Petroleum Geology of Silo Field, Wyoming*

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1

Abstract

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; this suggests 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.

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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.

**Selected References**


Petroleum Geology of Silo Field

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Colorado School of Mines
Niobrara Petroleum System - Denver Basin
Shallow Biogenic Gas
Deep Thermogenic Oil and Gas

Typical Depth

4300'
4800'
6800'
7100'
7600'
7800'

Pay

PIERRE SHALE
SUSSEX (TERRY) SS
PIERRE SHALE
SHANNON (HYGIENE) SS
PIERRE SHALE
Sharon Springs Member
NIORARA “A”
NIORARA “B”
NIORARA “C”
FT HAYS LIMESTONE
CODELL SAND
CARLILE SHALE
GREENHORN LS
GRANEROS SHALE D Sand
J2 SAND
J1 SAND
SKULL CREEK SHALE
DAKOTA SAND
SILO FIELD
Niobrara Fm.

Discovery:

1981
Amoco Champlin 300 1
SE SE Sec 5, T15N, R64W
Ft Hays completion
78 BOPD

1990
First horizontal:
Warren # 1
Sec. 11, T15N, R65W
600 BOPD

Vertical Depths:
7100 to 8800 ft

Cum Prod:
10.4 MMBO
8.9 BCFG
6.3 MMBW

Structure Niobrara
Silo Field
CI: 50 ft
Lee 41-5
NE NE Sec. 5-T15N-R64W

TOC: 3.17
4.2
2.5
2.3
7.8

Sharon Springs
A Chalk
B1 Chalk
C Chalk
Fort Hays
Codell SS

CORE

Pfs: 7898-8035; IP: 76 BOPD
Reservoir Properties

- Porosity: < 8%
- Permeability: < 0.1 md
- Pay: 30 – 60 ft
- GOR: 1030 cu ft per barrel
- Oil gravity: 35° API
Modified from Lockridge and Scholle, 1978
Resistivity Mapping and Accumulation

Sonnenberg and Weimer, 1991
Fractures

- Differential compaction over paleotectonic high (Thomas, 1992)
- Folding over basement faults (Davis and Lewis, 1990)
- Wrench faults (Sonnenberg and Weimer, 1991; Svoboda, 1995)
- Permian salt dissolution (Campbell and Saint, 1991)
- Regional fracture system (Lorenz et al., 1991)
- Pore pressure fractures (Meissner, 1978)
- Compaction & dewatering (Brown, 2004)
- Neogene extension (Vincelette and Foster, 1992)
Vertical Stylolites and Fractures
Structure Top Niobrara

Sonnenberg and Weimer, 1993
Extension Fractures and Wrench Faults

Silo Field
Fracture Orientation

Svoboda, 1995
Lewis, 1986

Fracture Trend
N25-40W

Salt Dissolution Edge
~N70W
Great Western Warren # 1
Sec. 7-T15N-R64W

Polar Frequency Plot
Fracture intensity & orientation
Silo Fractures

- Structural monocline
- Basement faults control Permian salt dissolution
- Some wrench movement on faults

Modified from Svoboda, 1995
## Lee 41-5

### Sec. 5-T15N-R64W

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Niobrara Marls

• TOC: 1 – 6 wt. percent
• Kerogen type: Type II
Source Rocks Silo Field

PI Tmax

Lee 41-5
Sec. 5-T15N-R64W
7980-8017
Solution Gas and partial water drive

Vertical Drilling

Horizontal Drilling
Structure Niobrara & Cum Production
Silo Field
CI: 50 ft
Silo Production-EUR

• Vertical wells: 34824 BO/w

• Horizontal wells: 111251 BO/w

• Field EUR 11.5 MMBO (existing wells)
UPR Berry 41-13
NE NE NE Sec. 13-T16N-R66W
Summary

• Silo Field is located in basin-center setting
• No oil-water contact observed
• Fracturing plays a key role in production
  ➢ Matrix porosity still present so matrix also has a role
• Dominant fracture trend NW-SE (N25-40W)
  ➢ Subsidiary set NE-SW
• Basement faults influence Permian salt dissolution and create monocline
• Left-lateral wrenching suggested
• New wells drilled at flanks of field suggest additional potential!
Colorado School of Mines
Niobrara Consortium

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