[PS]Development of Stranded Gas in the Niobrara Shale*

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Abstract

Shale gas is often described as a continuous resource, in that it is generally producible across wide areas without the need for conventional structural or stratigraphic traps, migration pathways, or reservoir rock. However, much of this gas is not being produced because it occurs in locations that are too far from existing transmission pipelines. Such "stranded" gas may represent a significant energy resource that can be developed and used locally. With funding from the U.S. Departments of Energy and Interior, a cooperative research program between the Rosebud Sioux (Indian) Reservation and the South Dakota School of Mines and Technology has been assessing the production potential and possible utilization of shallow gas (< 600 m depth) in the Cretaceous Niobrara Formation in South Dakota. The study provided practical, problem-solving challenges to geoscience graduate students, and introduced tribal college students to oil and gas as a possible career choice. Hydrocarbon potential was initially evaluated using publicly-available cores and logs, although none were located close to the reservation. The South Dakota State Geological Survey provided a fresh, local drill core that supplied lithologic, rock eval, and core analysis samples.

Results indicate that the Niobrara is a prospective gas resource on the Rosebud Reservation, containing biogenic gas under relatively low pressures that could provide a local energy supply. People on the reservation typically use electricity, propane, fuel oil, and even wood for space heating, all of which are brought in from outside. The shallow depth should allow the development of Niobrara gas to be accomplished by pinnate drilling with a coiled tubing rig at relatively low cost. Such technology has been successful in eastern Colorado, recovering more than a TCF of shallow Niobrara gas since 2005. Potential uses for natural gas on the reservation include heating for homes and businesses, electrical generation, low-cost energy for industrial parks and greenhouses to provide jobs and grow fresh produce, and fuel for natural gas-powered vehicles. Development will require a demonstration well, environmental monitoring, and design of a local distribution and metering system to deliver the gas, all of which are currently in progress. If successful, this could become a model for developing stranded gas resources elsewhere, encouraging local utilization of gas, and improving energy self-reliance on reservations.

Development of Stranded Gas in the Niobrara Shale

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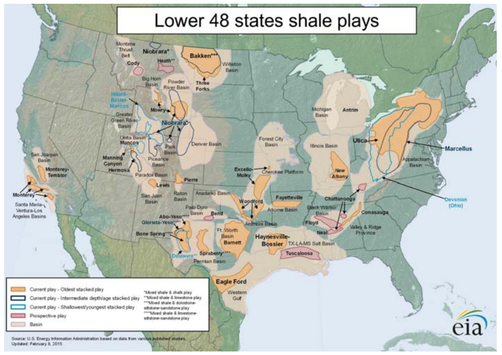
Abstract

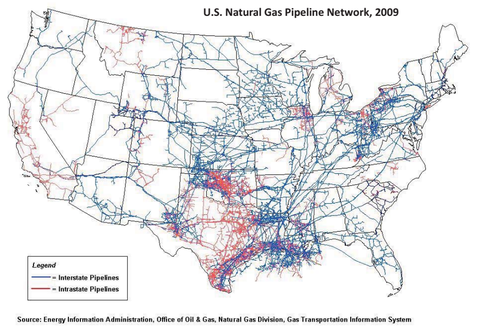
Shale gas is often described as a continuous resource, in that it is generally producible across wide areas of shale formations without the need for conventional structural or stratigraphic traps, migration pathways, or reservoir rock. However, the most practical method for transporting gas is by pipeline, and gas resources in areas that do not have access to an existing gas pipeline are said to be "stranded." There are two varieties of stranded gas: 1) non-associated or "dry" gas in locations far from existing pipelines that is simply not developed, and 2) associated gas in areas of oil production, which is often flared to allow the liquid hydrocarbons to be produced and transported to markets.

Stranded gas, especially if shallow, represents a significant energy resource that can be developed and used locally. A cooperative research program among the Rosebud Sioux Indian Reservation, the South Dakota School of Mines and Technology, and the DOE National Energy Technology Laboratory has investigated the production potential and possible use of shallow gas in the Cretaceous Niobrara Formation in South Dakota. The study concluded that the Niobrara is a prospective gas resource on the Rosebud Reservation, containing biogenic gas at relatively low pressures, and could provide a local energy supply for heating homes and businesses, electrical generation, low-cost energy for industrial parks and greenhouses to provide jobs and grow fresh produce, and fuel for natural gas-powered vehicles. Because of the shallow depths, development of Niobrara gas should be relatively inexpensive, and could be accomplished by pinnate drilling with a coiled tubing rig. Such technology has been successful in eastern Colorado, recovering more than a TCF of shallow Niobrara gas since 2005. Development will require a demonstration well, environmental monitoring, and installation of a local distribution and metering system to deliver the gas, all of which are currently in the design stage.

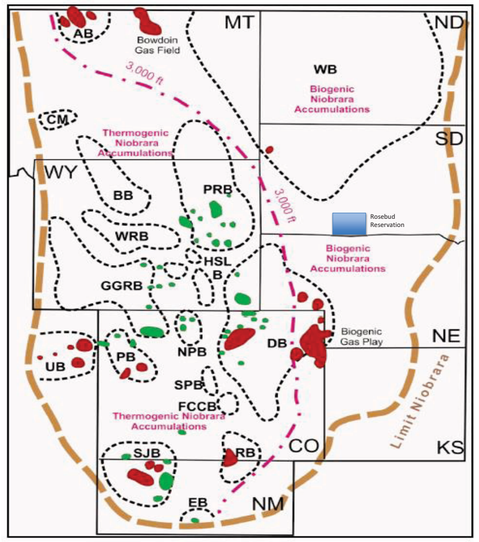
For flared gas in oil plays like the Bakken, the goal is to turn a waste stream into revenue. In this case, modular chemical processing units placed on the production well pad would convert produced methane gas into methanol, or possibly polymerize it into plastic or other petrochemical feedstocks. These products could be stored on the pad as liquids or solids until a routine pick-up was made by a tanker truck. Investigations are being supported by the U.S. Department of Energy.



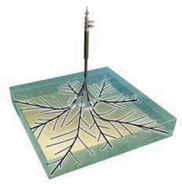
Maps of U.S. shale gas production areas and pipelines, showing that the two don't always coincide.



Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

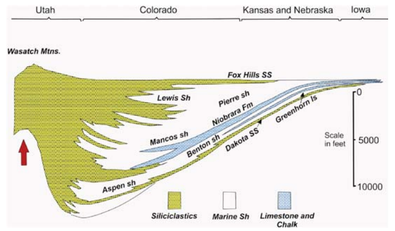


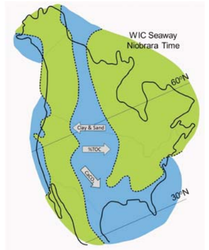
Niobrara map from Sonnenberg, 2011



Hybrid coiled tubing rig (left); pinnate drilling pattern (above)

Gas being flared at a Bakken oil production site in North Dakota, USA (photo by D. Soeder 2017)





Top left: Generalized geologic section of the Niobrara Fm. across the Western Interior Cretaceous Seaway; top right: sedimentation trends in the WIC Seaway during Niobrara deposition (both from Sonnenberg 2011)

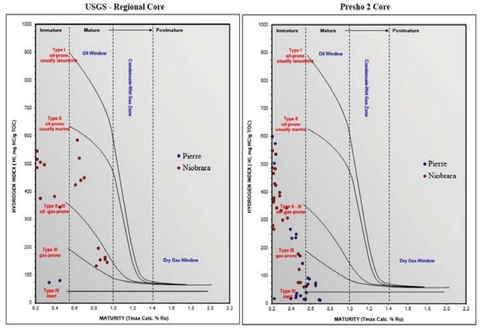
Above left: organic-rich Niobrara outcrop at Slim Butte, Oglala Lakota County, SD; above right: upper contact of chalky Niobrara with overlying muddy Pierre Shale at Elm Creek near the Missouri River in central SD (photos by Dan Soeder)

An assessment of shallow Niobrara gas resources in south central South Dakota, USA, was carried out by SD Mines in cooperation with the U.S. Department of Energy, the SD Geological Survey, and the Rosebud Sioux (Lakota) Indian Reservation, and engaged students from SD Mines and Sinte Gleska University, the Rosebud Reservation tribal college.

U.S. Geological Survey regional Niobrara cores were used for the initial assessments, although none of these were located close to the Rosebud Reservation. The South Dakota Geological Survey collected continuous core through the Pierre Shale and underlying Niobrara Formation near the town of Presho, SD in 2014-15. This core provided samples within 35 miles (56 km) of the Rosebud Reservation. Analyses on all cores included rock eval pyrolysis, thin section analysis, and total organic carbon (TOC) determination, which was as high as 6%. The research concluded that the Niobrara under the reservation probably contains enough immature biogenic gas to make local use feasible (Soeder et al., 2015).

Shallow Niobrara gas has been successfully produced in eastern Colorado using pinnate drilling with a hybrid coiled tubing rig. Similar technology was recommended for Rosebud. Utilization of the gas could include electrical generation, domestic and industrial space heating, natural-gas fueled vehicles, and potential conversion of natural gas to liquid or solid products that don't require a pipeline for transport. Engineering designs for the wells, transmission lines, and distribution system are currently underway.

Top left: South Dakota Geological Survey coring the Pierre Shale and Niobrara Formation near Presho, SD in 2014; top right: students and interns process drill core at the Presho borehole – the SDGS drill rig is visible in the background.

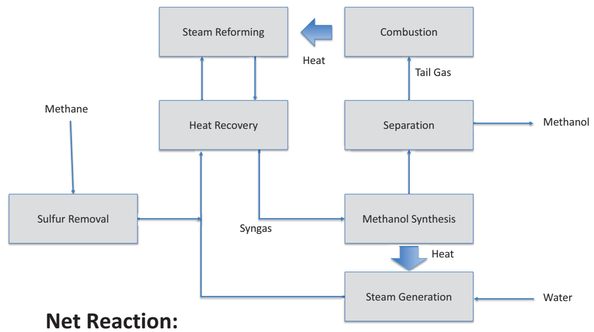


Above: SDSMT Geology student Kelsey Marzolf with regional Niobrara cores at the USGS Core Library in Denver, 2012. Photograph by Subodh Singh. Right: Source rock analysis data on Pierre and Niobrara samples from regional USGS cores and Presho core. The organic content of 3-6% generally falls into the gas-prone, thermally immature window, indicating the Niobrara may produce early-stage biogenic gas.

A USDOE-sponsored program called Rapid Advancement in Process Intensification Deployment or RAPID within the National Network of Manufacturing Institutes is seeking ways to utilize stranded gas, especially gas currently being flared. RAPID proposes developing technologies to convert stranded gas into useful products like plastics and chemicals at the wellhead.

Ideas include conversion of methane gas to methanol, polymerizing methane into higher hydrocarbons with better storage properties and higher value, such as propane, butane, hexane, etc., or polymerizing gas into solid compounds like polyethylene or other plastics.

The process would be skid mounted and scaled to handle a representative input of produced natural gas. Additional modules could be added during the early stages of high gas production, and removed to other sites as production declined.



Net Reaction:

$CH_4 + H_2O \rightarrow CH_3OH + H_2$

Conceptual process from DOE Pacific Northwest National Laboratory for converting methane gas to methanol.

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