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Quarterly Research Performance Progress Report

(Period Ending 09/30/2018)

Kinetic Parameters for the Exchange of Hydrate Formers

Project Period (07/01/2013 to open)

Submitted by:

Mark White



Signature

Pacific Northwest National Laboratory

DUNS #: 32987476

P.O. Box 999

Richland, WA 99352

Email: mark.white@pnnl.gov

Phone number: (509) 372-6070

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**NATIONAL ENERGY
TECHNOLOGY LABORATORY**

Office of Fossil Energy

RESEARCH PERFORMANCE PROGRESS REPORT

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ACCOMPLISHMENTS:

BP5-Task 13.0 Nitrogen Injection (KIGAM-funded, Separate, Coordinated PNNL Project #68908)

No accomplishments to report for this task during the third quarter of FY18.

BP5-Task 14.0 Geomechanics Implementation and Verification

This task is closely linked with the BP5-Task 13.0 and 15.0, as geomechanical modeling capabilities are required to complete the nitrogen injection simulations and the code comparison study problems. Accomplishments reported for BP5-Task 13.0 and 15.0 equally during this quarter equally apply to this task.

BP5-Task 15.0 International Hydrate Code Comparison

During this quarter the third and fourth benchmark problems were finalized, and problem descriptions have been developed and posted on the NETL EDX system. The first benchmark problem is championed by Mark White at PNNL, USA and involves straight hydrate dissociation via either thermal stimulation or depressurization. This problem was part of the 1st International Gas Hydrate Code Comparison Study, and does not include a geomechanical component. Eight teams submitted solutions to Benchmark Problem 1; University of Texas, Austin (UTA), Lawrence Berkeley National Laboratory (LBNL), University of California Berkeley (UCB), Pacific Northwest National Laboratory (PNNL), Jilin University (JLU), National Energy Technology Laboratory (NETL), Lawrence Livermore National Laboratory (LLNL), and GEOMAR Kiel (GEOMAR). Those solutions were compared during the IGHCCS2 teleconference series. The second problem is championed by Shubhangi Gupta, GEOMAR Kiel, Germany and is an extension of the classical Terzaghi Problem with four cases. The first case maintains the temperature outside of the hydrate stability zone; the second case yields hydrate formation and dissociation, the third case alters composite mechanical strength of the hydrate bearing layer, and the fourth case considers rapid hydrate formation and dissociation kinetics. Five teams submitted solutions to Benchmark Problem 2: GEOMAR Kiel (GEOMAR), University of California Berkeley (UCB), Pacific Northwest National Laboratory (PNNL), Lawrence Livermore National Laboratory (LLNL), and GEOMAR Kiel (GEOMAR). Submitted solutions were compared during the IGHCCS2 teleconference series. The third benchmark problem is championed by Matt Reagan, Alejandro Queiruga, and George Moridis, at LBNL, USA and

considers coupled flow, transport and geomechanics in a radial domain. Eight teams submitted solutions to Benchmark Problem 3; Lawrence Berkeley National Laboratory (LBNL), University of California Berkeley (UCB), Jilin University (JLU), National Energy Technology Laboratory (NETL), and Lawrence Livermore National Laboratory (LLNL). The fourth benchmark problem is championed by Sayuri Kimoto at Kyoto University, Japan and is modeled after the Nankai Trough field experiment. The study currently comprises 54 participants, representing 24 teams, from 5 countries (i.e., United States, United Kingdom, Germany, Korea, Japan, and China). A workspace within the NETL EDX system has been created for the study, and accounts have been granted for requesting participants. Five study teleconferences were held during the quarter:

- Teleconference #15: July 05, 2018
 - IGHCCS2 Benchmark Problem 2
 - Update of submitted solutions
 - GEOMAR
 - University of California Berkeley (UCB)
 - Pacific Northwest National Laboratory (PNNL)
 - Lawrence Berkeley National Laboratory (LBNL)

- Teleconference #16: July 26, 2018
 - IGHCCS2 Benchmark Problem 2
 - Update of submitted solutions
 - GEOMAR
 - University of California Berkeley (UCB)
 - Pacific Northwest National Laboratory (PNNL)
 - Lawrence Berkeley National Laboratory (LBNL)
 - Lawrence Livermore National Laboratory (LLNL)
 - National Energy Technology Laboratory (NETL)
 - IGHCCS2 Benchmark Problem 3
 - Problem description
 - Preliminary solutions
 - Matt Reagan, Alejandro Queiruga, and George Moridis

- Teleconference #17: August 09, 2018
 - IGHCCS2 Benchmark Problem 2
 - Update of submitted solutions
 - GEOMAR
 - University of California Berkeley (UCB) [gas pressure]
 - Pacific Northwest National Laboratory (PNNL)
 - Lawrence Berkeley National Laboratory (LBNL)
 - Lawrence Livermore National Laboratory (LLNL)
 - National Energy Technology Laboratory (NETL) [Case 2 and 3]
 - IGHCCS2 Benchmark Problem 3
 - Problem description
 - Preliminary solutions
 - Matt Reagan, Alejandro Queiruga, and George Moridis

- Teleconference #18: August 09, 2018
 - Potential Benchmark Problem 5
 - Isotropic consolidation test with hydrate dissociation
 - Problem Champion: Shun Uchida (RPI)

- IGHCCS2 Benchmark Problem 1
 - Update of submitted solutions
 - GEOMAR
- IGHCCS2 Benchmark Problem 2
 - Update of submitted solutions
 - National Energy Technology Laboratory (NETL) [Case 4]
- IGHCCS2 Benchmark Problem 3
 - Review of submitted solutions
 - Lawrence Berkeley National Laboratory (LBNL)
 - Lawrence Livermore National Laboratory (LLNL)

- Teleconference #20: September 13, 2018
 - Benchmark Problem 4 (Nankai Trough)
 - Problem description
 - Preliminary solutions
 - Sayuri Kimoto, Kyoto University

- Teleconference #21: September 27, 2018
 - IGHCCS2 Benchmark Problem 3
 - Review of submitted solutions
 - Lawrence Berkeley National Laboratory (LBNL)
 - Lawrence Livermore National Laboratory (LLNL)
 - Jilin University (JLU)
 - National Energy Technology Laboratory (NETL)
 - Open Discussions

The study teleconferences were principally focused on code descriptions and establishing initial benchmark problems. All teleconferences were recorded and those recordings were posted on the NETL EDX system, along with the slide decks from the presentations. A logo for the study was created based on the infamous burning gas hydrate photo taken by Bill Lawson.

MILESTONES:

Milestone Title	Milestone Description	Planned Completion Date	Actual Completion Date	Status / Results
Nitrogen Injection (KIGAM-funded, Separate, Coordinated PNNL Project #68908)	Conduct a series of numerical simulations using its STOMP-HYDT-KE simulator to assess the feasibility of the nitrogen injection technology for production natural gas.	6/30/2018	Partially completed	Simulations with STOMP-HYDT-KE against a series of nitrogen injection experiments. Dr. Won Suk Lee visiting PNNL during April to discuss next steps.
Geomechanics Implementation and Verification	Develop algorithms for its STOMP-HYDT-KE simulator for computing the geomechanical	3/31/2018	7/4/2018	Verification simulation executed with STOMP-HYDT-KE against the classical Terzaghi problems.

	properties as a function of hydrate saturation.			
IGHCCS2: Problem Definition	Initial Problem Set Drafted and Participants Identified for the 2nd International Hydrate Code Comparison Study.	9/30/2017	4/26/2018	A series of four benchmark problems have been identified along with problem champions. Problem descriptions being developed and vetted.
IGHCCS2: Problem Issue	Initial Problem Set Issued for the 2nd International Hydrate Code Comparison Study.	12/31/2017	Partially completed	Problem #1 released, and first solution submissions reviewed on April 12, 2018 during the IGHCCS2 teleconference. Problem #2 released and first solution submissions reviewed on May 31, 2018. Problem #3 released and first solutions submissions reviewed on August 9, 2018. Problem #4 released on September 13, 2018.
IGHCCS2: Problem Submission	Initial Problem Set Submission for the 2nd International Hydrate Code Comparison Study.	6/30/2018	Partially completed	Problem #1 released, and first solution submissions reviewed on April 12, 2018 during the IGHCCS2 teleconference. Problem #2 released and first solution submissions reviewed on May 31, 2018. Problem #3 released and first solutions submissions reviewed on August 9, 2018. Problem #4 released on September 13, 2018.

PRODUCTS:

No publications nor presentations were released this quarter.

IMPACT:

No significant impacts occurred this quarter.

CHANGES/PROBLEMS:

The IGHCCS2 is progressing with benchmark problems being developed and submissions being review. Participants are joining the regularly scheduled teleconferences, but discussions are minimal.

SPECIAL REPORTING REQUIREMENTS:

No special reporting requirements occurred during this quarter.

BUDGETARY INFORMATION:

Actual Cost (this quarter)	Actual Cost (cumulative for BP)	Funds available (for the BP)	Balance of unspent funds (for the BP)	Actual Cost (cumulative for the full FWP)	Funds available (for the full FWP)	Balance of unspent funds (for the full FWP)
\$24,197	\$74,883	\$100,000	\$25,117	\$311,159	\$370,000	\$58,841

National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

1450 Queen Avenue SW
Albany, OR 97321-2198

Arctic Energy Office
420 L Street, Suite 305
Anchorage, AK 99501

Visit the NETL website at:
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Customer Service Line:
1-800-553-7681



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