The History of Oil and Gas Development in the Denver Basin*

Debra K. Higley¹

Search and Discovery Article #70187 (2015)**
Posted September 21, 2015

*Adapted from presentation at History of Petroleum Geology Forum, 2015 AAPG Convention & Exhibition, Denver, Colorado, May 31, 2015

Abstract

The Denver Basin encompasses an area of about 70,000 square miles in eastern Colorado, southeastern Wyoming, and western Nebraska. More than 1.3 billion barrels of oil, 7.4 trillion cubic feet of natural gas, and 3.6 million barrels of water have been produced from more than 47,000 wells across the basin. Petroleum production is from Mississippian through Upper Cretaceous strata. The first oil well in the basin was completed in 1881 in the Upper Cretaceous Pierre Shale in the Florence field, the oldest active oil field in the United States. Depths of production across the basin vary from less than 900 feet (270 meters) from the Pierre Shale in the Florence field to about 10,000 feet (3048 meters) in Lower Cretaceous Muddy (J) Sandstone in the Wattenberg field. Focus of conventional production in the basin is the Muddy (J) Sandstone. There is scattered Paleozoic conventional production along the borders of the basin, in Nebraska, Lincoln County in southeast Colorado, and structural traps along the northern boundary of the Wattenberg field. Knowledge of petroleum source rock(s) and resources for Paleozoic strata within the basin are limited by lack of deep drilling; oil and gas in Mississippian and Pennsylvanian units in Lincoln County may have been sourced from Paleozoic strata of the Denver Basin, or migrated westward from the Anadarko Basin. Unconventional, primarily horizontal oil and gas wells are concentrated in the Wattenberg field area of the deep basin; production from low-permeability sandstones of the Muddy (J) began in 1970. Exploration and production from tight calcareous shale of the Upper Cretaceous Niobrara Formation was initiated in the early 1900s in the basin, accelerated in the early 1980s, and continues to expand outward from the Wattenberg field, particularly to the northeast. Unconventional sweet spots are concentrated in an area of elevated basement heat flow that enhanced oil and gas generation from bounding organic-rich shales and the Niobrara Formation.

Selected References

Carpenter, L.C., 1961, Florence-Canyon City field, *in* J.M. Parker, editor, Colorado-Nebraska oil and gas field volume: Rocky Mountain Association of Geologists (RMAG) volume, p. 130–131.

Fritz, M., 1990, Something old, something new: AAPG Explorer, July 1990, p. 1, 12, 13.

^{**}Datapages © 2015 Serial rights given by author. For all other rights contact author directly.

¹Energy Science Center, USGS, Lakewood, Colorado, United States (<u>higley@usgs.gov</u>)

Higley, D.K., and D.O. Cox, 2005, Oil and Gas Exploration and Development along the Front Range in the Denver Basin of Colorado, Nebraska, and Wyoming (Chapter B): USGS Professional Paper 1698, Chapter B. Website accessed August 31, 2015, http://pubs.usgs.gov/pp/2005/1698/508/chapB.html#heading128618824

Higley, D.K., D.O. Cox, and R.J. Weimer, 2003, Petroleum system and production characteristics of the Muddy (J) Sandstone (Lower Cretaceous) Wattenberg continuous gas field, Denver basin, Colorado: AAPG Bulletin, v. 87/1, p. 15–37.

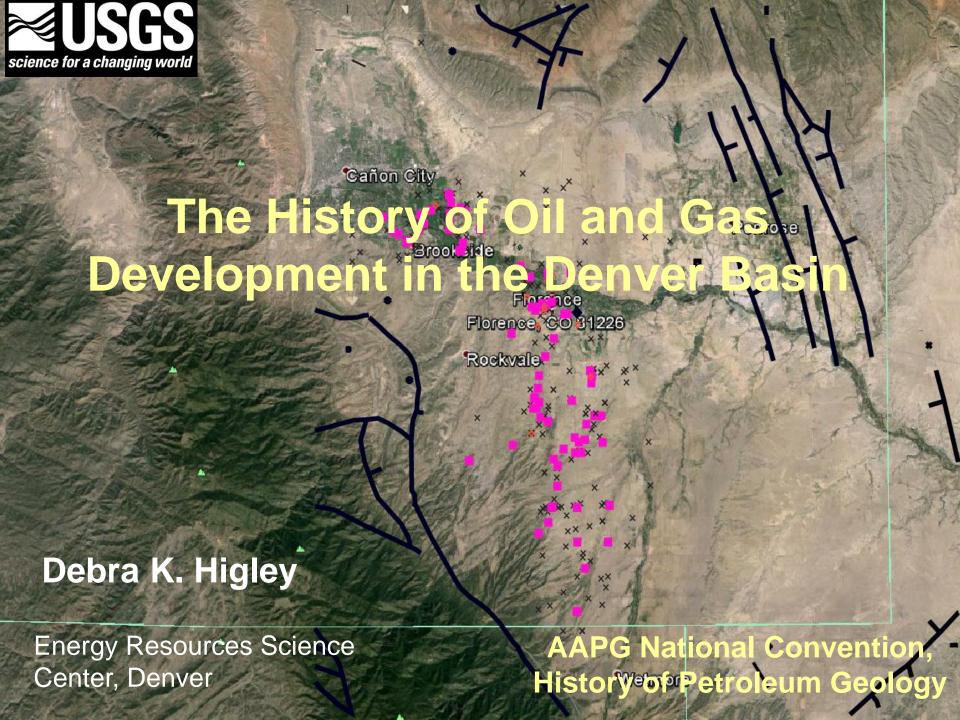
Kupfer, D.H., 1999, Colorado's early oil happenings—Florence oil field: The Outcrop (RMAG newsletter), v. 48/6, p. 7,9.

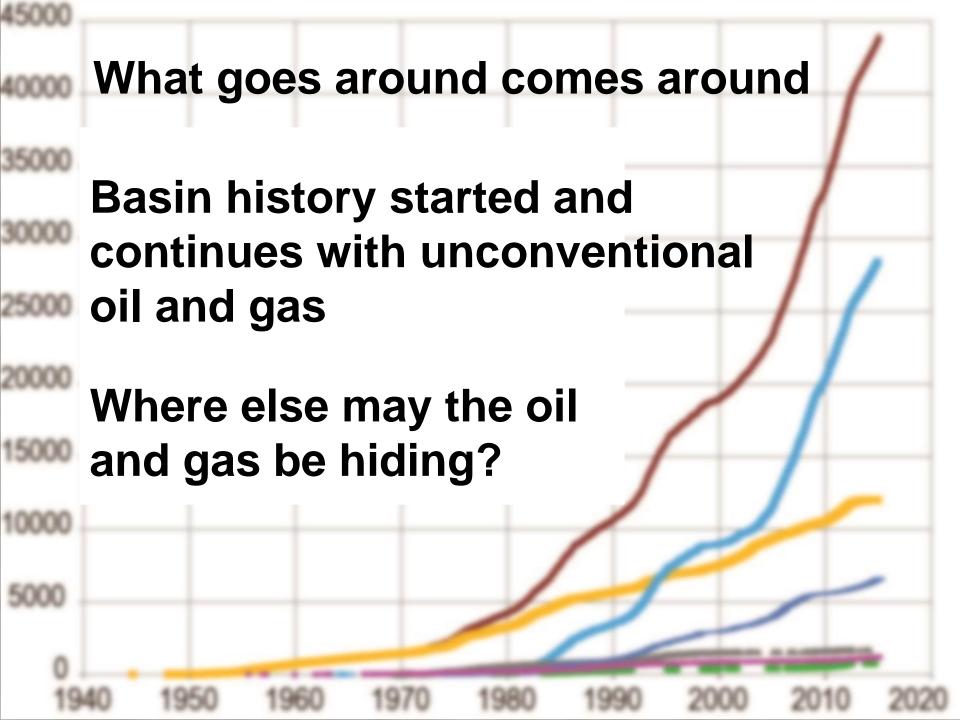
Lillis, P.G., M.P. Dolan, A. Warden, and J.D. King, 1998, Organic geochemistry of oils from Oil Spring and Florence oil field near Canon City, Colorado: U.S. Geological Survey Open-File Report 98–617, 20 p.

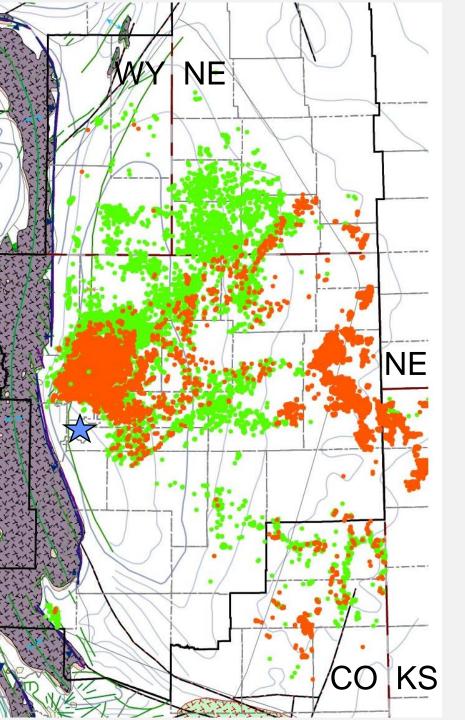
Pollastro, R.M., 1992, Clay minerals as geothermometers —Indicators of thermal maturity for hydrocarbons, *in* L.B. Magoon, editor, The Petroleum System—Status of Research and Methods, 1992: U.S. Geological Survey Bulletin 2007, p. 61–65.

RMAG, 2014, Tectonic GIS Data from the Geological Atlas of the Rocky Mountain Region: RMAG, Denver, CO.

Smagala, T.M., C.A. Brown, and G.L. Nydegger, 1984, Log-derived indicator of thermal maturity, Niobrara Formation, Denver Basin, Colorado, Nebraska, Wyoming, *in* J. Woodward, F.F. Meissner, and J.L. Clayton, editors, Hydrocarbon Source Rocks of the Greater Rocky Mountain Area: RMAG, p. 355–363.







Denver Basin

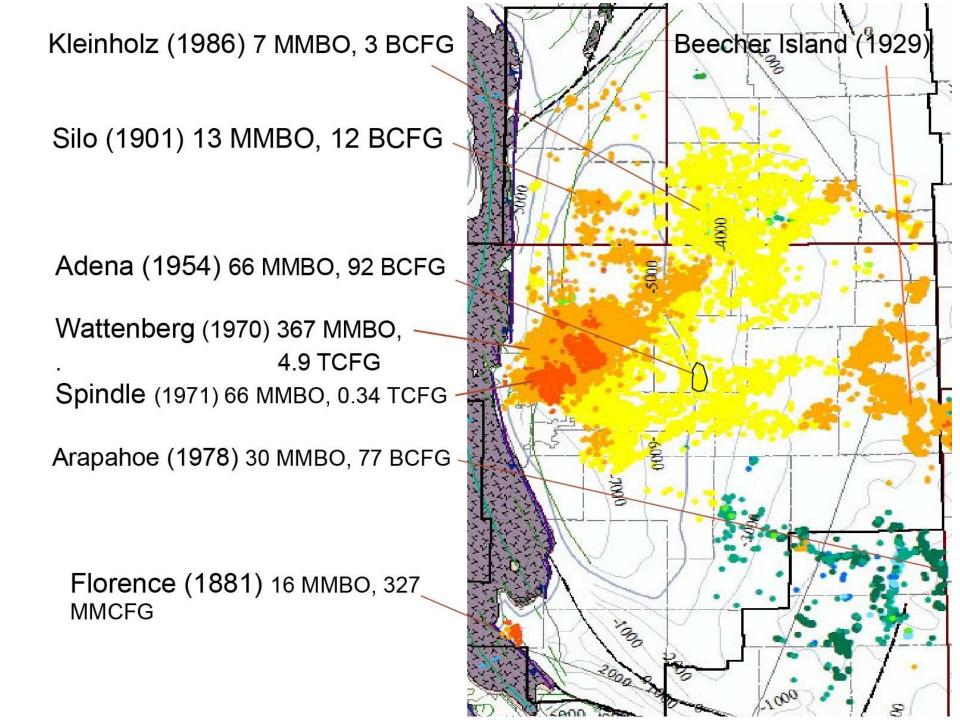
- Laramide foreland basin, west basin axis
- Mainly Cretaceous & also Paleozoic oil, gas
- Conventional and unconventional
- ✓ Thermogenic and biogenic
- ✓ Florence field (1881)
- ✓ Wattenberg, Spindle

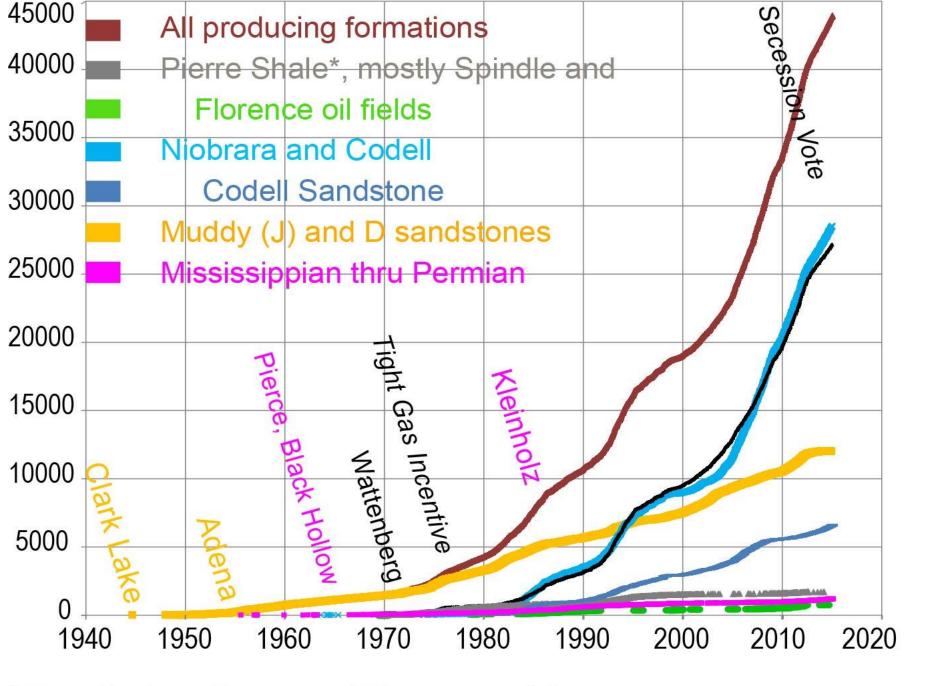
RMAG Tectonic GIS (2014); IHS Energy (2015)

Oil and Gas Production

- Cumulative ~1.5 BBO, 8.4 TCFG, 4.1 BBW from +53,000 oil and/or gas wells¹
- 104 MMBO, 2.5 TCFG, 52 MMBNGL Mean remaining undiscovered resources²
- Miss thru Permian: 174 MMBO, 0.37 TCFG
- D and Muddy (J): 895 MMBO and 3.3 TCFG
- Niobrara Sh³, Codell Ss: 416 MMBO and 4.2 TCFG
- Pierre Shale: 72 MMBO, 0.45 TCFG







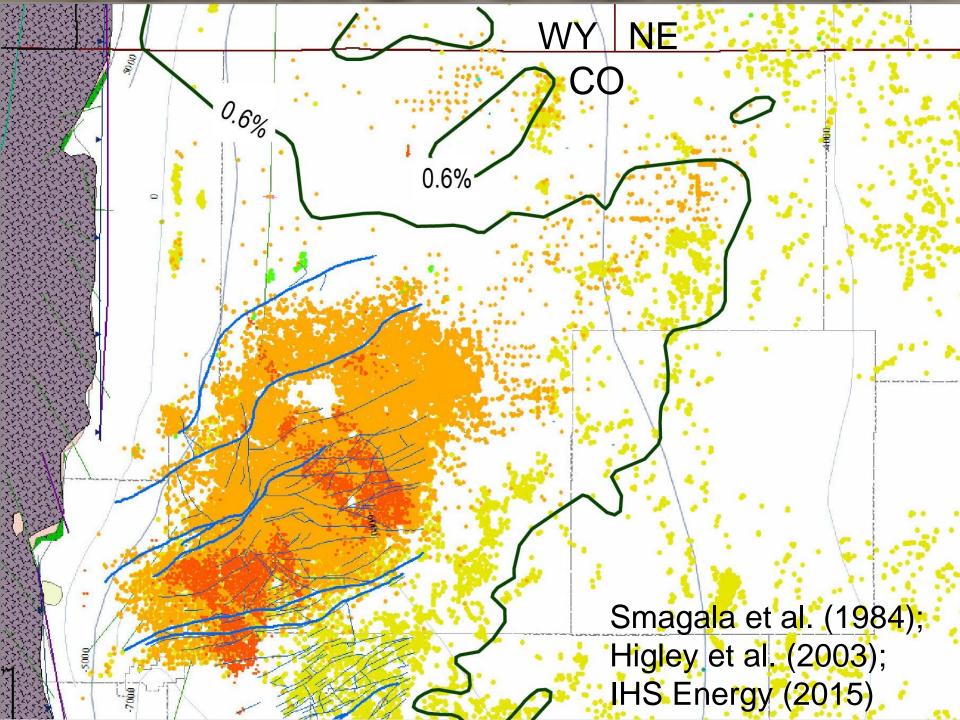
^{*} Terry, Hygiene, Sussex, and Shannon sandstones

What goes around - in 1881

- Florence (1881) is the oldest oil field in the US1
- Discovery followed the 1862 oil show in a water well, named and sold as the Oil Springs well. In1864 oil sold for up to \$5 a gallon (Fritz, 1990).
- Produced was more than 16 MMBO, 327 MMCFG²
- From... fractured Upper Cretaceous Pierre Shale.

Sourced from ... Upper Cretaceous Niobrara Formation (Pollastro, 1992) and/or Lower or Upper Cretaceous shales (Lillis et al., 1998)

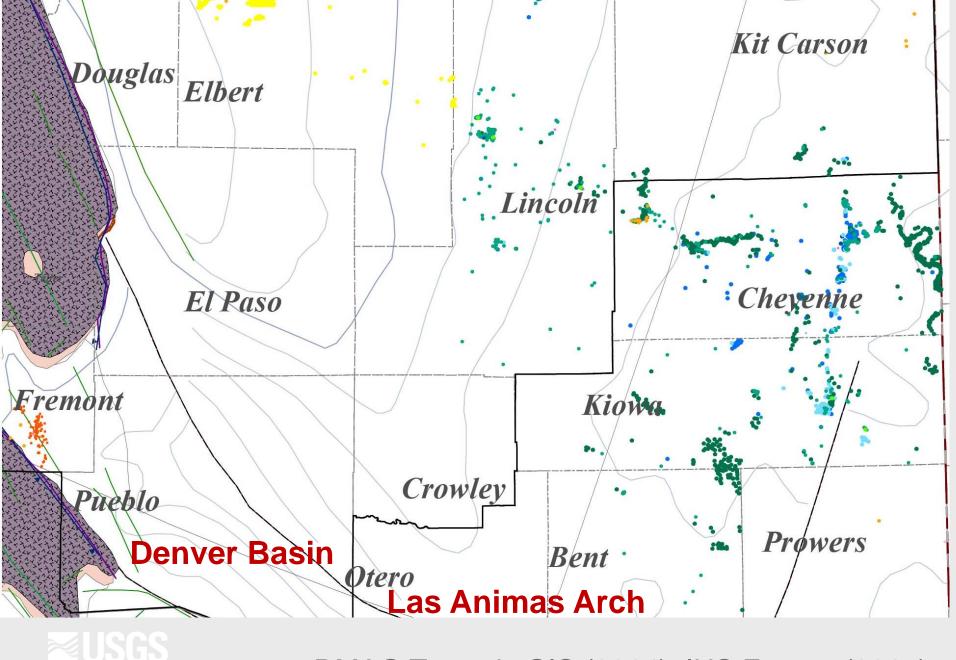
> ¹Carpenter (1961), Kupfer (1999) ²IHS Energy (4/15), 14.5 MMBO estimated



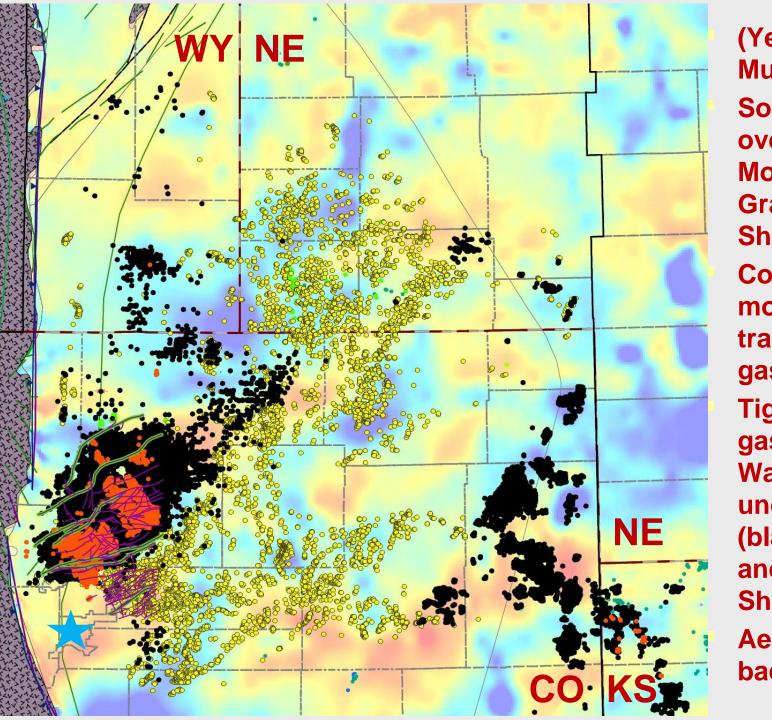
History of Oil and Gas in the Basin

- Started in 1881 with the Florence Field
- Major up- and downturns in exploration
- Cumulative ~1.5 BBO, 8.4 TCFG, 4.2 BBW from +53,000 oil and/or gas wells
- Mainly Cretaceous production, but Paleozoic and basin areas are underexplored





RMAG Tectonic GIS (2014); IHS Energy (2015)



(Yellow) D and Muddy (J) Ss **Source rocks** overlying **Mowry and Graneros Shales Conventional** mostly strattrapped oil and gas Tight Muddy (J) gas in the Wattenberg field under the (black) Niobrara and (red) Pierre Shale prod.

Aeromagnetic background