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a. REPORT	b. ABSTRACT	c. THIS PAGE			Cass Miller
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RPPR Final Report
as of 13-Sep-2019

Agency Code:

Proposal Number: 72031MARIP

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Report Date: 29-Aug-2019

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Final Report for Period Beginning 03-Jun-2018 and Ending 29-May-2019

Title: Equipment to support the validation of multiscale mathematical models of multiphase transport phenomena

Begin Performance Period: 03-Jun-2018

End Performance Period: 29-May-2019

Report Term: 0-Other

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Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: 0

STEM Participants: 2

Major Goals: The goal of this project was to obtain specialized equipment to perform experiments of multiphase flow through porous media. These experiments will enable the validation of a new class of multiscale mathematical models based upon the thermodynamically constrained averaging theory.

Accomplishments: We purchased and have installed a full bench-top core flooding device for investigating multiphase flow through porous medium system of varying permeability, pressure, and temperature. This equipment includes:

- One high pressure and temperature core holder,
- Three high pressure and temperature fluid accumulators
- Heating elements for the entire system
- One high pressure pump
- One high pressure gas injection system
- Three high pressure transducers
- One liquid fraction collector
- One gas/liquid fraction collector
- Computer with custom software for use of the device
- High pressure and temperature valves, tubing, and other ancillary operation equipment
- Spare parts and equipment for 5 years of operation
- Installation and training

This equipment has been installed in the Michael Hooker Research Center at the University of North Carolina, Chapel Hill to allow effective use by university students and fellow researchers. Two graduate students have been trained on the device and have gained useful skills in operating the research equipment. Such equipment is usually only available at large national or industry labs due to its versatile and specialized nature.

This equipment is specifically designed to simulate the operating pressure and temperature conditions that are experienced during hydraulic fracturing, as well as any other subsurface operations that may be of interest to the public in the future. Shale core samples have been procured from several different shale plays of interest, including the Marcellus, Eagle Ford, and Barnett plays, thus results from research using this system will be applicable to a large part of the United States. Shale cores are mounted in the stainless steel core holder, and fluids are applied to the sample at a set temperature and flow rate, during which transducers record the pressure at the inlet and outlet of the system, as well as the pressure drop. Sample collectors take time averaged samples from the outlet of the system at user set time intervals, allowing for chemical analysis of the sample, as well as relative permeability calculation when multiphase experiments are carried out.

The data from this equipment is used to validate new mechanistic macroscale models, as well as microscale computer simulations of fluid flow which attempt to capture physics that have not been accounted for in traditional mathematical models. One example of such physics is the flow of non-Newtonian fluids in single and multiphase systems, a class of complex fluids that are typically used in enhanced subsurface techniques, such as hydraulic fracturing, but which exhibit behavior that is poorly understood. Validation using experimental results is vital to the perpetuation of correct modeling techniques that match reality, with these models being necessary to accurately assess the risk that subsurface operations pose to the public. Model validation is carried out for single and multiphase fluid flow when non-Newtonian fluids are present in isothermal conditions as well as variable thermal conditions, and for dilute species transport modeling.

In addition to model validation, other experimental uses of the equipment are being investigated. In particular, due to the high pressures and temperatures involved during hydraulic fracturing, in-situ techniques of determining system parameters of interest are being developed. In-situ techniques allow calculation of system parameters, such as viscosity, under conditions which cannot be adequately replicated in a normal laboratory environment. It may be possible to use data from core flooding experiments to determine how non-Newtonian viscosity parameters change under different operating conditions, such as different pressure drops, static pressures, and temperatures. It may also be possible to determine how transport parameters, such as dispersion and molecular diffusion, change under large static pressures in excess of 8000 psi. These experiments would not be possible without this equipment. Other uses for the equipment include determination of sorption of chemicals on shale media during the hydraulic fracturing process; reactivity of geological formations with carbon dioxide during carbon sequestration operations; and observation of in-lab fracturing of a shale media.

Training Opportunities: Two graduate students have been trained in the operation of this specialized equipment.

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: This equipment provides the means to validate a new class of TCAT models. This work is being done collaboratively with the ERDC lab.

PARTICIPANTS:

Participant Type: PD/PI
Participant: Cass T Miller
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Chrisopher Alan Bowers
Person Months Worked: 3.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Minge Jiang
Person Months Worked: 3.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

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