

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

## Highlights from Research Performance Progress Report 4

Reporting Period: January 1, 2019 – March 31, 2019

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### PROJECT GOALS

The Field Laboratory for Emerging Stacked Unconventional Plays (ESUP) in Central Appalachia project 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<sub>2</sub> 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 and Planning

EnerVest, the US Department of Energy's National Energy Technology Laboratory (DOE/NETL) and Virginia Tech (VT) held bi-weekly conference calls and the Virginia Tech research team had weekly technical meetings to discuss progress on updating the Authorization for Expenditure (AFE), core analysis, geologic characterization, reservoir modeling, and plans for field work. Virginia Tech and EnerVest continued meetings and discussions with Virginia Tech's Office of Procurement to develop a Request for Proposal (RFP) for all items in excess of \$50,000 required to drill and characterize the basement well test. This process is necessary for fair selection of competent vendors to drill the deep well and in accordance with Commonwealth of Virginia and

federal regulations. Virginia Tech received 29 proposals by March 6, 2019, for the 14 services outlined in the RFP. The proposals were reviewed by VT and EnerVest for quality and cost and a preliminary ranking was completed based on a scoring matrix outlined in the RFP. Qualifying questions were developed and presented to the vendors, to verify the services offered, availability, and cost. In the following quarter the process of selecting vendors and services will begin in order to update the AFE for the deep characterization well and submit and present the AFE to DOE/NETL for review.

## Task 2 – Data Management Plan

During the previous quarter, DOE/NETL communicated comments and suggested changes to the draft Data Management Plan (DMP) submitted by the team. A revised DMP was submitted to DOE/NETL on October 30, 2018. The original draft DMP document 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 updated version included information on cataloguing all samples and sharing those with DOE/NETL annually, as well as disseminating information through conference presentations and publications. The approved DMP is now in place.

## Task 3 – Establishment of the ESUP Advisory Stakeholder Group

The Advisory Stakeholder Group (ASG) had their second meeting on February 15, 2019, at EnerVest's offices in Abingdon, Virginia. The meeting was attended by 8 of the 9 members and focused on the design of the logging and coring program for the deep characterization well. The research team provided information to the ASG regarding the risk of loading the wellbore with a column of fluid for the purposes of logging and coring the intermediate section that could potentially lead to wellbore instability within the Lower Huron Formation. In order to minimize that risk, the research team proposed five options:

1. Load hole with fluid from Trenton Ls. to Surface Casing;
2. Air filled hole;
3. Load hole with fluid from Trenton Ls. to 100' above Onondaga;
4. Load hole with fluid from Trenton Ls. to 100' above Lower Huron; or
5. Drill Intermediate hole to Onondaga top and core Lower Huron before drilling to Trenton Ls.

The discussions focused on available core and logs in the vicinity of the ESUP test site. The ASG provided recommendations to not leave the Lower Huron covered in water for an extended period of time and to utilize the existing core and nearby logs from the Lower Huron well for core analysis and to build an accurate velocity model for micro-seismic monitoring.

## Task 5 – Project Reporting, Dissemination of Results, and Outreach

The Outreach and Education Plan was completed, approved by research team partners, and submitted to DOE/NETL. An outreach working group consisting of Principal Investigator Nino Ripepi, Outreach Coordinator Margaret Radcliffe, and Media Specialist (web developer) Damaris Anderson was formed and met to plan the design, content, and deployment of the ESUP web site. A newsletter and mailing list Mailchimp account was established to be used to maintain quarterly newsletter mailing. The Outreach Coordinator performed testing in Mailchimp in preparation for the first newsletter, to be issued in conjunction with web site launch. This mailing list will also be used to promote any special events or to make any special announcements associated with ESUP. The Outreach Coordinator will be responsible for drafting, soliciting approvals before release, and mailing newsletters and announcements. Mailchimp will ensure compliance with applicable law regarding identification of the sender and will allow individuals to subscribe/unsubscribe without contacting the VCCER.

These steps were put into effect to develop and expand the mailing list:

- First newsletter will be sent to the Stakeholder Advisory Group and to Research Team Members. They will be requested to share it with any individuals or organizations they feel would be interested and encourage sign up.
- Mailing will also be sent to the VCCER Advisory Board to promote sign up and with request to share with others who would be interested.
- Mailing will be sent to government and non-governmental organizations such as chambers of commerce, county boards of supervisors, state legislators, etc., in the region to encourage sign up.
- VT media/communications team will be asked for assistance in disseminating the sign-up invitation to journalists.
- Link will be established on the ESUP website to allow sign up.
- Computer and tablets will be available at VCCER booths at events, to promote immediate signup.

## Task 6.1 – Initial Characterization and Design

The researchers will conduct a preliminary geologic investigation based on existing data. This subtask task will also conduct preliminary design considerations of the ESUP field Laboratory and include factors such as, but not limited to, the placement of existing access roads and infrastructure (offset well pads or other facilities) for monitoring or other utilization, favorable leasehold, site terrain, facilitation of monitoring over the project lifecycle (including acquisition of baselines), location of residences and community structures, risk profile, and anticipated and perceived impacts to the local environment and community.

Researchers at Virginia Tech worked on geologic characterization, core testing and reservoir modeling of the Lower Huron shale in order to inform completion strategies. Geologic

Characterization included analyzing drilling reports, production and completion data and geochemical disclosure data from the Commonwealth of Virginia and Fracfocus for all horizontal wells targeting the Lower Huron shale in Virginia. Data was organized and analyzed to estimate the ultimate recovery (EUR) and determine key factors that affect production. Core Analysis included acquiring slabbed core (stored at East Tennessee State University) through the upper portions of the Lower Huron shale as well as drill cuttings from the full Lower Huron formation from EnerVest. This core is being analyzed in order to inform completion strategies for the Lower Huron shale.

The following core analyses are currently being completed:

Measurement	Equipment	Specifics
Permeability	CoreLab SMP – 200 (Matrix Permeability) CoreLab PDP-200	Matrix permeability is being measured on crushed samples and will be compared with core plug permeability next quarter.
Adsorption	High Pressure Adsorption Isotherms for CO <sub>2</sub> , N <sub>2</sub> and CH <sub>4</sub>	Initial tests with CH <sub>4</sub> were performed. CO <sub>2</sub> and N <sub>2</sub> isotherms will be performed next quarter.
Fracture Conductivity	Fracture conductivity with different proppants under reservoir pressure and temperature (P&T)	The conductivity cell was modified to allow for placement of shale samples to study embedment.
Contact Angle	Contact angle was measured for the Upper and Middle Lower Huron	The measured contact angle ranges from 42.38 to 47.41 degrees and indicates that Lower Huron shale is water-wet (hydrophilic) and could lead to water uptake.
Scanning Electron Microscope (SEM)	Add 7% KCl solution to study water swelling on shales	Initial results show KCl could help control water-induced swelling. More tests will be performed next quarter.

The reservoir simulation group focused work on three different tasks to characterize the Lower Huron shale and evaluate completion strategies. This included the following:

1. Building a field scale reservoir simulator for current Lower Huron horizontal wells in Virginia;
2. Building a fracture model by applying different fracturing fluids and proppants; and
3. Calculation of molecular diffusion coefficients for methane, N<sub>2</sub> and CO<sub>2</sub> under nano-pore confinement.

Research continued on designing the monitoring portion of the ESUP field laboratory and included seismic and micro-seismic sensors that might be well suited to project objectives. This included research on the best array configurations based on reservoir geometry and site conditions. Research into High Energy Gas Fracturing that could be coupled with typical hydraulic fracturing is ongoing.

The SMP-200 equipment was utilized to test Lower Huron samples for matrix permeability and a protocol was developed based on testing the variation of permeability on different sample sizes. Completion data for wells targeting the Lower Huron in Virginia was summarized including stages,

length, volume of N<sub>2</sub> used, breakdown pressure, instantaneous shut-in pressure (ISIP), and water injection. Production analysis showed a change in mechanics of gas flow based on production. Two preliminary fracture propagation models were developed for two different fracturing fluids using the EFRAC software. The first model was created using Nitrogen (N<sub>2</sub>), while for the second model CO<sub>2</sub>-foam (CO<sub>2</sub>) was used as the fracturing fluid. The goal here was to compare the fractures created by N<sub>2</sub> and CO<sub>2</sub> and use the stimulated reservoir volumes for future reservoir modeling work. Results show that N<sub>2</sub> diffusion coefficient increases with increasing N<sub>2</sub> concentration, however CO<sub>2</sub> diffusion coefficient decreases with increasing CO<sub>2</sub> concentration in the reservoir.

In the next quarter, the Recipient will continue analysis of potential completion strategies in order to optimize the production process with consideration of economic costs. The goal is to characterize both permeability and adsorption distribution with change of depth in the Lower Huron shale. Lower Huron shale samples will be cut with diamond tools by an outside company in order to fit the required size of the modified fracture conductivity cell.

#### Task 6.1 – Site Access Agreements

The team focused on National Environmental Policy Act (NEPA) and state permitting for the deep characterization well at the ESUP test site. A NEPA Categorical Exclusion (CX) form was prepared by Virginia Tech and EnerVest and submitted to DOE/NETL on January 29, 2019. EnerVest submitted the permit to Virginia's Division of Gas and Oil on January 11, 2019. A spacing hearing was held on February 19, 2019, to request an exception for statewide spacing for any conventional well with an existing producer closer than 2,500 feet from the proposed location based on the case that there are no offset wells producing from the deep targets anticipated in the characterization well. On February 12, 2019, a signed NEPA CX form was received for the deep characterization well that will allow field activities to take place in Budget Period 2. On March 21, 2019, a permit was issued by Virginia's Division of Gas and Oil for drilling the deep characterization well. Based on the NEPA CX and the state permit received, EnerVest is in position to legally drill, log and core the deep characterization well.

### **Other Project Activities**

#### Dissemination of Results and Outreach Activities

Virginia Tech, and EnerVest had a meeting with DOE/NETL to update progress on Phase I in Morgantown, West Virginia, on January 31, 2019. The Advisory Stakeholder Group met on February 15, 2019, in Abingdon, VA to discuss risks associated with drilling and logging the deep characterization well.