Research LAUNCHER Program

About You

First Name: Jared_____ Last name: Freiburg_____

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Check which apply to you: ☒ Student ☐ Non Student ☒ Independent Researcher ☐ Professor ☐ Corporate Research ☐ Other

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Short Bio: (250 words or less)

Jared T. Freiburg is an assistant geologist at Illinois State Geological Survey, a division of the Prairie Research Institute at the University of Illinois Champaign-Urbana. His research interests include carbonate and clastic depositional environments, diagenesis, and Mississippi Valley-Type mineral deposits. He specializes in sedimentary petrography and employs light microscopy, cathodoluminescence, fluid inclusion analysis, isotopic analysis, scanning electron microscopy, electron microprobe, and x-ray diffraction techniques in his research. He received his B.S. and M.S from the University of Illinois at Urbana –Champaign and is currently pursuing his PhD at the Institute for Geography and Geology in Greifswald, Germany. His current research involves understanding seal integrity of shale's and mudstones in the Illinois Basin via 3D mapping of pore networks and mineralogy. He recently completed a manuscript titled "The depositional and diagenetic characterization of the Cambrian-age Mt. Simon Sandstone for the Illinois Basin Decatur Project". This publication is currently in press at the Illinois State Geological Survey-Prairie Research Institute.

Project Description

1. Name of project: Pore network, mineralogical, and diagenetic characterization of Paleozoic shale's and mudstones in the Illinois Basin: Experimental responses to CO_2

2. Brief synopsis/areas of geosciences or engineering (50-75 words)

In the Illinois Basin there are three major shale formations (New Albany, Maquoketa, Eau Claire) among numerous minor mudstone units. This study will identify shale and mudstone pore networks, controls on pore networks, and the response (pore network, mineralogical, and organics) to CO_2 via ultra-high resolution microscopic three-dimensional mapping. Shale and mudstone samples will be investigated before and after brine/rock/CO_2 interaction experiments at variable pressures and temperatures simulating different depths within the basin.

3. Bullet list of 5-7 main outcomes/goals.

- Identify and classify pore and pore network types in the New Albany, Maquoketa, and Eau Claire shale's and Mt. Simon mudstones
- Determine controls on porosity and pore network connectivity via three-dimensional mapping of pore networks, mineralogy and organics using XRD, TEM, and FIB-SEM-EDX-EBSD

- Complete brine/rock/ CO_2 experiments at seal/reservoir pressures and temperatures and re-map pore networks, mineralogy and organics using XRD, TEM, and FIB-SEM-EDX-EBSD
- Re-construct paragenetic sequence through identification of diagenetic events (plane-light microscopy and SEM)
- Quantify and separate illite polytypes in samples (XRD). Clay diagenesis is proposed to play a major role on shale and mudstone porosity development and connectivity. Shale and mudstone in the Illinois Basin are compositionally dominated by illite; three illite polytypes are found: $2M_1$ of detrital origin, and $1M_d$ and 1M of diagenetic origin
- Using K-Ar radiometric dating to date diagenetic and detrital illite throughout variable formation core depths, identify sealing integrity of rocks and determine most recent fluid migration event

4. In two or three sentences, describe why your research is important. Please mention who will benefit from your work.

Shale and mudstones are the most abundant sedimentary rocks on Earth and are of great economic importance as they variously act as hydrocarbon source rocks, seals (hydrocarbons, waste water, and carbon capture and storage), and hydrocarbon reservoirs. It is imperative for the energy sector to distinguish pore networks and potential hydrocarbon (shale gas) migration pathways in unconventional fine-grained rocks and to provide landowners assurance of the sealing capabilities and integrities of these rocks. Of further interest is CO_2/rock reactions; with the advent of carbon capture and storage, there is the potential of hydrocarbon production via stimulation and injection of CO_2 into organic-rich shale formations.

5. Timeline with milestones (12 month/18 month) **3 months:** Complete core sampling; set-up and initiate 12 month brine/rock/CO_2 high pressure/temperature experiments; prepare samples for XRD (polytype separation); begin macroscopic investigation for paragenetic reconstruction. **6 months:** Complete FIB-SEM-EDX-EBSD, XRD, and TEM analysis on shale/mudstone samples before CO_2 reaction; begin 3D reconstruction of FIB-SEM-EDX-EBSD data; K-Ar dating of illite polytypes samples. **9 months:** Continue 3D reconstruction of FIB-SEM-EDX-EBSD data with incorporation of TEM and XRD data for pore, mineral, and organic identification and correlation. **12 months:** Begin report on origin of illite including clay diagenesis, detrital and diagenetic illite age-dates, and seal integrity based on observed diagenesis. Extract brine/rock/CO_2 samples and prepare for FIB-SEM-EDX-EBSD, XRD, and TEM analysis. **15 months:** Complete FIB-SEM-EDX-EBSD, XRD, and TEM analysis on shale/mudstone samples after CO_2 reaction; begin 3D reconstruction of FIB-SEM-EDX-EBSD data. **18 months:** Deliverables included manuscripts prepared for publication and a report on pore network, mineralogical, and diagenetic characterization of Paleozoic shale's and mudstones in the Illinois Basin: Experimental responses to CO_2.

6. Funding amount needed to achieve first basic goals within 12 months. Please provide a brief summary overview of your budget. List costs of 5-10 main items. A total of $30,000 is requested to complete the first 12 months of proposed research. Analytical costs include $10,000 for FIB-SEM-EDX-EBSD, $10,000 for K-Ar dating of illite, $5,000 for travel to complete analyses, $3,000 for XRD, and $2,000 for TEM. All additional analysis and experiments will be supported by the Illinois State Geological Survey or other available grants if needed.

7. In the process of gaining background knowledge in the field of your proposed research, who did you find to be the top two or three researchers? What are the main concepts that are being explored? Please briefly describe.

Dr. Mark Curtis- 3D investigation of gas shales using FIB-SEM. Observations show that shale's are rather heterogeneous especially with respect to porosity associated with organics

Dr. Georg Grathoff-Identification, separation, and origin of illite polytypes

Dr. Crawford Elliott- K-Ar dating of Illite to trace fluid movement and diagenesis in basins

8. Please provide a photo of yourself and a photo related to your proposed project. It will be very helpful in publicizing your project and potentially securing funding.

9. Who will benefit? Oil and Gas Industry, Environmental Consulting Industry, CCS Industry

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AAPG Research LAUNCHER supporters receive

The opportunity to work directly with you and receive reports, information, and findings, depending on the level of support.

The Deal

The researcher agrees to:

- Develop a brief public presentation on the research to be made available to AAPG
- Share an annotated bibliography and review of relevant published articles
- Present research findings on project at an AAPG Forum, GTW, or Research Symposium
- Write a detailed report on the results of your research to be made available to LAUNCHER supporters
- Write a extended abstract on the results of your research to be made available to AAPG

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Thank you for submitting your research proposal to the AAPG Research LAUNCHER Program. Your proposal will be reviewed and upon acceptance you will be contacted by AAPG Education/Research. If your proposal is accepted, we will publicize your proposal and encourage funders to contact you directly. AAPG does not guarantee funds nor have any connection with the success or failure of the endeavor. The goal is to support scientific research in the petroleum geosciences and engineering and launch the next generation of geological advances.

Jared T. Freiburg	6/11/14		
Research Candidate (print)	Date	AAPG Education/Research (print)	Date
Jared T. Freiburg	6/11/14		
Research Candidate (sign)	Date	AAPG Education/Research (sign)	Date

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