Liquid-Rich Shale Potential of Utah's Uinta and Paradox Basins: Reservoir Characterization and Development Optimization

DE-FE0010667

Goal
The overall goal of the project is to provide reservoir-specific geological and engineering analyses of the emerging Green River Formation (GRF) tight oil plays in the Uinta Basin and the established yet understudied Cane Creek shale of the Paradox Formation in the Paradox Basin.

Performers
Utah Geological Survey, Salt Lake City, Utah
Energy and Geoscience Institute, University of Utah, Salt Lake City, Utah
Eby Petrography & Consulting, Inc., Denver, Colorado

Collaborators
Uinta Basin Petroleum Companies: Anadarko Petroleum Corp., LINN Operating, Inc. (Berry), Bill Barrett Corp., Newfield Exploration Co., QEP Resources, Inc., EOG Resources, Inc.
Paradox Basin Petroleum Companies: Anadarko Petroleum Corp., Fidelity Exploration & Production, SM Energy Co., Southwestern Energy, Castleton Commodities International
Other: U.S. Geological Survey, University of Alberta, Colorado School of Mines

Background
The 2009-2014 high price of crude oil, coupled with lower natural gas prices, generated renewed interest in exploration and development of liquid hydrocarbon reserves. Following on the success of the mid-2000s shale gas boom and employing many of the same well completion techniques, petroleum companies started exploring for liquid petroleum in shale formations. In fact, many shales targeted for natural gas include areas in which the shale is more prone to liquid production. In Utah, organic-rich shales in the Uinta and Paradox Basins have been the source of significant hydrocarbon generation, with companies traditionally targeting the interbedded sands or carbonates for their conventional resource recovery. Because of the advances in horizontal drilling and hydraulic fracturing techniques, operators in these basins started to explore the petroleum production potential of the shale units themselves.

The GRF in the Uinta Basin has been studied for over 50 years, since the first hydrocarbon discoveries. However, those studies focused on the many conventional sandstone reservoirs currently producing oil and gas. In contrast, less information exists about the more unconventional crude oil production potential of thinner carbonate/shale units, most notably the Uteland Butte member, but also the black shale facies, deep Mahogany zone, and other deep Parachute Creek member high-organic units.

The Cane Creek shale of the Paradox Basin has been a target for exploration periodically since the 1960s and produces oil from several small fields. The play generated much interest in the early 1990s with the successful use of horizontal drilling. Recently, the USGS assessed the undiscovered oil resource in the Cane Creek shale of the Paradox Basin at 103 million barrels at a 95 percent confidence level and 198 million barrels at a 50 percent confidence level. Nonetheless, limited research has been conducted or published to further define the play and the reservoir characteristics.

Potential Impacts
The specific objectives of the research are to (1) characterize geologic, geochemical, and geomechanical rock properties of target zones in the two designated basins by compiling data and by analyzing available cores, cuttings, and well logs; (2) describe outcrop reservoir analogs of GRF plays (Cane Creek shale is not exposed) and compare them to subsurface data; (3) map major regional trends for targeted intervals and identify "sweet spots" that have the greatest oil potential; (4) reduce exploration costs and drilling risks, especially in environmentally sensitive areas; (5) improve drilling and fracturing effectiveness by determining optimal well completion design;

and (6) reduce field development costs, maximize oil recovery, and increase reserves. The project will therefore develop and make available geologic and engineering analyses, techniques, and methods for exploration and production from the GRF tight oil zones and the Paradox Formation shales where operations encounter technical, economic, and environmental challenges.

Accomplishments

The first major task of this project was to locate and describe all available cores from the two primary target intervals in the Uinta and Paradox Basins. Project team members located and described in detail 13 Uteland Butte member cores and collected all associated data. These data are being used to develop a regional geologic picture of the Uteland Butte play. Project team members also described five cores from the Cane Creek shale in the Paradox Formation and collected data such as high-resolution X-Ray fluorescence, RockEval analyses, X-Ray diffraction, and other core analyses.

Four collaborations have been set up to help further explore both the Uteland Butte and the Cane Creek tight oil plays. The project team has (1) collaborated with Dr. Hans Machel, geology professor at the University of Alberta and renowned dolomite expert, to explore the origin of the Uteland Butte's productive dolomite intervals and subsequent diagenesis; (2) collaborated with Dr. Joseph Moore, research professor at the Energy and Geoscience Institute, University of Utah, and renowned fluid inclusion expert, to study fluid inclusions in the Cane Creek shale to help determine timing of fractures and oil generation; (3) collaborated with research geologists from the U.S. Geological Survey to study the origins of Green River oils and thermal maturity of Green River shales; and (4) collaborated with Dr. Rick Sarg, carbonate geologist at Colorado School of Mines, to study the eastern extent of the Uteland Butte in the Uinta Basin.

TerraTek, a Schlumberger company, has completed all geomechanical testing on cores from the Uteland Butte and Cane Creek tight oil formations. This newly acquired data will be used to help determine reservoir mechanical properties and help optimize well completion strategies in both the Uteland Butte and Cane Creek plays.

Over the course of the project, the research team has given 12 presentations at both regional and national AAPG meetings; a 13th presentation will be delivered at the 2017 AAPG meeting in Houston, TX.

Current Status (November 2016)

Epifluorescence and fluid inclusion analyses on the Cane Creek shale are finished and final reports are being generated and incorporated into the overall Cane Creek report.

Research continues on the origin and diagenesis of dolomites within the Uteland Butte, including thin section petrography and several other analyses.

All geomechanical testing has been completed and researchers at EGI are using this data to study fracture toughness as well as other aspects of the reservoir mechanics.

So far, four research papers have been published and one paper is currently "in press" and should be published soon:

1) Schamel, S., 2015, Shale Oil Resource Play Potential of the Green River Formation, Uinta Basin, Utah: Open-File Report 639.
2) Johnson, R.C., Birdwell, J.E., Mercier, T.J., Brownfield, M.E., Charpentier, R.R., Klett, T.R., Leathers, H.M., Schenk, C.J., and Tennyson, M.E., 2015, Assessment of Undiscovered Oil and Gas Resources in the Uteland Butte Member of the Eocene Green River Formation, Uinta Basin, Utah: USGS Fact Sheet 2015-3052.
3) Logan, S.K., Sarg, J.F., and Vanden Berg, M.D., 2016, Lithofacies, Deposition, Early Diagenesis, and Porosity of the Uteland Butte Member, Green River Formation, Eastern Uinta Basin, Utah and Colorado: UGS Open-File Report 652.
4) Birdwell, J., Vanden Berg, M.D., Johnson, R.C., Mercier, T.J., Boehlke, A.R., and Brownfield, M.E., 2016, Geological, Geochemical, and Reservoir Characterization of the Uteland Butte Member of the Green River

Formation, Uinta Basin, Utah, in Dolan, M.P., Higley, D.K., and Lillis, P.G., editors, Hydrocarbon Source Rocks in Unconventional Plays, Rocky Mountain Region: Rocky Mountain Association of Geologists.

5) Chidsey, T.C., and Eby, D.E., in press, Potential Oil-Prone Areas in the Cane Creek Shale Play, Paradox Basin, Utah, Identified by Epifluorescence Microscopy Techniques: UGS Special Study. (due out March 2017)

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Performer Contribution, including subcontractor cost-share: $184,348

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