NETL-RUA
Regional University Alliance

NEWS

Shared Intellect • Shared Laboratories • Shared Resources

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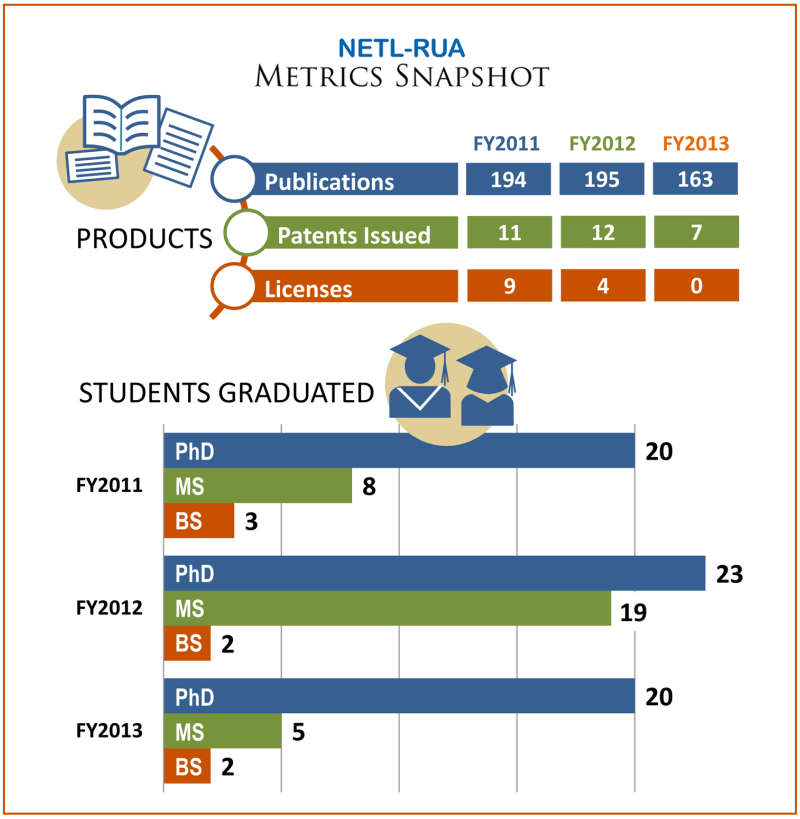
A Discussion with Depth: NETL-RUA Researchers Invited to Write Chapter on CO_2 Injected Underground

A team of National Energy Technology Laboratory-Regional University Alliance (NETL-RUA) researchers has been invited to contribute a chapter to *Reviews in Mineralogy and Geochemistry* (RIMG), published by the Mineralogical Society of America and the Geochemical Society. The chapter considers the disposition of carbon dioxide (CO_2) injected into deep, saline formations that are promising candidates for long-term CO_2 storage. It focuses on the role CO_2 dissolution into brine can play in reducing the volume required to store injected CO_2 as compared to storage of supercritical CO_2 by structural and stratigraphic trapping alone. Because CO_2-saturated brine is denser than unsaturated brine, it will gradually sink deeper below the surface, further contributing to storage security. NETL's **Angela Goodman** says the information in this chapter is pertinent because when CO_2 is stored as a dissolved phase, as opposed to a supercritical phase, the geologic subsurface volume is reduced by 45 to 65 percent.

Because graduate students studying geosciences use RIMG in their courses, the research team—which consists of **Robert J. Bodnar**, **Matthew Steele-MacInnis**, **Ryan M. Capobianco**, and **J. Donald Rimstidt** (from Virginia Polytechnic Institute and State University) and Goodman, **Robert Dilmore**, and **George Guthrie** (from NETL)—is advancing NETL-RUA's mission to educate the next generation of energy researchers. To that end, the chapter will not only be featured in RIMG, but will be the basis of a short course on carbon sequestration held during the upcoming American Geophysical Union Fall Meeting in December. Dilmore credits the NETL-RUA for assembling a team of collaborators with strong expertise in geochemistry and CO_2 sequestration. "This is an excellent example of how these collaborations help to advance both the scientific understanding of complex engineered geologic systems and development of core competencies in tomorrow's scientists and engineers," says Dilmore.



What's in This Issue

"Passionately Curious" Middle Schooler Stands Out at EIC ..... p. 2

High-Performance Rechargeable Batteries May Help Keep the Lights On ..... p. 3

"Powerhouse of Great Research": NETL-RUA Fosters Cooperative Research in Fuel Cells and Coal ..... p. 3

NETL-RUA Member Organizations Publicize Research Collaborations with NETL ..... p. 4

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"Passionately Curious" Middle Schooler Stands Out at EIC

It was Albert Einstein who admitted, "I have no special talent, I am merely passionately curious." But curiosity is the forerunner of success, since it sets the table for the dogged practice and study that make for mastery. In light of that, 12-year-old aspiring scientist and inventor Alex Stoker is off to a good start. Although the seventh-grader may have been the youngest attendee at the third annual Energy and Innovation Conference, his inquisitive spirit made him stand out.

Stoker attends Chartiers Valley Middle School in Collier Township, Pennsylvania. The third of four children, Alex is not the son of scientists. His father is in law enforcement, while his mother, Susan Stoker, has a background in urban planning. When she showed Alex an advertisement for the conference, he asked her to take him for the day. While his friends were in class, Alex spent the day asking NETL scientists questions and got a different kind of education.

When asked to name a presentation that stood out at this year's event, Stoker pointed to NETL materials scientist **John VanOsdol** and his project to create a sensor for hazardous, aggressive, industrial environments. A self-cleaning lens, allowing the viewer to peer inside a working furnace, was the "coolest" component of VanOsdol's project. Perhaps the innovation will give Alex an idea or two for a future science fair project. This year's project is already in the bag: a perpetual motion machine.

Above: Alex participates in a panel discussion at the 2013 E&I Conference.

At right: Alex and Riley Bell (not pictured) took 3rd Place out of 300 exhibits at the 2013 Pittsburgh Regional Science and Engineering Fair.

Alex can see himself pursuing astronomy or engineering in the future, with a particular interest in the science of rollercoaster design, which he admits is also a good excuse to ride 'coasters. For that pursuit, he'll need some math, too. Fortunately, he's got that covered. "I love it," he says. Strong in algebra, he's currently awaiting the results of his latest test on slopes. "I probably got an A-plus," he says. And when he's not studying math or science…he plays video games, of course! Alex is also an athlete, taking on the fast-paced geometry of ice hockey as goalie for the Lebanon Hornets.

Albert Einstein also said "We cannot solve our problems with the same thinking we used when we created them." One surefire solution to such thinking must be new thinkers like Alex Stoker. Einstein—Alex's favorite science celebrity—would be pleased.

Upcoming Event

- **NETL-RUA Spring Meeting**
  March 11, 2014
  Waterfront Place Hotel
  Morgantown, WV

Join Us Online

Did you know?

The Members Only SharePoint Site (MOSS) has undergone several changes over the past few months. MOSS serves as both an information portal for all NETL-RUA members and a collaborative workspace for NETL-RUA members. Recently, the Solicitation & Opportunity Announcements section of MOSS has been updated to allow the potential for researchers to jointly communicate and participate on new funding opportunities. An interactive comments column has been added to the Opportunity Announcements. If interested in an opportunity, just enter your contact information and other pertinent details. Other researchers will be able to view your interest and may join you in teaming for proposal development. This MOSS improvement enables researchers to join with new investigators, expanding their network and research within NETL-RUA.

A new reference guide has also been prepared. This guide provides a MOSS overview as well as step by step instruction on using the Opportunity Announcements. The reference guide is located on MOSS here. We welcome your interest in MOSS, and to request a MOSS account for yourself or a team member, please send a request to NETL-RUA-FB@netl.doe.gov.

Technology Spotlight

High-Performance Rechargeable Batteries May Help Keep the Lights On

The energy industry is faced with a persistent challenge: risk wasting energy if the supply of electricity exceeds demand or potentially sustain mass blackouts if the electrical grid cannot compensate during unexpected peaks in demand. Large power plants have yet to flexibly adapt to changes in the rate of electricity production, meaning they burn more fossil fuels and emit more CO_2 when they are not operating at a constant rate. Fortunately, NETL-RUA researchers from the University of Pittsburgh (Pitt) and Pennsylvania State University (Penn State) have teamed with NETL scientists on an Innovative Process Technologies project to design rechargeable magnesium (Mg) batteries that store electricity when demand is low and discharge it when demand is high.

Magnesium is inexpensive, abundant, lightweight, non-toxic, biodegradable, and offers markedly higher theoretical energy density than lithium-ion batteries. Magnesium batteries also increase the current traveling through current collectors needed to regenerate the electrodes by cycling two electrons instead of just one (as is the case for lithium-ion batteries). Unfortunately, magnesium tends to react strongly with many substances, which can result in corroded battery components. A major technical challenge is finding compatible materials for the anode, cathode, electrolyte, and current collector components that enable the battery to be recharged many times over an extended period.

NETL-RUA researchers at NETL, Pitt and Penn State identified and developed compatible current collector components by testing several metals in an Mg-based electrolyte. While some of the metals quickly corroded, nickel and titanium proved to be highly stable and efficient, making them strong candidates for manufacturing current collectors for Mg-ion batteries. The results of the study were published in the *Journal of the Electrochemical Society*. NETL and Pitt researchers also developed several novel cathodes and electrolytes which show promising electrochemical performance characteristics for rechargeable battery application. They have also successfully developed scalable, less expensive chemical and mechanical milling methods that have higher yields than current manufacturing methods and could cost-effectively produce enough material to supply a battery manufacturing operation.

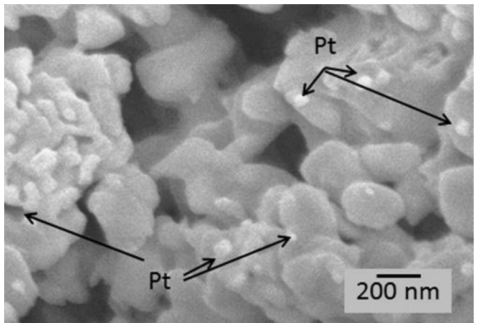
The NETL-RUA team consisted of Professor **Prashant Kumta** and **Partha Saha** and **Moni Datta** (Pitt); Professor **Donghai Wang** and **Dongping Lu**, **Shuru Chen**, and **Mikhail Gordon** (Penn State); and **Ayyakkannu Manivannan** (NETL).

While the research has concluded, the NETL-RUA research team continues to develop patents and reports documenting significant improvements made to cathodes, current collectors, and electrolytes during the course of the project.

"Powerhouse of Great Research": NETL-RUA Fosters Cooperative Research in Fuel Cells and Coal

As Dr. **Edward Sabolsky**, a researcher from West Virginia University's Department of Mechanical and Aerospace Engineering, explains, it can be difficult to find research-team members with expertise in different areas, especially as a new researcher. But the NETL-RUA eases that burden, and Sabolsky is grateful for the "beautiful opportunity" NETL-RUA has afforded him.

As contributing members of the NETL-RUA Fuel Cell Research Team, Sabolsky and his colleagues have conducted experiments designed to modify microstructures to increase the efficiency of fuel cells by changing their porosity and pore sizes. The team used an *in situ* foaming process in these experiments to optimize the porosity of a cathode by reacting foam insulation spray with water vapor in the air to produce CO_2, which caused polyurethane to foam and expand into a porous polymer structure. This process resulted in the desired porous network, allowing sufficient distribution of nanocatalysts throughout the cathode. The distribution in pore sizes improved electrochemical performance by 43 percent.



Scanning electron microscope micrograph of the impregnated foamed LSCF cathode at a distance of ~ 2-5 µm from the active cathode layer.[1]

Sabolsky also completed a project investigating new emissions sensors to monitor gases such as sulfur dioxide, hydrogen sulfide, nitrogen dioxide, and carbon monoxide, as well as beneficial gases such as hydrogen, in coal gasification processes. The team verified that the nanomaterial they developed could maintain its integrity while sensing hydrogen at high temperature by subjecting it to 1,000 degrees Celsius (°C) for 150 hours. These results are important because high-temperature and pressure-resistant sensors are vital components of devices that will be needed to monitor and control the technology used in advanced power generation systems.

Sabolsky credits NETL-RUA with making these scientific advancements possible. While researchers may pursue different funding streams, their projects often complement each other and NETL-RUA can bring these researchers together. Sabolsky feels privileged to work with an alliance of government and university laboratories that exemplifies a "powerhouse of great research."

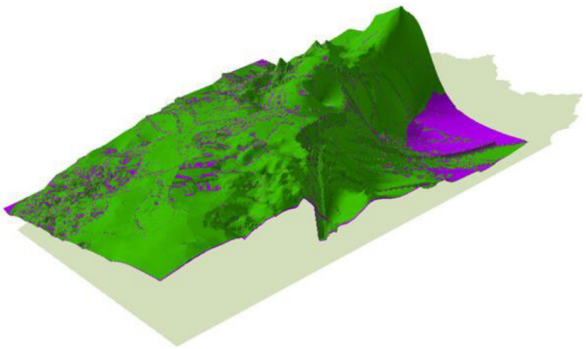
[1] Gandavarapu, Sodith R., et. al. "Direct foamed and nano-catalyst impregnated solid-oxide fuel cell (SOFC) cathodes." *Materials Letters* 95 (2013): 131-134.

NETL-RUA Member Organizations Publicize Research Collaborations with NETL

The research NETL-RUA collaborations cultivate is so valuable that NETL-RUA member organizations have been publicizing it. Carnegie Mellon University's (CMU) Civil and Environmental Engineering Department (CEE) featured two NETL-RUA projects on its website in October. The projects were discussed as part of a series of articles about how CEE scientists are studying carbon capture, utilization, and storage (CCUS).

One article explains how **Brian Strazisar**, an NETL research scientist, contacted CEE department head **Dave Dzombak** about exploring how oil and gas fields containing cement-filled wellbores fare as CO_2 storage sites. CEE professor **Greg Lowry** and NETL research scientist **Barbara Kutchko** (then a doctoral candidate at CMU) joined the research team. Their work is significant because it may help prevent the release of greenhouse gases to the atmosphere via wellbores. Their research also informed federal policy on CO_2 injection. The Environmental Protection Agency relied on results of an NETL/CMU study on the degradation of wellbore cement in the presence of CO_2 when formulating a proposed rule on subterranean CO_2 injection.

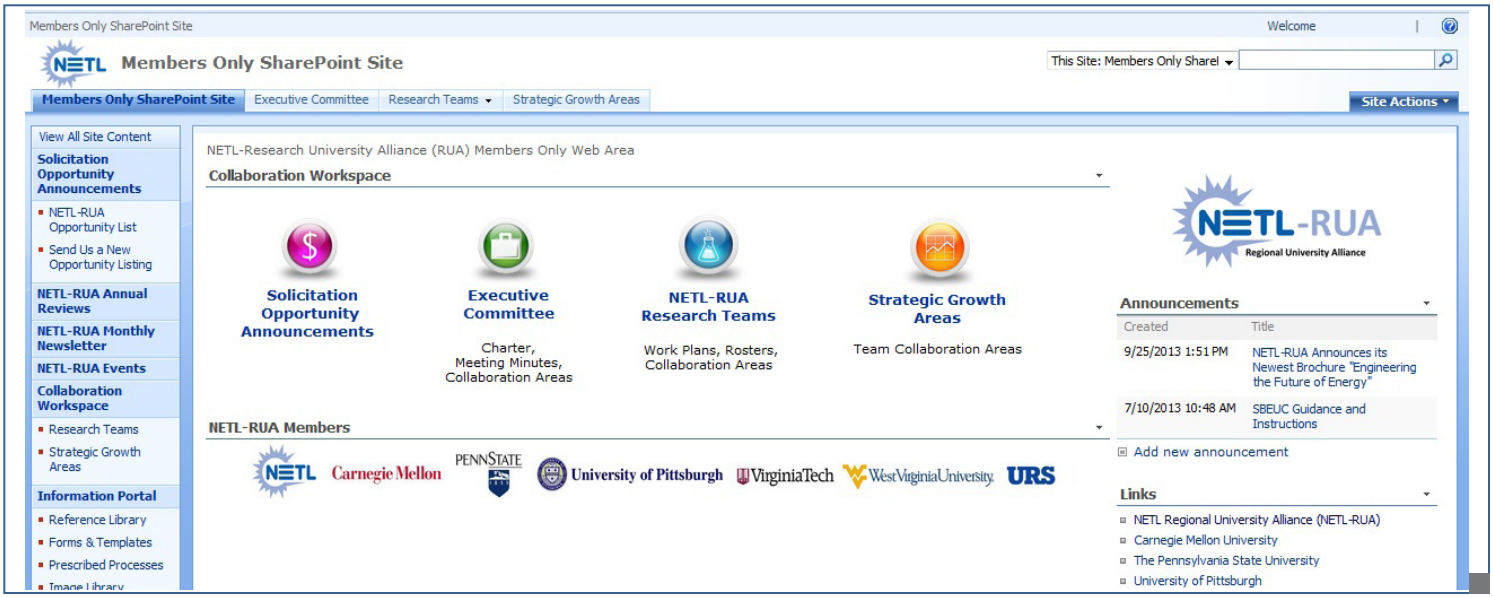
Another article spotlights CMU assistant research professor **Athanasios Karamalidis** and his investigation of how CO_2 interacts with underground brine. Karamalidis teamed with NETL research scientist **Alexandra Hakala** and researchers from Lawrence Livermore and Pacific Northwest National Laboratories to study how heavy metals move in carbon-storage environments. The experiments the team conducted on samples taken from CCUS demonstration sites revealed the average concentrations of heavy metals found in CO_2-saturated brine. This knowledge is useful because CO_2 can acidify brine, which can then dissolve the surrounding rock and mobilize the heavy metals contained within it, potentially contaminating the groundwater supply should the brine migrate to an aquifer.



Calculated CO_2 storage volume maps, like this one for the Oriskany Sandstone formation, help researchers assess storage resources.

NETL-RUA member organizations that tout productive research resulting from their connections to NETL promote NETL-RUA overall. If you know of an NETL-RUA sponsored project that a member organization has publicized, please send that information to NETL-RUA-FB@netl.doe.gov and the topic will be considered for a future edition of the NETL-RUA newsletter.

MOSS has a NEW LOOK!



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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