hakala's presentation focused on field monitoring efforts and gave an overview of the Unconventional Resources research portfolio. "The research we are performing through the NETL-RUA is focused on being able to understand how the geologic system changes and being able to monitor and interpret what is happening," said Hakala.

Graduate students **Jessie Wishart** and **Jonathan Yang**, both from Oregon State University, gave poster presentations. Wishart's presentation was on the microbiology associated with Marcellus shale and Yang's was on evaluating the release of potential contaminants such as arsenic, and the potential to use rare earth elements as environmental tracers. CMU graduate student **Clint Noack's** oral presentation provided an overview of the research he has done (with Karamalidis, URS Corporation scientist **Jinesh Jain**, and CMU professor **David Dzombak**) into rare earth elements and their potential use as geochemical tracers for natural-gas-drilling wastewater. Noack commented, "I look forward to presenting my work to other researchers in the field; AGU brings together many of the best scientists in the world." Through conferences such as the AGU Fall Meeting, NETL-RUA research is being transferred to the public domain. These conferences allow project team members to network with and receive feedback from other experts from around the world. Noack is very grateful that his NETL-RUA affiliation affords him the opportunity to perform work that is relevant and of such interest to his peers.

## NETL-RUA SPRING MEETING POSTPONED

The NETL-RUA Spring Meeting, previously scheduled for March 11, has been postponed and will be held in the fall of 2014. The Fall Meeting will review and mark progress against plans made at the time of the RUA's inception in 2010, showcasing the accomplishments of this successful strategic partnership between NETL and its corporate and academic partners. Check future editions of the NETL-RUA Newsletter for more information on the date and location.

If you have information that you would like to feature in future newsletters, send that information to NETL-RUA-FB@netl.doe.gov. All issues of E News can be found on MOSS and the NETL-RUA website.

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