Petroleum Geology of the Niobrara Formation, Silo Field, Wyoming

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The Silo Field is located in the northern part of the Denver basin. Production is from the fractured Niobrara Formation at depths ranging from 7600 to 8500 ft. (2318 to 2593 m). Cumulative production from 40 vertical and 68 horizontal wells at Silo is in excess of 10.4 million barrels of oil and 8.9 billion cubic feet gas. Recent drilling success with horizontal wells and multistage-fracture stimulation suggests much greater future production. Initial potentials from the new horizontal wells range from 500 to 2000 bbl of oil/day.

The dominant lithologies of the Niobrara are limestones (chalks) and interbedded calcareous and organic-rich shales. Niobrara thickness ranges from 280 to 300 ft. (85 to 92 m). Four limestone intervals, averaging 30 ft. (9.2 m), and three intervening shale intervals (averaging 47 ft or 14.3 m) occur regionally and are easily recognized on geophysical logs. The lower limestone is named the Fort Hays, and the overlying units are grouped together as the Smoky Hill member. Limestone beds in the Smoky Hill are informally named the A, B, and C intervals in increasing depth order. The fractures are concentrated in the more brittle limestones. The main production is from the middle limestones (B interval) of the Smoky Hill. Shows and production also come from the A, C, and Fort Hays chalk intervals in older vertical wells which suggest they may be future targets of horizontal drilling. The current target of horizontal drilling is the B chalk interval. The intervening shales have high organic matter content and served as source beds and seals.

Open fracture systems are essential to Niobrara production because little matrix porosity exists in the limestones. Open fractures in the field are very consistent and are oriented N25-40W. The consistent orientation of fractures suggests that this is the orientation of the maximum horizontal stress. Open fractures may be created by: (1) solution of Permian evaporites; (2) folding over basement fault systems; (3) regional horizontal stress field; (4) hydrocarbon pore pressure; (5) differential compaction over paleotopographic highs; (6) movement on wrench faults; (7) compaction and dewatering of the chalks; and (7) other uncertain causes. Additional data are needed to resolve the origin of the fractures.

High resistivities are observed in limestone beds at Silo. These resistivity anomalies appear to be related to the presence of a large hydrocarbon accumulation delineated by isoresistivity mapping.

Factors present at Silo will serve as a model for future Niobrara production in the Rocky Mountain region. These factors include (1) mature source rocks interbedded with brittle limestone; (2) open fractures to form the reservoir; (3) resistivity anomalies indicating accumulation; and (4) technology to efficiently produce the reservoir.