Field Laboratory for Emerging Stacked Unconventional Plays (ESUP) in Central Appalachia

Highlights from Research Performance Progress Report 1-2

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PROJECT GOALS

The project "Field Laboratory for Emerging Stacked Unconventional Plays (ESUP) in Central Appalachia" will investigate and characterize the resource potential for multi-play production of emerging unconventional reservoirs in Central Appalachia. The project is designed to improve characterization of the multiple emerging unconventional pay zones that exist in the established Nora Gas Field through the drilling and coring of a deep vertical stratigraphic test well up to 15,000 feet. Additionally, the ESUP Field Laboratory team will explore and quantify the benefit of novel non-aqueous well completion strategies in this region. The project team will monitor the drilling of at least one multi-stage lateral well in the emerging (and technologically accessible) Lower Huron Shale for completion using non-aqueous fracturing techniques such as CO_2 and advanced proppant technologies. Laboratory analysis, reservoir simulation, and monitoring observations will be integrated. An assessment will be made of the multi-play resource potential and a recommended strategy advanced for prudent development that considers regional environmental and socioeconomic impacts.

ACCOMPLISHMENTS

Work Related to Project Tasks

Task 1 – Project Management & Planning

The first project milestone was completed with the submission of the Project Management Plan (PMP) on August 27, 2018. An initial PMP document was prepared, reviewed by team members (Virginia Tech [VT], Gerald Hill, and EnerVest) and submitted to the US. Department of Energy's National Energy Technology Laboratory (DOE/NETL) on August 27, 2018. The team received comments and suggested changes from DOE/NETL and will submit an updated version early in the next quarter. The PMP included plans for bi-weekly conference call meetings with EnerVest and bi-monthly in-person meetings in order to keep the project moving forward while Virginia Tech continued to negotiate contracts with both DOE/NETL and EnerVest. The PMP included a milestone log, project funding profile, spending plan, project timeline, success criteria and decision points.

Task 2 – Data Management Plan

An initial Data Management Plan (DMP) document was prepared, reviewed by the team, and submitted to DOE/NETL on August 27, 2018. The team received comments and suggested changes from DOE/NETL and will submit an updated version in the next quarter. The initial DMP included information on the type and format of data to be collected and how it will be shared and preserved, including core, cuttings and other geologic samples, well logs, time-series data, natural gas and water samples, and numerical modeling and computer simulations. The DMP includes information on preservation of data, but also on sharing data with interested parties.

Task 3 – Establishment of the ESUP Advisory Stakeholder Group

The research team finalized membership of the Advisory Stakeholder Group (ASG) this quarter by inviting nine members, all of whom accepted the invitation. The group includes technical experts, community leaders, environmental groups, state government and a representative from NETL/DOE. The ASG includes the following individuals:

- Randy Albert, Owner and CEO, Shale Advisory Group, Bluefield, West Virginia
- Ed Diminick, Principal Petroleum Engineer, Marshall Miller & Associates, Kingsport, Tennessee
- Jerry Grantham, Vice President-Southern Appalachian Division, Range Resources (retired), Abingdon, Washington County, Virginia
- Shannon Blevins, Associate Vice Chancellor for Economic Development and Engagement, The University of Virginia's College at Wise, Wise County, Virginia
- Freddie Mullins, Freddie Mullins, Esq., Clintwood, Dickenson County, Virginia
- John Schoolcraft, Board of Supervisors, County of Wise District III and Project Coordinator- Workforce Development, Mountain Empire Community College, Big Stone Gap, Wise County, Virginia
- Leon Boyd, Virginia District Chair and Chair of the Southwest Virginia Coalfields Chapter, Rocky Mountain Elk Foundation, Buchanan County, Virginia
- William Clear, Director of Finance and Project Administration, Virginia Department of Mines, Minerals and Energy, Big Stone Gap, Wise County, Virginia
- Richard Hammack, Geological and Environmental Systems Directorate, Office of Research and Development, US DOE's National Energy Technology Laboratory, Pittsburgh, PA

The diverse experience of the membership brings both breadth and depth to the group. The group will provide advice, suggestions and recommendations to the research team on all phases of the project, from site selection and operation to economic and social impacts studies. A kick-off ASG meeting and site visit has been scheduled for November 1, 2018, at EnerVest's offices in Abingdon, Virginia.

Task 6 – Site Selection

The research team focused on identifying the most promising sites for the deep characterization well and the Lower Huron horizontal shale well independent of each other.

For the Lower Huron horizontal shale well, the following procedure was undertaken to identify potential sites:

- Detailed geologic mapping of various stratigraphic horizons including gross thickness intervals.
- Interpretation of the mapping: the limited amounts of available seismic and other data, indicates that the western Virginia area of Wise and Dickenson counties where EnerVest has acreage is generally fairly quiet from a structural perspective.
- The general procedure for site selection was initiated from an analysis of available core data (both proprietary and nonproprietary) in the region to identify specific parameters indicative of good hydrocarbon generation, reservoir, and production qualities. The core variables of highest interest include maturity, total organic carbon (TOC), porosity, and gas composition (adsorbed, desorbed, etc.).
- The normalized core data was also used to identify critical reservoir indicators such as gamma ray counts, density, and resistivity values. These parameters can indicate increased hydrocarbon generation potential (gamma ray) and higher reservoir quality (density & resistivity). Optimal numerical cutoffs for each of these parameters were established and later used in the interpretive mapping process.
- Additional reservoir analyses were also incorporated into the evaluation, including gas-in-place (GIP) estimates, effective recovery factors, and reservoir pressure. This data often confirmed information interpreted from the ESUP team's internal core and reservoir analyses.
- Net reservoir thicknesses were also mapped in detail using the optimal reservoir parameters identified in the review of core data. Gamma ray cutoffs of 264 API units, density cutoffs of 2.64 g/cc, and resistivity cutoffs of 61 ohm-meters were applied to the vast petrophysical log dataset covering the area. These cutoffs are indicative of areas that have higher TOC contents and therefore are more prone to generate hydrocarbons.
- Production data from existing wells was analyzed to confirm optimal reservoir areas. Raw production data in the area is somewhat inconclusive due to varying well vintages, completion methods, etc. The team has attempted to normalize and interpret that data as accurately as possible as part of the site selection process.

For the deep characterization well, site selection focused on a review of the stratigraphic section for western Virginia and the very limited deep activity in the region. There are no basement tests drilled within the Nora field; however, activity in other areas suggests potential hydrocarbon reservoirs may exist in the Silurian age Keefer and Clinton, the Ordovician age Trenton/Black River and Beekmantown/Rose Run, and the Cambrian age Conasauga (Rogersville, Nolichucky) and Rome sections. The following procedure was undertaken to identify potential sites:

- Regional activity mapping of each of the above horizons indicates that the western Virginia area is significantly underexplored from a deep perspective. The neighboring states of Ohio, Kentucky, and West Virginia have all seen significant testing of deep horizons with significant discoveries in the Beekmantown/Rose Run of Ohio, the Marcellus and Trenton/Black River of West Virginia, and the Trenton and Rogersville Shale of Kentucky, but those deep units have largely been untested in Buchanan, Dickenson, and Wise Counties, Virginia.
- One deep horizon that has recently generated much publicity is the Rogersville Shale.

This interval has been tested on a limited basis in Kentucky, with multiple wells having been drilled by various operators. In addition, significant leasing has occurred in parts of Kentucky as operators work to conglomerate acreage blocks for potential development. Open flow and production data from the few wells that have been completed to date has remained confidential, but activity has created significant discussion in the industry.

- From a geologic perspective, the Rogersville deposition was typically confined to the most prolific basement feature in the area, known as the Rome Trough. This feature extends from north to south through the western part of West Virginia and into Kentucky, and then turns west into central Kentucky before jutting south into Tennessee. The Rome Trough feature itself is located completely outside of Virginia; however, there is a structural feature in Floyd County, Kentucky, known as the Floyd County Embayment which breaches the southern boundary of the trough and allowed Rogersville Shale deposition to spill into the easternmost counties of Kentucky, and likely into portions of several western Virginia counties. Deep wells in Pike County, Kentucky (Stratton #1), and Russell County, Virginia (Price #1, south of Nora acreage position), confirm the presence of Rogersville section across the ESUP area of focus. This section is a priority target for the basement test project and could potentially provide a blanket, resource-type play for the area.

A review of pipeline capacity, available compression, and acreage ownership was conducted. Acreage ownership in the area is important from a legal and regulatory standpoint and was verified along the entire length of the proposed lateral. Additionally, a reasonable plan for site access is a must for operations to occur. Pipeline capacity and available compression is also a requirement for uninhibited production analysis.

All of the above analyses were then combined to identify the optimal location for additional Lower Huron testing and development. Areas were identified that exhibited the best geologic and reservoir characteristics identified from core analysis and were located in areas where existing infrastructure and facilities were sufficient to accommodate additional activity. Two priority areas that exhibited many optimal characteristics were identified: one in the central portion of Dickenson County (which also corresponds to the central part of the Nora field), and one in the southwestern portion of Dickenson County.

The final site determination for the Lower Huron Horizontal and the Basement Stratigraphic Test projects was selected based on the combined analyses summarized above. It was determined that the most efficient use of capital and time would result from drilling both projects in the same area. By using the same area and drilling the Basement Test project first, that wellbore can be optimally placed along the proposed Lower Huron lateral to enable microseismic monitoring during completion of the horizontal Lower Huron project. This will be extremely beneficial in helping to determine the effectiveness of the novel completion technique selected for the horizontal well. With that in mind, the most southern of the initial two Lower Huron priority areas was selected for this project. This area provides the most optimal placement for both projects when all factors (geologic, reservoir, land, pipeline, compression, etc.) are considered.

Other Project Activities

Dissemination of Results and Outreach Activities

VT, DOE/NETL and EnerVest had a kick-off meeting with a presentation from VT on 04/23/2018. Nino Ripepi of VT presented an overview of the project and future plans at the 2018 Natural Gas Review Meeting in Pittsburgh, PA on 08/14/2018.