USGS
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*April 30th, 2022*

*Issue #6*

# Front & Center!

**Quarterly Science Newsletter**

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

## Center Director Note

Welcome to the sixth issue of the USGS Geology, Energy & Minerals Science Center (GEMSC or GEM) Quarterly Newsletter. Tina Roberts-Ashby, our Science Center Director, has taken a 6-month special assignment as a Senior Science Advisor on Policies with the Office of Management and Budget. In the interim, I am honored to serve as Acting Science Center Director and welcome this opportunity to share my thoughts. I have been with the USGS since January 2017 as an Associate Science Center Director, handling the Center's Mineral Resources Program research projects and, more recently, taking on management of GEMSC projects under the National Cooperative Geologic Mapping Program. I have years of experience in Energy as a researcher and program manager at the U.S. Bureau of Mines and worked for a large portion of my career with the National Resources Inventory of the Natural Resources Conservation Service (U.S. Department of Agriculture).

This is an exciting time to be working in the geosciences. The importance of critical minerals has been recognized by both the current and previous Presidential administrations. Conducting research to ensure that the United States has adequate supplies and reliable sources of critical minerals has become a priority for the USGS. Major efforts, such as the Earth Mapping Resources Initiative (Earth MRI) and the Bipartisan Infrastructure Law (BIL) have funneled additional funding to GEMSC. We are contributing our scientific expertise to these activities, particularly with projects on assessments of mineral resources and evaluating the potential of mining wastes as a resource. We are pleased to work alongside USGS and DOI colleagues, our partners in the State Geological Surveys, other governmental agencies, and corporations in addressing critical minerals and other significant geologic topics. On the Energy side, we continue to assess and conduct research on petroleum resources in addition to supporting the administration's focus on climate change and the environment. We have major ongoing research efforts on the storage of carbon dioxide (a greenhouse gas), the characterization of produced waters from oil and gas drilling, and the environmental effects of oil spills and mineral mining.

Since the last newsletter, GEM staff have released 13 publications, 6 data releases, and presented at several conference venues. We welcomed one new employee this quarter and plan to advertise at least three new positions that we hope you will check out (see page 4 for more information). To explore more about what we do, please visit our 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. I encourage you to please reach out to me directly (cbrezinski@usgs.gov) with any comments, questions, or ideas for collaboration you may have.

***~ Carla Kertis Brezinski, Acting Center Director of the GEMSC***

## Science Spotlight

### Database of the "North America Tapestry of Time and Terrain" Map, U.S. Geological Survey Data Series 1150

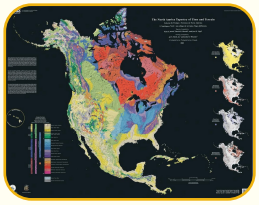


*Photo: Tapestry of Time and Terrain geologic map. Originally published in USGS GIS series I-2781.*

GEMSC scientists Steven Cahan and Chris Garrity and USGS colleagues Dave Soller and Joe Vigil have released a new publication containing the GIS data from the North America Tapestry of Time and Terrain (NATTT) map (Barton and others, 2003), which, in turn, includes map data from the earlier Tapestry map (Vigil and others, 2000). For this new publication, the data files for the NATTT map were retrieved, modified as needed, and processed into a usable GIS database format. The GIS files contain over 20,000 polygons in shapefile and feature class formats that represent geologic age and rock type. In addition, layer files are provided to facilitate a symbolized display of the map that is similar to that of the original NATTT map publication (Barton and others, 2003). The report, related work, and GIS database can be found HERE.

Photo: Field Sampling at Blacktail Creek, ND, courtesy of Adam Benthem, Hydrologist, USGS.

## Science Spotlight (Continued)

### Colville Foreland Basin and Arctic Alaska Prograded Margin Tectono-Sedimentary Elements, Northern Alaska and Southwestern Canada Basin

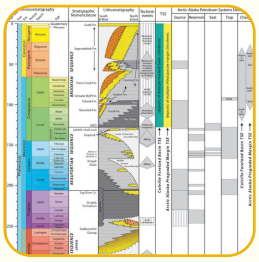


Image: Generalized chronostratigraphy of the Arctic Alaska region. Modified from Bird and Houseknecht (2011).

GEMSC scientist David Houseknecht recently published the second of two chapters in the *Geological Society of London's Memoir 57*. Both chapters focus on the petroleum systems of tectonically controlled stratigraphic successions, defined as tectono-stratigraphic elements (TSEs), beneath the North Slope of Alaska, the Beaufort Sea shelf and slope, and the Chukchi Sea shelf. Mississippian-Neocomian (360-125 Ma) and post-Neocomian-Quaternary (126 Ma-present) strata comprise TSEs and composite TSEs which contain both hydrocarbon source rocks and known hydrocarbon accumulations. The development of TSEs and composite TSEs is associated with sedimentation related to multiple phases of tectonic activity resulting from continental rifting, foreland basin development, and shelf margin progradation. These elements contain known hydrocarbon accumulations of more than 33 billion barrels of oil equivalent and the potential for similar volumes of undiscovered resources. Links to these and other chapters contained in this volume can be found on the publisher's website.

### Microbially Induced Anaerobic Oxidation of Magnetite to Maghemite in a Hydrocarbon-Contaminated Aquifer

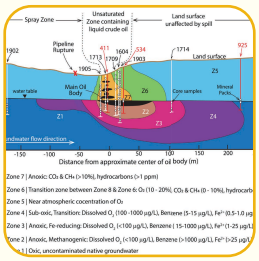


Image: Characterized geochemical zones (modified from Delin et al., 1998; Cozzarelli et al., 2016).

GEMSC scientist Isabelle Cozzarelli, along with collaborators from several universities, recently published a research paper in the *Journal of Geophysical Research Biogeosciences*. The authors investigated the loss of magnetization in iron minerals resulting from cycling by microorganisms in a hydrocarbon-contaminated site. This study used measurements of magnetic susceptibility for monitoring the natural attenuation of hydrocarbons related to iron cycling. Their data show that the core samples and magnetite-filled mineral packets displayed decreasing magnetization with time and that this loss in magnetization was accompanied by increasing bulk coercivity consistent with decreased average grain size and/or partial oxidation. Magnetite transformation to maghemite typically occurs under oxic conditions, however the authors propose that maghemitization occurs within the anoxic portions of the plume via microbially mediated anaerobic oxidation and that mineral dissolution also occurs within the contaminant plume. Full article HERE.

### In Situ Enhancement and Isotopic Labeling of Biogenic Coalbed Methane

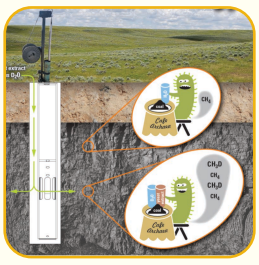


Image: Courtesy of Elliot Barnhart, USGS Research Hydrologist (Microbiologist), 2022.

A team of GEMSC research scientists, led by Elliot Barnhart (Wyoming-Montana Water Science Center), worked with a group from Montana State University and Biosqueeze Inc. to evaluate biogenic methane production. The team designed both laboratory- and field-based studies to determine the role of complex carbon-containing nutrients in generating methane. Using downhole monitoring methods, in combination with deuterated water ($D_2O$) and yeast extract (YE), they were able to stimulate and isotopically label newly generated methane. Downhole samples, collected with subsurface environmental samplers, indicated that methane increased 132% above pre-injection levels based on isotopic labeling from $D_2O$, 108% based on pressure readings, and 183% based on methane measurements 266 days post-injection. These findings highlight the need to develop and demonstrate new technologies that can quantitatively track and measure biogenic methane in the environment to better understand greenhouse gas emissions and quantify biogenic natural gas for energy generation. Full article HERE.

Photo: Jane Hammarstrom, Research Geologist, USGS.

## *Scientist Profile ~ Jane Hammarstrom*

I started with the USGS as a physical scientist technician when I was a sophomore at George Washington University in December of 1969. I had gone to the Department Chair that Fall asking about a job and he put me in touch with an emeritus professor, Charlie Milton. Dr. Milton was working on minerals with Mary Mrose at the USGS. At the time, USGS had offices and labs in the Government Services Administration building a block from campus. Mary was a mineralogist with the Branch of Experimental Geochemistry and Mineralogy (known as EG&M). I was hired as a WAE (When Actually Employed) physical science technician. EG&M was an amazing group of mineralogists, crystallographers, and experimental petrologists who were systematically studying rock-forming minerals. At some point I started working for E-an Zen who was working on metamorphic rocks in New England. E-an would go up to Stony Brook, NY to do microprobe work and bring back sheafs of yellow teletype paper with the raw counts that I would process on a hand calculator and type punch cards to run overnight on a mainframe computer to get the results.


**Photo:** *Jane Hammarstrom, Research Geologist, USGS.*

After I graduated in 1972 I became permanent part-time, and, after the move to the new building in Reston, VA, I eventually became a full-time geologist. Virginia Tech started an extension MS program in geology, and, with USGS support, I was able to focus my thesis work on a project related to E-an's mapping in SW Montana by studying the mineral chemistry of the Pioneer batholith. We knew from contact relations and volcanics that the Pioneer was relatively shallow. I was also working on the mineral chemistry of another shallow igneous complex–the Mt. Aetna Volcanic Complex in Colorado. E-an had collected samples of very different calcalkaline granitoids in Alaska that contained what we interpreted as magmatic epidote. That was a controversial topic – epidote was supposed to be metamorphic. We became aware of other examples of possible magmatic epidote in Alaska, Idaho, and British Columbia. In addition to the epidote, I found that these rocks all had aluminum-rich hornblendes. Comparison of those compositions with those from shallow intrusions led to the development of an empirical igneous hornblende geobarometer. At the time, there were few tools for estimating pressures of pluton emplacement and our work spurred numerous studies by others.

In the 1970's and 80's, I also got to work on mineral chemistry of lunar samples, emeralds from Pakistan, skarn deposits in Nevada, and synthesized nontronite as a potential Martian surface material as part of the Mars Viking project. With the demise of EG&M, our group was put into the Branch of Resource Analysis and my projects expanded to include mineral resource assessments. I was lucky to be involved with projects in Montana and Idaho for the U.S. Forest Service and Bureau of Land Management (BLM). I did a brief stint as acting deputy for mineral assessments of public lands in the Office of Mineral Resources in the mid-1990's which was a good experience but confirmed my belief that management was not my cup of tea! Following the awful reduction-in-force that hit the Minerals Program hard, I went to the Eastern Minerals group and started working on geoenvironmental characterization of mineral deposits. It was a fun, new direction and I was able to continue my interest in mineralogy by focusing on mine waste solids and efflorescent sulfate minerals and the way they contribute to acid rock and mine drainage. I had many memorable adventures in the field with fellow USGS researcher Bob Seal (of GEMSC) in the Smokies and later we were joined by Nadine Piatak (also of GEMSC) and others working in Vermont, Pennsylvania, and Virginia looking at inactive and abandoned mines. Bob and I discovered a new sulfate mineral and were delighted to get it named alpersite after our USGS colleague, Charlie Alpers (USGS, Sacramento).

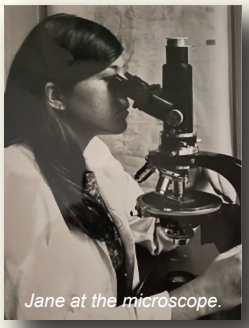
In 2008, Mike Zientek (USGS, Spokane) and I inherited the global mineral resource assessment. It was a very challenging project but gave me great opportunities to work with geologists from other countries and visit Mexico, South Korea, and China. The first global assessment of undiscovered copper resources of the world finally came out in 2019. In retrospect, it was worth the effort. The Sagebrush Mineral Resource Assessment (SaMiRA) – a project for BLM that evaluated mineral resources in prime sage grouse habitat – took up most of 2015.

Starting in 2018, Mike Zientek and I, along with others, conducted a 2-year mineral resource assessment training project to launch the next generation of assessment folks. I'm happy to say that the "students" completed 3 tungsten assessments (a critical mineral!) and things are in good hands. Earth MRI has dominated most of my time the last few years. It's an exciting time to work in mineral resources because critical minerals are on everyone's radar screen (literally and figuratively). It's ironic that my first paper published with E-an in 1975 was on dawsonite – a mineral that was being considered as a potential domestic aluminum resource at the time and now aluminum is on the critical minerals list!

After 50 years at USGS, some wonder why I have stayed so long. As the Ben & Jerry's bumper sticker says, "If it's not fun, why do it?". It's still fun!

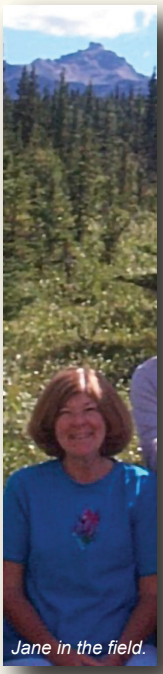
Photo: Outcrop eroded by an Alaskan river system, courtesy of David Houseknecht, Research Geologist, USGS.

## Scientist Profile ~ Jane Hammarstrom (Continued)



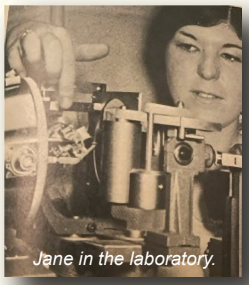
Jane at the microscope.

Jane examining mineral samples.



Jane in the field.

Suited up to sample chrysotile in VT.



Jane in the laboratory.

With Bob Seal at the Elizabeth Mine, VT.

With Nora Foley and Bob Seal in the Smokies, TN.

**Photos:** *Examples of the extensive work and collaborations of Jane Hammarstrom, Research Geologist, USGS.*

## Employee Corner

### Kimberly Griffin

Kimberly joined the GEMSC in November 2021 as an Acting Budget Analyst on Detail from the Office of International Programs, Afghanistan Project. Kim is now full-time with the Center and works on a range of financial projects critical to operations. Kim is a proud Nana of 2 and enjoys live music and sporting events, biking, and singing in her local community choir.

## Join Our Team! ~ Job Opportunities

GEMSC frequently has opportunities for bringing in new staff. Active opportunities include:

- Research Geologist GS 13/14 (Remote sensing)
- Research Geologist GS 12/13

These vacancies will be advertised in USAJobs.

Stay tuned to this space for news on future job opportunities with GEMSC.

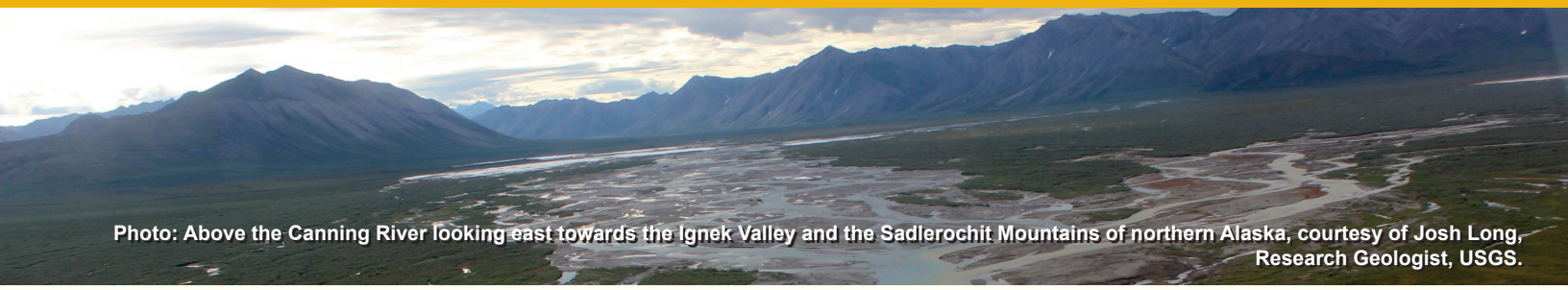


Photo: Above the Canning River looking east towards the Ignek Valley and the Sadlerochit Mountains of northern Alaska, courtesy of Josh Long, Research Geologist, USGS.

# Quarter 2 Publications and Data Releases by GEMSC Authors

## Publications (USGS and External)

Arctic Alaska Basin, Hanna Trough and Beaufortian Rifted Margin Composite Tectono-Sedimentary Elements:
https://doi.org/10.1144/M57-2018-26

Colville Foreland Basin and Arctic Alaska Prograded Margin Tectono-Sedimentary Elements, Northern Alaska and Southwestern Canada Basin:
https://doi.org/10.1144/M57-2018-65

Constraints on Triple Oxygen Isotope Kinetics:
https://doi.org/10.1016/j.chemgeo.2021.120646

Database for the "North America Tapestry of Time and Terrain" Map:
https://doi.org/10.3133/ds1150

Decision Analysis and $CO_2$–Enhanced Oil Recovery Development Strategies:
https://doi.org/10.1007/s11053-021-09983-6

Detrital Zircon Provenance of the Cretaceous–Neogene East Coast Basin Reveals Changing Tectonic Conditions and Drainage Reorganization Along the Pacific Margin of Zealandia:
https://doi.org/10.1130/GES02404.1

Evaluating Aromatization of Solid Bitumen Generated in the Presence and Absence of Water: Implications for Solid Bitumen Reflectance as a Thermal Proxy:
https://doi.org/10.1016/j.coal.2022.104016

Germanium Re Distribution During Weathering of Zn Mine Wastes: Implications for Environmental Mobility and Recovery of a Critical Mineral:
https://doi.org/10.1016/j.apgeochem.2022.105341

Microbially Induced Anaerobic Oxidation of Magnetite to Maghemite in a Hydrocarbon-Contaminated Aquifer:
https://doi.org/10.1029/2021JG006560

Molecular Mechanisms of Solid Bitumen and Vitrinite Reflectance Suppression Explored Using Hydrous Pyrolysis of Artificial Source Rock:
https://doi.org/10.1016/j.orggeochem.2022.104371

National Assessment of Carbon Dioxide Enhanced Oil Recovery and Associated Carbon Dioxide Retention Resources—Results:
https://doi.org/10.3133/cir1489

Stable Isotope Tracers of Cretaceous Arctic Paleoprecipitation:
https://doi.org/10.3390/geosciences12040143

The Effect of Diagenesis and Acetolysis on the Preservation of Morphology and Ultrastructural Features of Pollen:
https://doi.org/10.1016/j.revpalbo.2022.104679

U-Pb and Fission Track Data from Zircon and Apatite Resolve Latest- and Post-Alleghenian Thermal Histories Along the Fall Line of the Atlantic Margin of the Southeastern United States:
https://doi.org/10.1130/GES02447.1

## USGS Data Releases

Absorbance and Fluorescence Excitation-Emission Matrix Data for Produced Waters from Oil and Gas Producing Basins in the United States:
https://doi.org/10.5066/P9YYDQ2O

Data Compiled on Historical Water Use, Spatial Land Disturbance, Aquifer Disturbance and Uranium Produced by In Situ Recovery of Uranium from Sandstone Hosted Uranium Deposits in the South Texas Coastal Plain, USA:
https://doi.org/10.5066/P9U7QKC1

Maturation Study of Vitrinite in Carbonaceous Shales and Coals:
https://doi.org/10.5066/P9KNB6GP

Model of Potential Multiphase Methane Evolution in the Subsurface of Southern Ontario Across a Wide Range of Initial Gas Contents:
https://doi.org/10.5066/P9I7O770

Reflectance and Spectral Fluorescence Data from the Effect of Diagenesis on the Preservation of Morphology and Ultrastructural Features of Pollen:
https://doi.org/10.5066/P9PXDVEJ

TOC, Reflectance and Raman Data from Eocene Green River Mahogany Zone:
https://doi.org/10.5066/P9S46QKG