# Front & Center!

Quarterly Science Newsletter

Frontline Geoscience within the Geology, Energy & Minerals (GEM) Science Center, Reston, Virginia

Center Director Note

Welcome to the ninth issue of the USGS Geology, Energy & Minerals Science Center (GEM or GEMSC) quarterly newsletter. Since the last newsletter, GEM staff have released 8 publications, 9 data releases, and presented at several conference venues.

With so much focus recently on critical minerals and supply chains, the USGS has turned its attention to evaluating the potential recovery of critical minerals from mine waste and waste products from oil and gas production. GEMSC is actively involved in research on energy and minerals waste from a minerals perspective, an energy perspective, and even an environmental standpoint. Our projects are focused on remote sensing of legacy mine deposits to evaluate locations and volumes of waste materials, on the speciation and deportment of critical elements in mine tailings, on the recovery of critical minerals and rare earth elements from produced waters and coal fly ash, on the sequestration of carbon through mineralization processes, and on the environmental effects of slag, mineral processing, and hydrocarbon spills. The Biden Administration and the Department of Interior are keenly interested in exploring waste as a resource to strengthen the economy and promote national security. Because of this emphasis, GEMSC may have future opportunities for collaboration and employment to work on these topics. Keep an eye on the *Join Our Team!* section in upcoming newsletters for your chance to get involved with this important and timely issue.
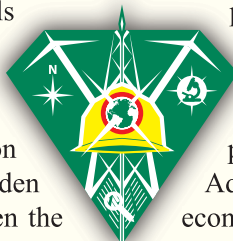
To explore more about what we do, please visit our U.S. Geological Survey (USGS) GEMSC website. If you know anyone who may be interested in receiving this newsletter, or if you would like to adjust your subscription status, please refer to the online subscription form. As always, please reach out to Tina directly (troberts-ashby@usgs.gov) with any comments, questions, or ideas for collaboration.

~ Carla Kertis Brezinski on behalf of Tina Roberts-Ashby, Center Director of the GEMSC

Science Spotlight

Geologic Energy Storage: USGS Fact Sheet 2022-3082

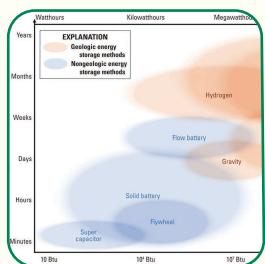**Image:** Graph of typical energy storage capacity compared to typical discharge duration, from Figure 3 of USGS Fact Sheet 2022-3082.

The USGS has the capability to research and assess possible domestic geologic energy storage resources to help prepare the United States for the future of renewable energy. Scientists from the GEMSC, led by Marc Buursink, along with Erick Burns from the USGS Geology, Minerals, Energy, and Geophysics Science Center, have recently published USGS Fact Sheet 2022-3082 to introduce the potential for geologic energy storage research and assessments to a general audience. Renewable energy sources, primarily wind and solar, are by their nature, variable. Therefore, storing excess energy created by renewable sources will help during periods when the renewable power supply drops below power demand. Battery storage is one method to store power. However, geologic (underground) energy storage may be able to retain vastly greater quantities of energy over much longer durations compared to typical battery storage. Geologic energy storage also has high flexibility; many different types of materials can be used to store chemical, thermal, or mechanical energy in a variety of underground settings. Initial work on a USGS assessment of geologic energy storage could focus on natural gas and hydrogen (chemical), compressed air and solid-mass gravity (mechanical), and geothermal (thermal) storage methods.

Photo: USGS Powdered X-Ray Diffraction (XRD) Laboratory in Reston, Virginia capable of providing state-of-the-art analyses of unique mineralogical characterizations and high quality data, 2019, courtesy of Nadine Piatak, Research Geologist, USGS.

Science Spotlight (Continued)

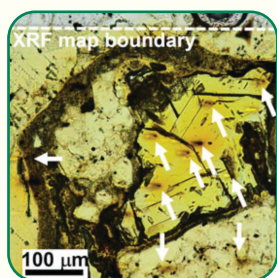### Non-Destructive Evaluation of Germanium and Correlated Elements in Zinc Sulfide Minerals

Image: Transmitted light image from Figure 2, Frontiers in Earth Science paper, 2023.

GEMSC scientists Sarah Hayes, Nadine Piatak, Sarah Jane White, and Bob Seal, in collaboration with Florence Bascom Geoscience Center scientist Ryan McAleer, recently published a paper outlining a new method for non-destructive evaluation of germanium and correlated elements in zinc sulfide minerals. The study utilized a suite of methods for pre-characterization including optical petrography, cathodoluminescence imaging, and electron microprobe analysis followed by micro-X-ray diffraction analysis, micro-X-ray fluorescence mapping, and X-ray adsorption spectroscopy performed at the Advanced Photon Source Synchrotron at Argonne National Lab. The workflow described in their study may be valuable in characterizing similarly challenging systems often encountered with byproduct critical elements hosted in low-abundance minerals. Furthermore, this study highlights the use of non-destructive techniques which enabled reanalysis, proving essential for verifying observations and validating unexpected results. A link to the paper published in *Frontiers in Earth Science* can be found HERE.

GEMSC Laboratory Staff Welcome a U.S. Committee and Local Elementary School Students

Image: Official logo for the U.S. Senate Committee on Energy & Natural Resources.

On December 2nd, 2022, GEMSC Scientists Bob Seal and Nadine Piatak led a tour of the X-ray Diffraction and Scanning Electron Microscope Laboratories for ten staffers from the United States Committee on Energy and Natural Resources. Their interest was in critical minerals, so the team highlighted Minerals Research Program (MRP) research and capabilities on critical minerals in mine waste and ongoing Earth Mapping Resources Initiative (Earth MRI) activities. GEMSC scientists Darryl Hoppe and Kathryn Hobart also participated and explained their roles in the lab.

On January 31st, the USGS National Center was visited by eighty 4th grade students from a local elementary school. The event was organized by the USGS Northeast Region (NER) with three GEMSC laboratories participating in the event: the Reston Microbiology Lab, the Organic Petrography Lab, and the Reston Electron Microbeam Lab. Students were shown lab demonstrations and experiments that not only highlighted USGS science but also promoted careers in science. Students also looked at high-resolution pictures of bugs and soil microbes.

Shale Gas Wastewater Management Marcellus and Utica: 2022 Recap

Image: Official logo representing the Shale Gas Wastewater Management Marcellus and Utica 2022 meeting.

GEMSC scientists Madalyn Blondes and Bonnie McDevitt were invited to present their USGS Energy Resources Program (ERP) Oil and Gas Waters Project research in Pittsburgh, PA on November 1-2, 2022, at the Shale Gas Wastewater Management Marcellus and Utica 2022 meeting. The meeting represents a regional combination of industry, regulators, academics, and government stakeholders to discuss current best practices and issues related to all aspects of oil and gas production in the Appalachian Basin. Madalyn presented produced water volume production data paired with commodity data to illustrate the commodity potential of produced waters in the Appalachian Basin. Bonnie presented potential hazards related to radium environmental behavior and applications to commodity extraction and beneficial reuse of produced water. USGS participation in regional meetings such as the Shale Gas Wastewater Management meeting is key for maintaining working collaborations with industry partners that include sample access, as well as informing current mission critical research. Questions can be directed to either Madalyn (mblondes@usgs.gov) or Bonnie (bmcdevitt@usgs.gov).

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Photo: Above-ground infrastructure in Reno County, Kansas, for a natural gas storage cavern hundreds of feet deep in a salt formation, modified from Figure 1, USGS Fact Sheet 2022-3082, courtesy of Marc Buursink, Research Geologist, USGS.

Science Spotlight (Continued)

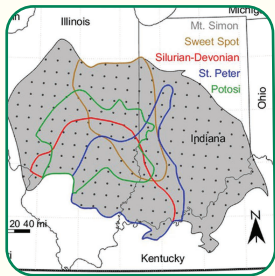### Brine Injectivity Flow Modeling Estimate Methodology Publication

Image: Figure 2 from Plampin et al., 2022.

GEMSC employees Michelle Plampin, Steven Anderson, and Steven Cahan recently published a paper in *Greenhouse Gases Science and Technology Journal* that evaluates CO_2 storage potential in the Illinois Basin as constrained by brine reinjection pressure studies. Their study developed a methodology to estimate brine injectivity from formation depth and thickness using flow modeling. Results indicate that a large area exists where CO_2 injectivity could be optimized by brine extraction and reinjection. This work was conducted as part of the Economics Task of the Carbon and Energy Storage, Emissions and Economics (CESEE) Project. Steve Anderson and Phil Freeman are the Task leads, and Matt Merrill and Sean Brennan are the Project Managers. A link to the study can be found HERE.

Center Achievements & Recognition

GEMSC Management Highlights the Retirements of 2 Exceptional GEMSC Staff Members

Photo: *Allan Kolker, Research Geologist, USGS GEMSC.*

Supervisory Research Geologist – Allan Kolker

Congratulations to Allan on his retirement from Government - a career defined by 25+ years of service to the USGS and a prior career in academia. Allan is an internationally recognized geologist, coal resources specialist, and geochemist who has been an important contributor in many areas of research. He is particularly known for his work on understanding how mercury occurs in coal and mechanisms for rare-earth element enrichment of coal fly ash. We recognize Allan for his technical leadership, scientific expertise, and analytical approach to various scientific pursuits to provide information on fundamental parameters needed to use coal in a more effective, efficient, and environmentally sound manner. Thank you, Allan!

Photo: *William Orem, Research Chemist, USGS GEMSC.*

Supervisory Research Chemist – William (Bill) Orem

We would like to congratulate Bill on his retirement after 40+ years of service to the USGS and the Federal Government, a career defined by scientific leadership and impact. Bill has made significant contributions to geochemistry, biogeochemistry, and related fields across domestic and international locations, including notable medical geology work on the environmental causes of Balkan Endemic Nephropathy. Bill is probably best known for his work establishing a link between sulfate from agricultural runoff and the generation of toxic methyl mercury in the Florida Everglades backed up by 25+ years of research. Bill has also shown tremendous dedication as an advocate, teammate, and mentor to USGS colleagues and collaborators across the world. Thank you, Bill!

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Photo(s): A few examples of the extensive work and collaborations of Laurel Woodruff, Research Geologist, USGS.

Scientist Profile ~ Laurel Woodruff

My career in geology began when I was unable to enroll in Logic 101 at the University of Michigan. I reluctantly signed up for Introduction to Geology, but, as it turned out, geology was the only class that freshman year that I enjoyed. I received a B.S. in geology from the University of Michigan, followed by an M.S. at Michigan Technological University, and then began a Ph.D. program at the University of Chicago. After 2 years, I left (in what was called 'good standing') to take a position at the University of Wisconsin as a stable isotope technician for Wayne C. (Pat) Shanks. During my 4 years at Wisconsin, I took a break from the isotope lab to volunteer with the U.S. Geological Survey (USGS) to run gas flights, collecting sulfur and carbon dioxide measurements, for 3 months after the 1980 eruption of Mt. St. Helens. Thus, when Pat Shanks was hired by the USGS in 1983, it was an easy decision for me to accept a job in Reston to set up a new stable isotope lab. I was encouraged to return to Chicago to finish my Ph.D., which I did, completing research on diabase in the Culpeper basin. In 1991, I was able to convince the USGS Eastern Mineral and Environmental Resources Science Center (now part of GEM) and the Mineral Resources Program (MRP) that with the funding of a new 10-year project focused on the Midcontinent Rift System (MRS) in the Lake Superior region, it was to the bureau's benefit to allow me to co-locate to the USGS Minnesota Water Science Center, where I have remained for the past 32 years.

My USGS projects have evolved through those 32 years. Project work began with a series of 1:100,000-scale geologic maps emphasizing MRS rocks across northern Michigan and Wisconsin, but after 1995, research emphasis shifted from bedrock mapping to more environmental-related research, which led me to a new career path, digging soil holes. This resulted in fruitful interdisciplinary projects with USGS Water and Biology Resources research scientists in Voyageurs and Isle Royale National Parks, as well as in Michigan, New York, and South Carolina. The 'expertise' at hole-digging resulted in participation in the planning, design, and finally execution of the multi-year Landscapes Geochemistry Project. I was responsible for collecting soil samples across the

Photo: Laurel Woodruff, Research Geologist, USGS GEMSC.

midsection of the conterminous U.S. for the pilot project and throughout the Midwest and Mid-Atlantic States for the spatial sampling. Final products describing the massive *Landscapes* geochemical and mineralogical dataset were released in 2013. Because more than 65% of the randomly selected sites were on private land, field crews talked with landowners to obtain permission to dig a hole on their property: the most valuable lesson learned was that most people in this country are very cooperative and, more importantly, very nice and generous. Despite all this hole-digging, I never really lost my interest in the MRS, and in 2015 became co-project chief for a new MRP project on the tectonic development of the MRS. Through that project and its evolution into tasks under an MRP project emphasizing geophysical characterization of the MRS, a 3D model is being developed with potential field geophysicists, using legacy seismic data from Lake Superior. Suzanne Nicholson, Connie Dicken, and I also are finalizing a MRS geodatabase that summarizes bedrock geology, rock geochemistry, age dates, drill core availability, and mineral deposits. Our mineral deposit file became a USGS Open-File Report and was expanded and summarized in a publication in *Ore Geology Reviews*.

With MRP interest in possible mineral assessment efforts, I was tasked with two deposit models, Magmatic sulfide-rich Ni-Cu deposits in mafic rocks and Magmatic Fe-Ti-oxide deposits in massif anorthosite suites. This work resulted in co-authoring a chapter on titanium for Professional Paper 1802—Critical mineral resources of the United States. This publication laid the groundwork for the on-going Earth Mapping Resources Initiative (EMRI) project. I am currently the Central Region co-lead for EMRI and have participated in the yearly workshops with State geological surveys, through which we have laid the foundation for development of critical mineral prospectivity across the United States.

It is possible that if I had been able to get into Logic 101, my career would have been different, but based on the illogical path that I have followed within the USGS, this seems doubtful.

Employee Corner

Matthew (Matt) Jones - Research Geologist

Matt joins the Center and the CESEE project following a fellowship at the Smithsonian (National Museum of Natural History) from 2021 to 2022 and a postdoctoral position at the University of Michigan in carbonate geochemistry from 2019 to 2021. He is a sedimentary geologist with a background in Cretaceous stratigraphy and isotope geochemistry. His research of the U.S. Western Interior Basin, along with deep-sea cores drilled with the International Ocean Discovery Program (IODP), has focused on greenhouse paleoclimates and oceanic anoxic events, "OAE." Matt received his Ph.D. from Northwestern University and a B.A. in Earth Science from the University of New Hampshire. He enjoys hiking, watching soccer, and exploring the area with his wife and son.

Andrew (Andy) Masterson - Research Chemist

Andy worked in higher education for ~15 years, most recently at Northwestern University. He is a low temperature stable isotope geochemist with research experience in minor/trace isotope systematics of oxygen and sulfur, early diagenesis of organic matter in marine systems, and organic isotope proxies for paleohydroclimate reconstructions. Andy received his Ph.D. from Harvard University, and B.S. degrees in Biochemistry and Geology from the University of Maryland, College Park. He enjoys spending time with his wife and three children, running, and spending time on the water.

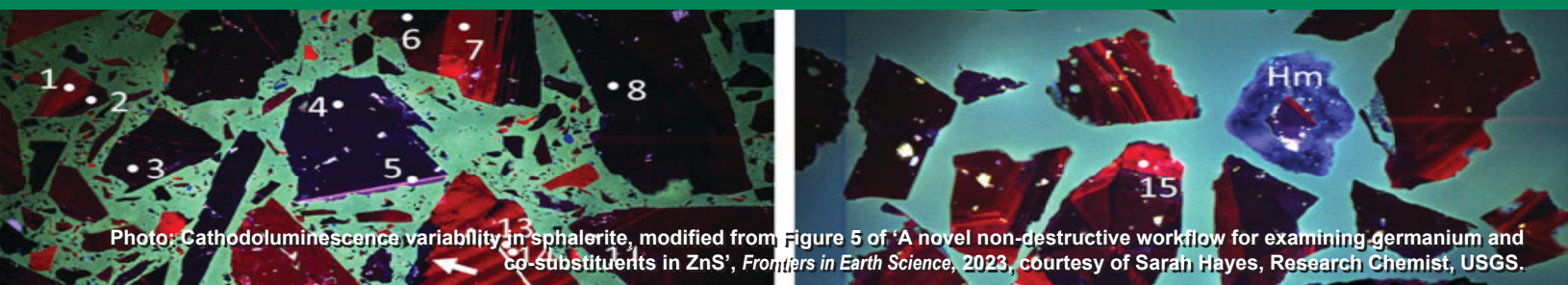### Elisha (Eli) Moore - Research Chemist

Eli worked at Rowan University as an assistant professor for the past 4 years. He previously served as an *American Association for the Advancement of Science (AAAS) Policy Fellow* with the U.S. Department of Agriculture (USDA), a postdoc at Rutgers University, and a postdoc at the *Royal Netherlands Institute for Sea Research (NIOZ)*. Eli is an organic geochemist and geobiologist with research experience in marine proteomics, lipidomics, data science aimed at understanding connections between the geosphere and biosphere, and, more recently, tracking heavy metals and microplastics in storm water. Eli received his Ph.D. from the University of Maryland, and B.S. degrees in Chemistry and Bioresource Research from Oregon State University. He enjoys spending time with his family outdoors (wife and three kids), visiting museums, jogging, playing guitar and drums, and following collegiate and professional sports.

Teresa Sims - Senior Budget Analyst

Teresa worked as a Budget Analyst for the USDA Ozark-St. Francis National Forests for the past 3 years. She received a B.S. in Business Management from Arkansas Tech University and is working towards a Masters of Business Administration with a concentration in Business Analytics from Arkansas State University. She enjoys spending time with her husband and daughter and is part of the Audio Visual team at her church. She loves to perform karaoke (much to her husband's and daughter's dismay), is learning to DJ, and is working to set up a DJ booth for "family and friend" events.

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Photo: Cathodoluminescence variability in sphalerite, modified from Figure 5 of 'A novel non-destructive workflow for examining germanium and co-substituents in ZnS', *Frontiers in Earth Science*, 2023, courtesy of Sarah Hayes, Research Chemist, USGS.

Employee Corner (Continued)

### Tatiana "Kat" Smail - Budget Analyst

Kat transferred from the U.S. National Park Service, Glen Canyon National Recreation Area (GCNRA). Over the past 15 years, she has worked in vegetation restoration, project planning, interpretation, wildlife management, soil ecology, and rangeland health monitoring before transitioning into GCNRA's management office where she got her start in budget work. She received her B.F.A. from Northern Arizona University and is currently pursuing an M.S. in Biomimicry from Arizona State University, with an anticipated graduation of December 2024. She enjoys practicing permaculture design with her husband, as well as numerous hobbies that include botanizing for fun, hiking, casual geology, making art, and the pursuit of good food.

Brett Warner - Administrative Operations Assistant

Prior to joining USGS, Brett worked in the private sector as a customer experience researcher and business analyst. He received his B.B.A. in Management with a Political Science minor from Georgia College & State University. Outside of work, Brett enjoys traveling, experiencing new foods and restaurants, and spending time with friends and family.
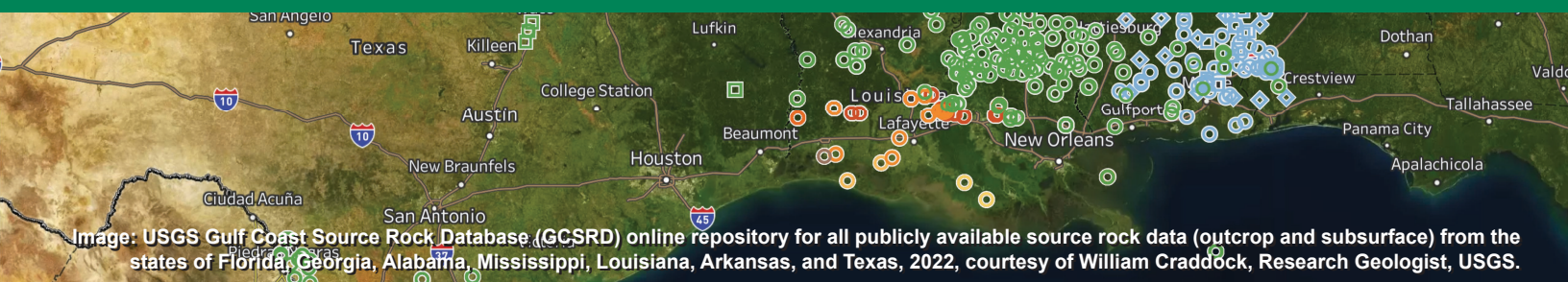
Ashton Wiens - Research Mathematical Statistician
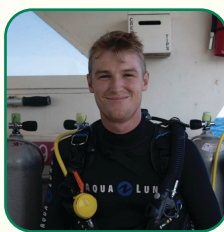
Ashton worked for the USGS Upper Midwest Environmental Sciences Center (UMESC) for 2 years. He received his B.S. in Mathematics from the University of Kansas and studied spatial statistics during his M.S. and Ph.D. degrees in Applied Mathematics from the University of Colorado Boulder. Outside of work, Ashton enjoys hiking and being outdoors, "bouldering," scuba diving, and Kansas basketball. His current research is focused on tasks associated with the GEMSC CESEE project.

Join Our Team! ~ Job Opportunities

The GEMSC frequently has opportunities for bringing in new staff. However, we currently are not advertising for any positions. We anticipate openings soon for geologists with remote sensing skills and physical scientists with mineralogy backgrounds to work on mine waste. Future GEMSC vacancies will be advertised in USAJobs. Stay tuned to this space for news on future job opportunities with the GEMSC.

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Image: USGS Gulf Coast Source Rock Database (GCSRD) online repository for all publicly available source rock data (outcrop and subsurface) from the states of Florida, Georgia, Alabama, Mississippi, Louisiana, Arkansas, and Texas, 2022, courtesy of William Craddock, Research Geologist, USGS.

Quarter 1 Publications and Data Releases by GEMSC Authors

Publications *(USGS and External)*

A Novel Non-Destructive Workflow for Examining Germanium and Co-Substituents in ZnS:
https://doi.org/10.3389/feart.2023.939700

Assessment of Resource Potential from Mine Tailings Using Geostatistical Modeling for Compositions: A Methodology and Application to Katherine Mine Site, Arizona, USA:
https://doi.org/10.1016/j.gexplo.2022.107142

Behavior of Potentially Toxic Elements from Stoker-Boiler Fly Ash in Interior Alaska: Paired Batch Leaching and Solid-phase Characterization:
https://doi.org/10.1007/s11356-021-15583-x

Contaminant Exposure and Transport from Three Potential Reuse Waters Within A Single Watershed:
https://doi.org/10.1021/acs.est.2c07372

Dynamic Estimates of Geologic CO_2 Storage Resources in the Illinois Basin Constrained by Reinjectivity of Brine Extracted for Pressure Management:
https://doi.org/10.1002/ghg.2189

Geologic Assessment of Undiscovered Gas Resources in Cretaceous–Tertiary Coal Beds of the U.S. Gulf of Mexico Coastal Plain:
https://doi.org/10.3133/ofr20171167

Geologic Energy Storage:
https://doi.org/10.3133/fs20223082

Potential for Critical Mineral Deposits in Maine, USA:
https://doi.org/10.4138/atlgeo.2022.007

USGS Data Releases

GIS, Supplemental Data Table, and References for Focus Areas of Potential Domestic Resources of Critical Minerals and Related Commodities in the United States and Puerto Rico:
https://doi.org/10.5066/P9DIZ9N8

Electron Microprobe Analyses of Sphalerite from Central and East Tennessee Mining Districts, the Red Dog Mining District (AK), and the Metaline Mining District (WA):
https://doi.org/10.5066/P94PW7EX

Molecular-Scale Speciation of Germanium and Copper Within Sphalerite from Central Tennessee Mining District (TN), Red Dog Mining District (AK), and Metaline Mining District (WA):
https://doi.org/10.5066/P93TEQTU

Optimization Simulations to Estimate Maximum Brine Injection Rates in the Illinois Basin:
https://doi.org/10.5066/P9544D9S

Organic Petrology of Cretaceous Mowry and Niobrara Source-rock Reservoirs, Powder River Basin, Wyoming, USA:
https://doi.org/10.5066/P9SQGBKQ

Petroleum Geology Data from Hydrous and Anhydrous Pyrolysis Residues (ver. 2.0, January 2023):
https://doi.org/10.5066/P9P60VDX

Strain Induced Molecular Heterogeneity in Ancient Sedimentary Organic Matter Mapped at Nanoscales Using Optical Photothermal Infrared Spectroscopy:
https://doi.org/10.5066/P9FCJJNY

Textural Occurrence and Organic Porosity of Solid Bitumen in Shales:
https://doi.org/10.5066/P9RSIEVF

Trace Element Composition and Molecular-scale Speciation Characterization of Sphalerite from Central and East Tennessee Mining Districts, Red Dog Mining District (AK), and Metaline Mining District (WA):
https://doi.org/10.5066/P92ZX0T7