WELL CORE DESCRIPTION AND NATURAL FRACTURES OF THE SEGO AND CASTLEGATE SANDSTONES OF THE CRETACEOUS MESAVERDE GROUP, GREATER NATURAL BUTTES FIELD, UINTA BASIN, UTAH

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ABSTRACT

A detailed description of over 200 feet (61 m) of slabbed core from the Sego and Castlegate Sandstones (Upper Cretaceous Mesaverde Group) was conducted to identify and characterize depositional environments and natural fractures in Greater Natural Buttes field (GNB), Uinta Basin, Utah. GNB field lies in an area of gentle northwest dip on the southern flank of the basin. The field produces natural gas primarily from the Mesaverde Group and the Tertiary Wasatch Formation. GNB has produced over 2 TCF of gas from about 3750 wells.

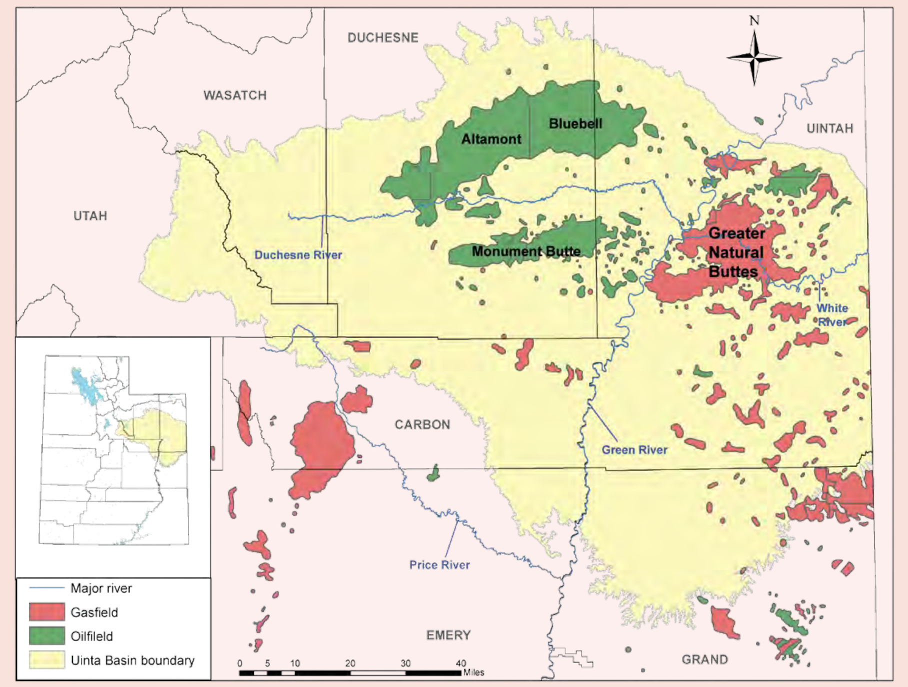
Most of the gas production is from highly compartmentalized, lenticular, channel sandstones in the upper portion of the Mesaverde Group. The Sego and Castlegate Sandstones in the lower portion of the Mesaverde typically have higher water saturation and are not typically productive, but have depositional and fracture characteristics similar to productive sandstones. Production in these tight-gas-sand reservoirs is achieved through massive hydraulic fracture treatments, so understanding the natural fracture systems and reservoir heterogeneity created by various depositional environments can aid in hydraulic fracturing optimization and lead to better drilling and completion strategies.

The Sego and Castlegate core was recovered from the Natural Buttes Unit (NBU) no. 253 well (section 10, T. 9 S., R. 21 E.). The well was initially completed in the Castlegate in a horizontal leg off the main bore hole, but due to low gas and high water volumes, the well was re-completed in Wasatch and upper Mesaverde sandstones in the vertical section. The cored interval was recovered from the vertical bore hole section.

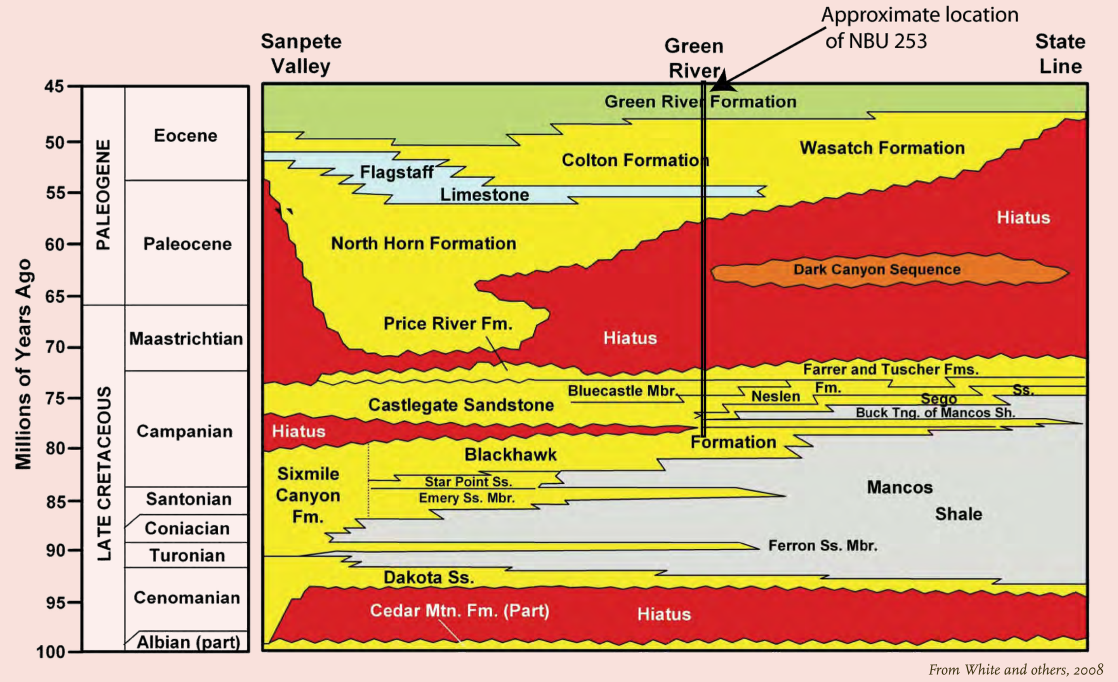
Core analysis shows that the Castlegate and Sego Sandstones have similar lithology and consist mostly of sandstone interbedded with black bioturbated and carbonaceous shale. Individual sandstones range from very fine to fine grained and have low-angle cross-bedding, small ripples, sparse burrows, and moderate bioturbation. The Castlegate was deposited in a marginal marine to lower coastal plain environment, whereas the Sego is a marginal marine deposit.

Twenty-six fractures were identified in core. Most are natural fractures between 2 and 9 inches (8 to 20 cm) long vertically, closed or slightly open with no discernable mineralization. Several appear to be drilling induced and are nearly vertical and very long (~ 2.5 ft [0.75 m]) with no mineralization. Portions of the core illustrating various depositional environments and fracture types will be available for viewing and discussion.

REGIONAL OVERVIEW

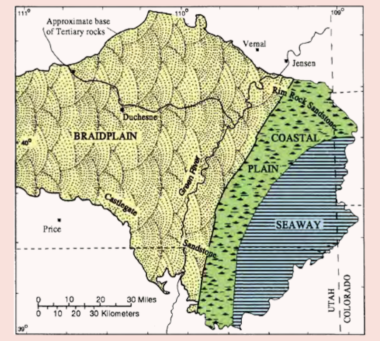


Location of Greater Natural Buttes Gas Field in the Uinta Basin, Utah.

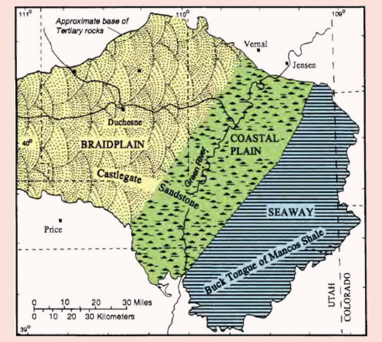


Stratigraphy of the Mesaverde Group in the Uinta Basin.

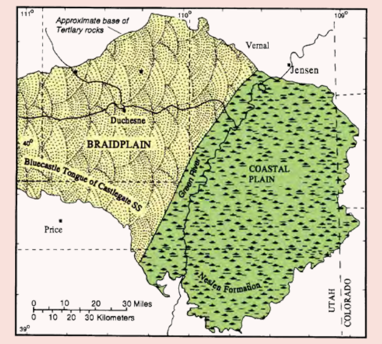
Paleogeography of the eastern Uinta Basin during the Late Campanian of the Late Cretaceous (modifed from Fouch and others, 1992).



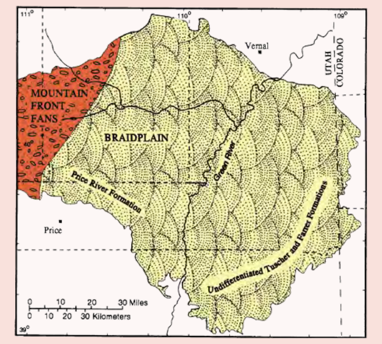
Deposition of the Castlegate Sandstone in a braided stream, lower coastal plain, and marginal marine environment.



Deposition of the Buck Tongue Member of the Mancos Shale in an offshore marine environment and the Sego Sandstone in a marginal marine environment.

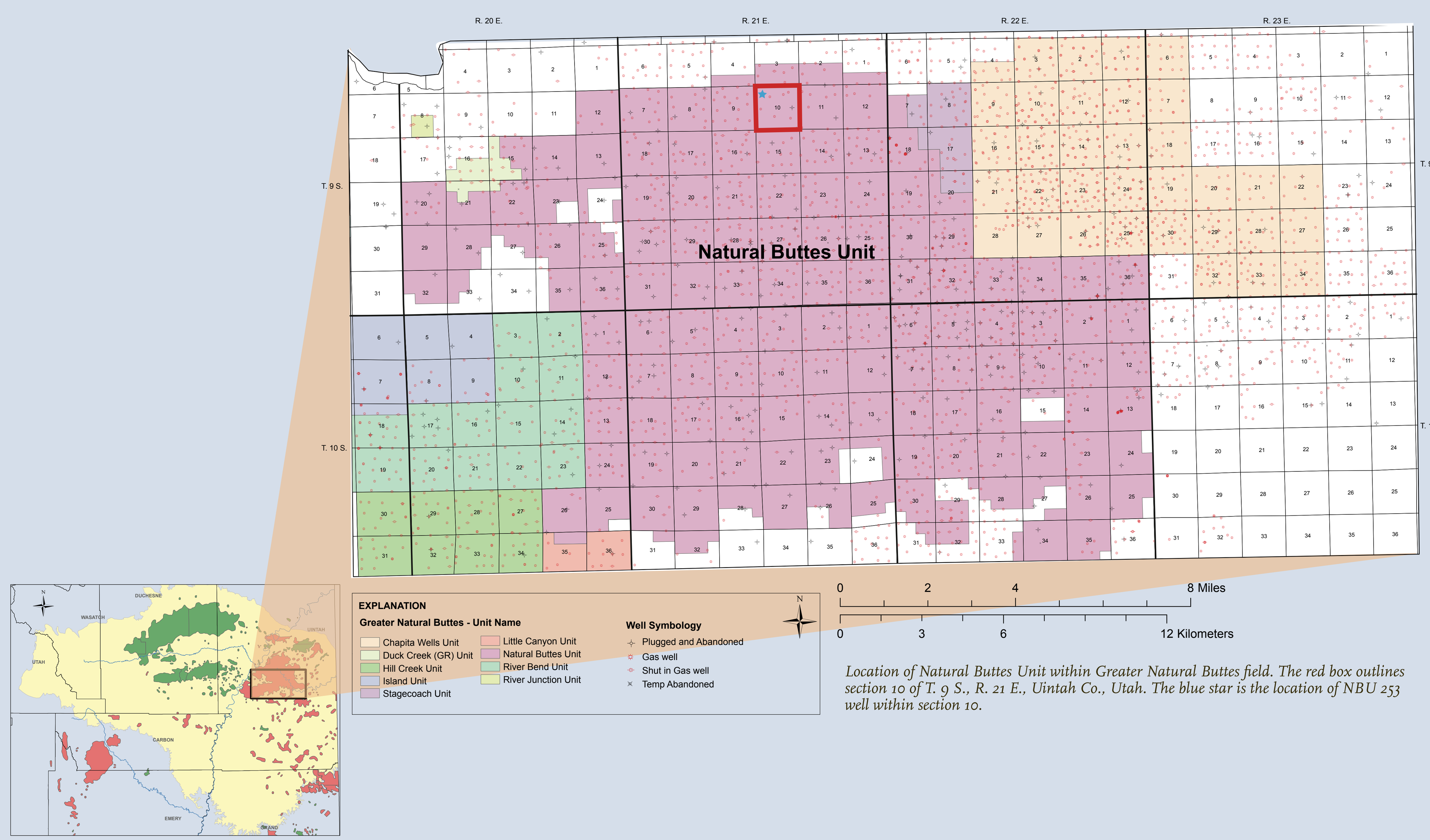


Deposition of the Neslen Formation in a coastal plain environment.



Deposition of the Farrer and Tuscher Formations in an alluvial plain environment.

GREATER NATURAL BUTTES FIELD GENERAL OVERVIEW



Location of Natural Buttes Unit within Greater Natural Buttes field. The red box outlines section 10 of T. 9 S., R. 21 E., Uintah Co., Utah. The blue star is the location of NBU 253 well within section 10.

Greater Natural Buttes Discovery Well Data

(Osmond, 1992; Utah DOGM, 2010)

Mesaverde Group

- Continental Oil Co. #1 Chapita Wells Unit (Sec. 16, T. 9 S., R. 23 E., Uintah Co., Utah)
- T.D. – 9517 ft (~ 2900 m)
- Completed – December 15, 1952
- Producing Reservoirs – Cretaceous Mesaverde Group
- IPF – 62 BOPD, 275 MCFGPD

Wasatch Formation

- Continental Oil Co. #2 Chapita Wells Unit (Sec. 28, T. 9 S., R. 23 E., Uintah Co., Utah)
- T.D. – 9125 ft (~ 2781 m)
- Completed – February 26, 1955
- Producing Reservoir – Tertiary Wasatch Formation
- IPF – 4,618 MCFGPD

Production Data

- Greater Natural Buttes field includes 13 individual units
- Production co-mingled Wasatch Formation and Mesaverde Group
- Currently Producing Wells – 3500
- Monthly Production (December 2009) – 189,651 BO & 18.3 BCFG
- Cumulative Production (as of December 1, 2009) – 15,310,852 BO & 2.02 TCFG
- Estimated Ultimate Recovery per well for co-mingled Wasatch-Mesaverde – 1.4 to 6 BCFG

General Reservoir Data

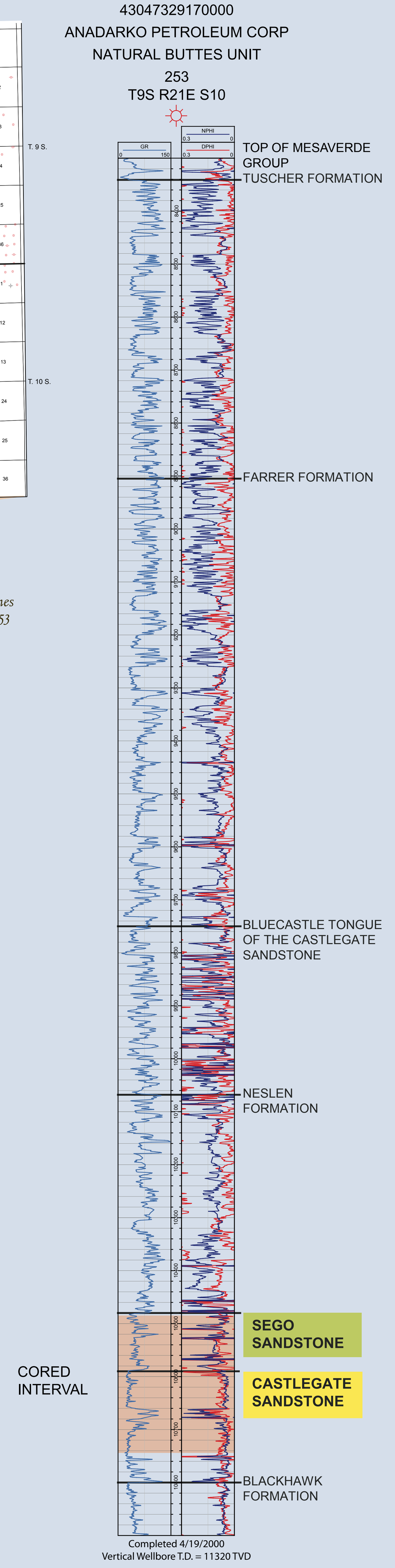
- Lithology:
  - Mesaverde Group - Fluvial and deltaic sandstones
  - Wasatch Formation - Fluvial sandstones
- Spacing – 40 acres
- Net Pay:
  - Mesaverde Group - Individual sand bodies up to 30 ft
  - Wasatch Formation - Individual sand bodies up to 40 ft
- Average Porosity (from core):
  - Mesaverde Group - 8.58%
  - Wasatch Formation - 8.75%
- Median Permeability (from core):
  - Mesaverde Group - 0.028 mD
  - Wasatch Formation - 0.095 mD
- Water Saturation:
  - Mesaverde - Average 50%
  - Wasatch - Average 45%
- Water Resistivity:
  - Mesaverde - 0.15 ohm/m
  - Wasatch - 0.1 to 0.15 ohm/m
- Type of Drive – Pressure depletion

Gas Characteristics

- Average BTU/cubic ft:
  - Mesaverde - 1114 (280 kg/cal)
  - Wasatch – 1088 (274 kg/cal)
- CO2 Content:
  - Mesaverde - < 2%
  - Wasatch - <0.5%

Mesaverde Group Characteristics

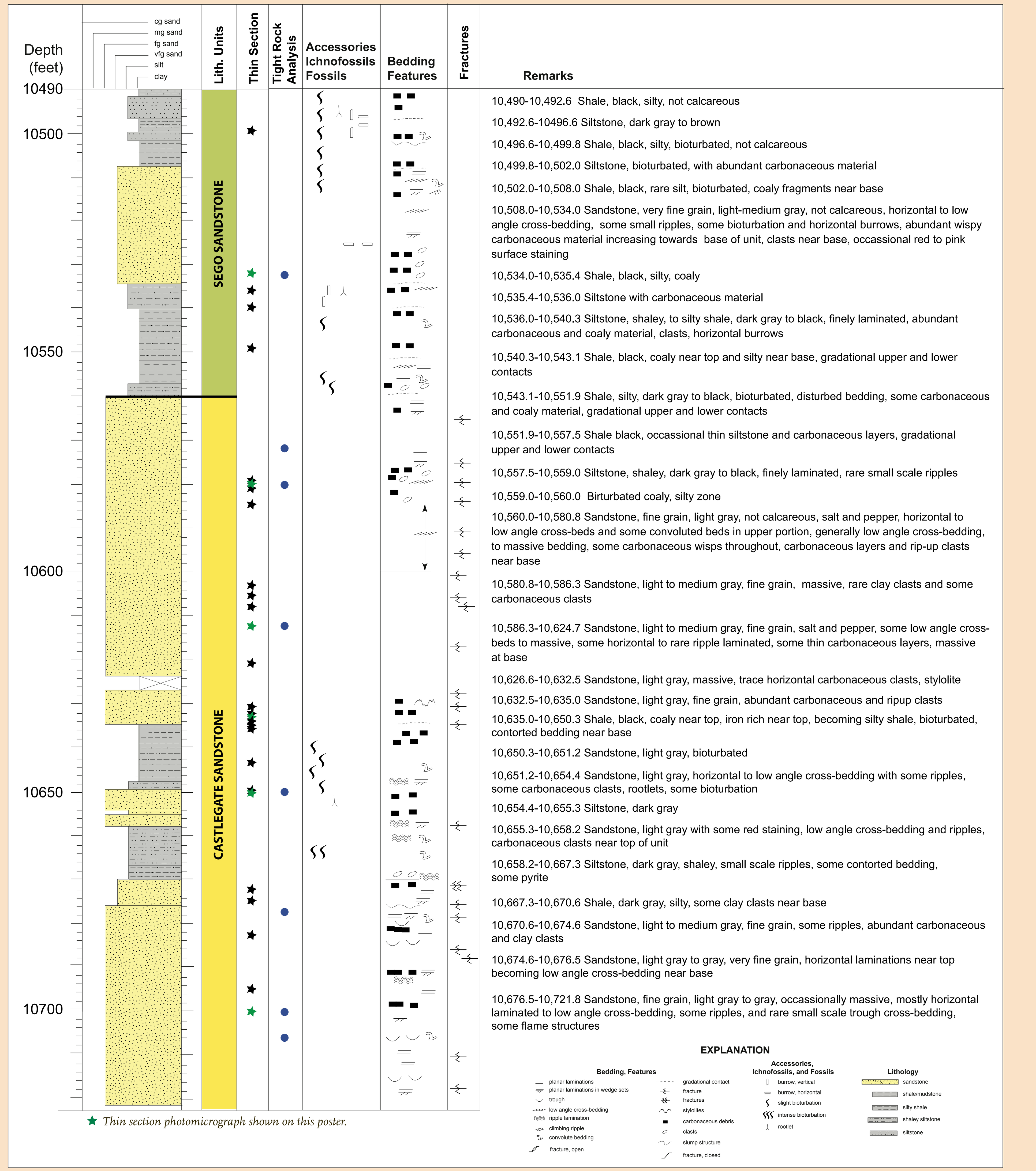
- Thickness - 2200 to 2900 ft
- Drill Depths to Base – 6000 to 12,000 ft
- Depositional Environments – Marginal marine at base to upper coastal plain and alluvial-plain deposits at top
- Reservoir Geometry – Stacked, lenticular channels with limited lateral extent.



Geophysical well log of the NBU 253 well, Greater Natural Buttes field, Uintah Co., Utah.

CORE DESCRIPTION OF NBU 253 WELL

API or Location Number 4304732917
Well or Location Name Natural Buttes Unit 253
Section 10 Township 9 S. Range 21 E.



★ *Thin section photomicrograph shown on this poster.*

Note: Core depth is -30ft from well log depth.

Lithology, Sedimentary Structures, and Petrology

Sego Sandstone

Highly bioturbated siltstone. (10,501 ft)

Bioturbated, fine-grained sandstone with carbonaceous, shaly laminations. (10,519 ft)

Bioturbated, carbonaceous shale. (10,553 ft)

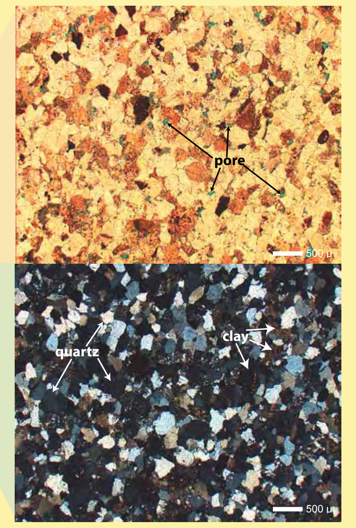
Bioturbated, siltstone with laminated shale above and below. (10,557 ft)

Pyrite nodule and carbonaceous clasts in sandstone. (10,559 ft)

Castlegate Sandstone

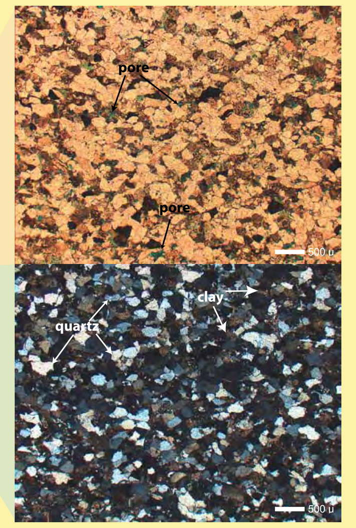
Fine-grained sandstone with cross-bedding. Sandstone has 5.69% porosity and 0.068 mD of permeability.(10,572 ft)

Fine-grained, laminated sandstone with slightly open, vertical, natural fracture. Sandstone has 5.13% porosity and 0.007 mD of permeability. (10,579.7 ft)



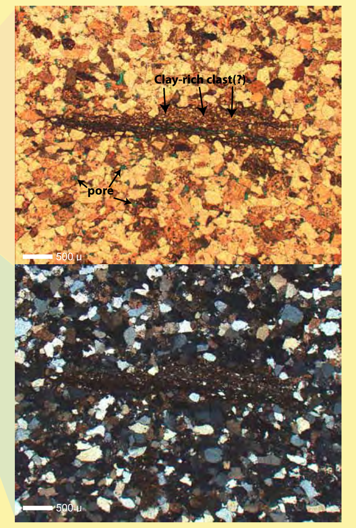
Thin section showing moderately sorted, sub-rounded to sub-angular quartz grains in a clay matrix.*

Massive, fine-grained sandstone with 5.74% porosity and 0.042 mD of permeability. (10,612 ft)



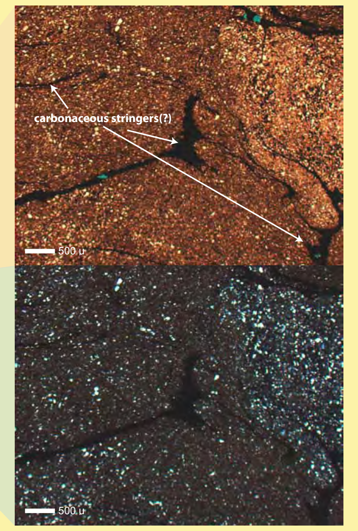
Thin section showing poorly sorted, sub-rounded to sub-angular quartz grains in a minor amount of clay matrix. Note lack of porosity.*

Fine-grained sandstone with rip-up clasts of red mudstone and carbonaceous shale. (10,633 ft)



Thin section showing clay-rich clast(?) surrounded by poorly sorted, sub-rounded to sub-angular quartz grains in a clay matrix. Note sparse porosity visible in top photo.*

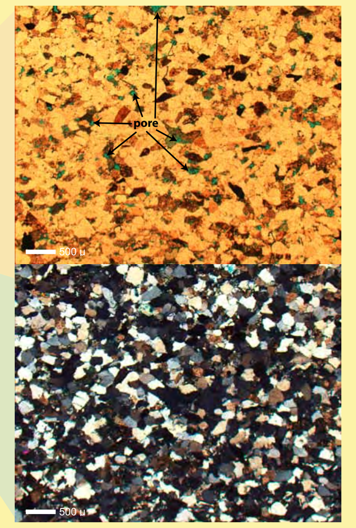
Bioturbated silty, sandstone with 3.88% porosity and 0.007 mD of permeability. (10,650.5)



Thin section showing moderately sorted, sub-rounded quartz grains in a clay matrix with carbonaceous(?) stringers. Note lack of porosity.*

Fine-grained sandstone with horizontal laminations. Sandstone has 5.43% porosity and 0.007 mD of permeability. (10,677 ft)

Very low-angle cross-beds in fine-grained sandstone. Sandstone has 5.72% porosity and 0.007 mD of permeability. (10,700 ft)



Thin section showing poorly sorted, sub-rounded to sub-angular quartz grains with sparse clay. Note more porosity than other samples.*

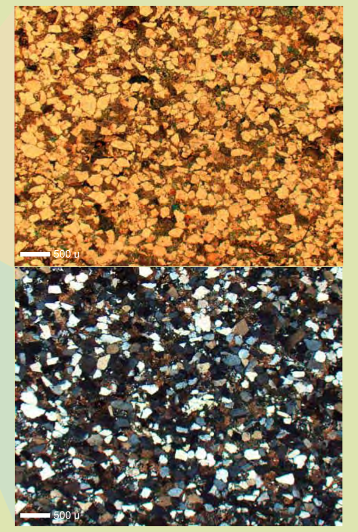
Convoluted bedding in fine-grained sandstone. Sandstone has 7.74% porosity and 0.054 mD of permeability. (10,706.5 ft)

*Note: Photomicrographs taken in plane(top) and cross polarized(bottom) light at 2.5 times magnification.

Fractures

Sego Sandstone

Open fracture in homogenous, fine-grained sandstone with slight iron(?) staining. Sandstone has 2.06% porosity. (10,532 ft)



Thin section showing poorly sorted, sub-rounded to sub-angular quartz grains in a clay matrix.*

Castlegate Sandstone

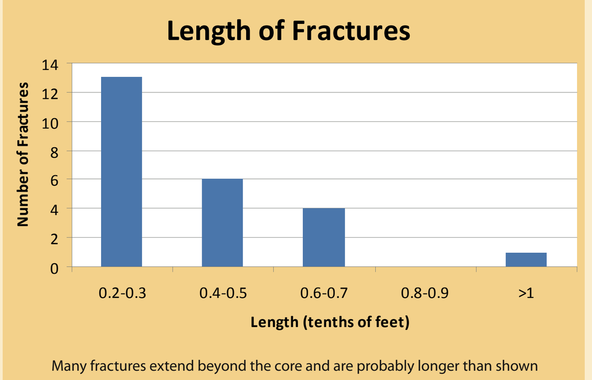
Open, vertical fracture in sandstone. No discernable mineralization in fracture. (10,590 ft)

Vertical, closed fracture offsetting laminated sandstone on left with massive sandstone on the right. Amount of offset is unknown. Fracture is offset at top by thin, carbonaceous laminae. (10,631 ft)

Fine-grained sandstone with high-angle cross-bedding and vertical natural fractures. Fractures are offset and slightly open with no discernable mineral fill. (10,718 ft)

Fracture #	Depth Top (ft)	Depth Base (ft)	Fracture Length (ft)	Orientation	Aperture	Mineral-ization?
1	10532.0	10532.2	0.2	Sub-vertical	Open	No
2	10565.7	10565.9	0.2	Sub-vertical	Closed	No
3	10575.5	10575.7	0.2	Sub-vertical	Closed	No
4	10579.4	10579.9	0.5	Vertical	Closed	No
5	10580.7	10581.2	0.5	Vertical	Open	No
6	10584.0	10584.6	0.6	Vertical	Closed	No
7	10584.8	10585.4	0.6	Sub-vertical	Closed	No
8	10590.0	10590.7	0.7	Vertical	Open	No
9	10596.1	10596.3	0.2	Vertical	Closed	No
10	10600.7	10600.9	0.2	Sub-vertical	Closed	No
11	10606.2	10606.5	0.3	Sub-vertical	Closed	No
12	10607.7	10607.9	0.2	Sub-vertical	Closed	No
13	10608.5	10608.7	0.2	Vertical	Open	No
14	10617.7	10617.7	0.2	Horizontal	Closed	No
15	10631.5	10631.9	0.4	Sub-vertical	Closed	No
16	10634.7	10634.9	0.2	Sub-vertical	Closed	No
17	10657.4	10657.9	0.5	Vertical	Closed	Possible
18	10671.7	10672.2	0.5	Vertical	Closed	No
19	10671.8	10672.0	0.2	Sub-vertical	Closed	No
21	10676.2	10676.4	0.2	Vertical	Closed	No
22	10679.1	10679.6	0.5	Vertical	Open	No
23	10686.3	10686.5	0.2	Vertical	Open	No
24	10688.0	10688.7	0.7	Vertical	Open	No
25	10711.5	10714.0	2.5	Vertical	Open	Yes
26	10718.0	10718.7	0.7	Vertical	Closed	No

Table of fractures from NBU 253 Well.



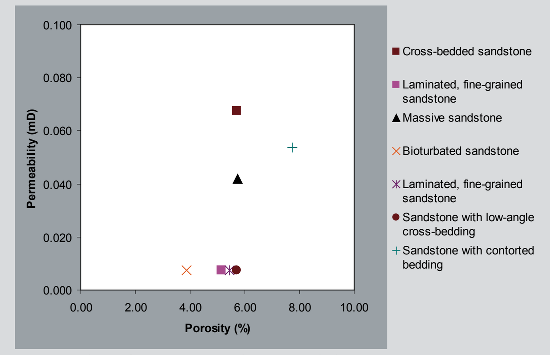
Bar graph showing the variation in vertical length of fractures

Tight Rock Analysis

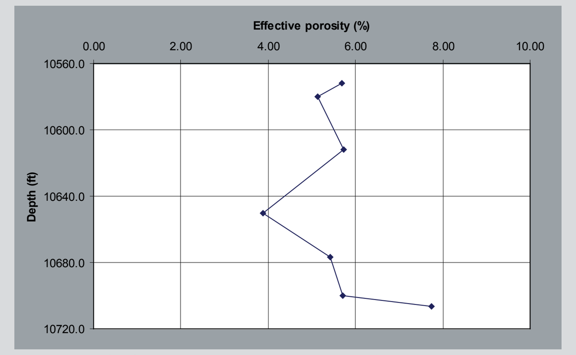
Sample ID	Sample Description	Depth (ft)	As Received Bulk Density (g/cc)	As Received Grain Density (g/cc)	Dry Grain Density (g/cc)	Effective Porosity (% of BV)	Water Saturation (% of PV)	Gas Saturation (% of PV)	Mobile Oil Saturation (% of PV)	Gas Filled Porosity (% of BV)	Bound Hydrocarbon Saturation (% of BV)	Bound Clay Water (% of BV)	Steady-State Permeability (mD)
1	Fine-grained sandstone with fracture	10532.0	2.655	2.705	2.710	2.06	2.86	88.55	8.59	1.82	0.07	2.80	162.238***
2	Cross-bedded sandstone	10572.0	2.518	2.660	2.667	5.69	2.13	93.79	4.09	5.34	0.09	0.74	0.068
3	Laminated, fine-grained sandstone	10580.0	2.535	2.667	2.671	5.13	0.18	96.53	3.28	4.95	0.07	0.83	0.007
4	Massive sandstone	10612.0	2.513	2.657	2.663	5.74	1.62	94.33	4.05	5.41	0.00	0.51	0.042
5	Bioturbated, sandstone	10650.5	2.562	2.653	2.662	3.88	4.88	89.03	6.09	3.45	0.00	2.65	0.007
6	Laminated, fine-grained sandstone	10677.0	2.538	2.676	2.682	5.43	0.86	94.81	4.32	5.15	0.00	0.42	0.007
7	Low-angle cross-bedding in sandstone	10700.0	2.533	2.677	2.684	5.72	2.46	94.59	2.95	5.41	0.07	0.75	0.007
8	Sandstone with contorted bedding	10706.5	2.477	2.670	2.681	7.74	3.66	93.38	2.96	7.23	0.00	0.82	0.054

*** Sample contained artificial induced fracture

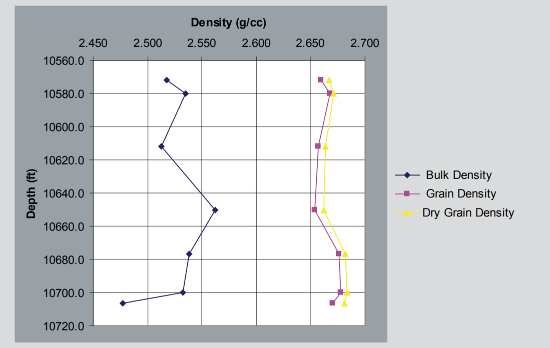
Tight Rock Analysis Results



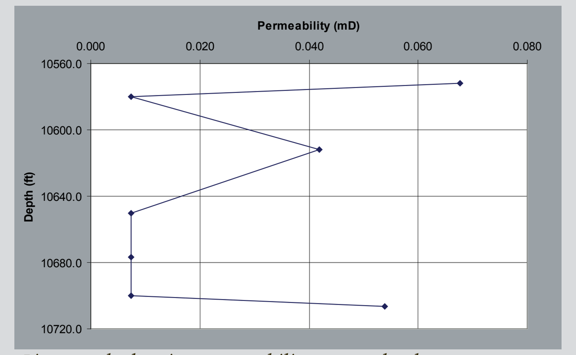
Cross plot of porosity and permeability



Line graph showing porosity versus depth



Line graph showing density versus depth



Line graph showing permeability versus depth

Summary

- The Upper Cretaceous Mesaverde Group was deposited in Campanian time in offshore marine, nearshore marine, coastal plain, and braided stream environments during the last phase of the Cretaceous Interior Seaway.
- The GNB field produces co-mingled gas from tight sandstones of the Tertiary Wasatch Formation and Cretaceous Mesaverde Group. As of December 2009, over 2 TCF of gas has been produced from over 3500 wells.
- Study of core from the Natural Buttes Unit 253, shows that the Castlegate and Sego Sandstones (lower Mesaverde Group) are mostly sandstones interbedded with carbonaceous siltstone and shale. Individual sandstones range from very fine to fine grained and have low-angle cross-bedding, small ripples, sparse burrows, and moderate bioturbation. At this location, the Castlegate was deposited in a marginal marine to lower coastal plain environment, whereas the Sego is a marginal marine deposit.
- Twenty-six fractures were identified in the core. Most are natural fractures between 2 and 9 inches (8 - 20 cm) long vertically, closed or slightly open with no discernable mineralization. Several appear to be drilling induced and are nearly vertical and very long (~2.5 ft [0.75 m]) with no mineralization.
- Tight Rock Analysis shows that the Castlegate and Sego Sandstones have low porosity (2.06 to 7.74%) and low permeability (0.007 to 0.068 mD).

Acknowledgments

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