geoconvention
Calgary • Canada • May 15-17 2023

Expanding the Giant: A Review of the Hugoton Area's Gas Fields' First 100 Years of Development in the Permian's Hydrocarbon-Helium Gas System.

Author information – Matthew, R, Fox
Affiliation – Fox Bros Energy LLC

Summary

Historical Context

The Hugoton and Panhandle Gas Fields' and their satellite extensions' ("The Hugoton"), produce low BTU (850-1050) dry gas enriched with economic helium concentrations (economic helium concentrations span 0.25 – 2.5% of the total gas by volume) predominantly from the shallow Permian reservoirs that extend across Southwest Kansas and further southward into the panhandles of Oklahoma and Texas (BLM). The Hugoton was originally discovered in Seward County, Kansas during December of 1922, but it wasn't until May of 1927 that the Hugoton Field was truly identified and subsequently became important (Hemsel 1939; Pippin 1968). Since the 1922 discovery well, the Hugoton has produced somewhere between 50-70 TCF of natural gas commingled with between 250 to 400 BCF of helium gas; the processed crude helium recovered volumes total to approximately 120 BCF (Bureau of Mines - AMY 1967-1993; BLM/USGS MCS 1991-2022). Although a century has passed and over 18,000 wells have been drilled to date, the Hugoton continues to capture roughly 1.2 BCF of helium annually (20% of current annual global production market) from 300-500 BCF of gross commercial natural gas, per year, which is remarkable for any gas field providing 100 years of consecutive depletion.

Geologic Context

The Hugoton's prolific primary gas reservoir, the Chase Group, was deposited during the Early Permian as cyclic platform and shelf carbonates across the vast shallow marine low relief Hugoton Embayment, a northwest extension to the Ancestral Anadarko Basin (Mazzullo, 1996). The Hugoton Embayment's shallow marine carbonate-dominated platform was bordered to the North and West by siliciclastic terrestrial facies that covered the entire area during episodes of relative lowstands of sea level (Rascoe, 1988; Johnson, 1989; Caldwell, 1991; Mazzullo, 1996; Olson, Babcock, and Wagner, 1996; Sorenson, 2005; Dubois et al., 2006). From detailed well-log analysis, it is apparent that the Chase Group's lowstand terrestrial accumulations' interfinger both laterally and vertically with the main field's shallow marine carbonate facies, around the northern and western Hugoton Field boundary (Mazzullo,1996; Dubois et al., 2006). These internal depositional facies boundaries offer vertical and lateral permeability contrasts, which in return segregates migratory reservoir fluids across the boundary and subsequently redistributes their relative fluid saturations within the reservoir. Essentially, by delineating and characterizing each reservoir's internal depositional facies boundary and then comparing production results across the facies boundary, it is apparent that a Chase Group reservoir's internal marine-terrestrial boundary (shoreline) has propensity to enhance and/or diffract internal permeability gradients between terrestrial and marine reservoir facies within in the same stratigraphic flow unit (Olson et al., 1996; Sorenson, 2005), which has profound economic consequences to development of stranded reserves in a vintage gas field, like the Hugoton. Similarly, the consistency of the gas

partitioning in each separately defined field has implications on timing of helium charge to the hydrocarbon-petroleum system.

Scope of Study

1) demonstrate the economic significance of the Hugoton's stratigraphic sealing units across the Hugoton Field and how these sealing layers and their unique burial history are integral to identifying the subregional gas compartmentalization overprinting the primary Chase group's reservoirs' productivity

2) characterize a typical 640 acre section's primary development on the perimeter of the Hugoton in terms of the reservoirs lateral/vertical extent/geometries and saturation parameters, highlight contrasts with that of typical Hugoton

3) observe a schematic depiction of a Bradshaw Field's primary development infill wells' cost and uplift efficiency in the primary reservoir, contrasted to those in the Hugoton-Panoma Fields.

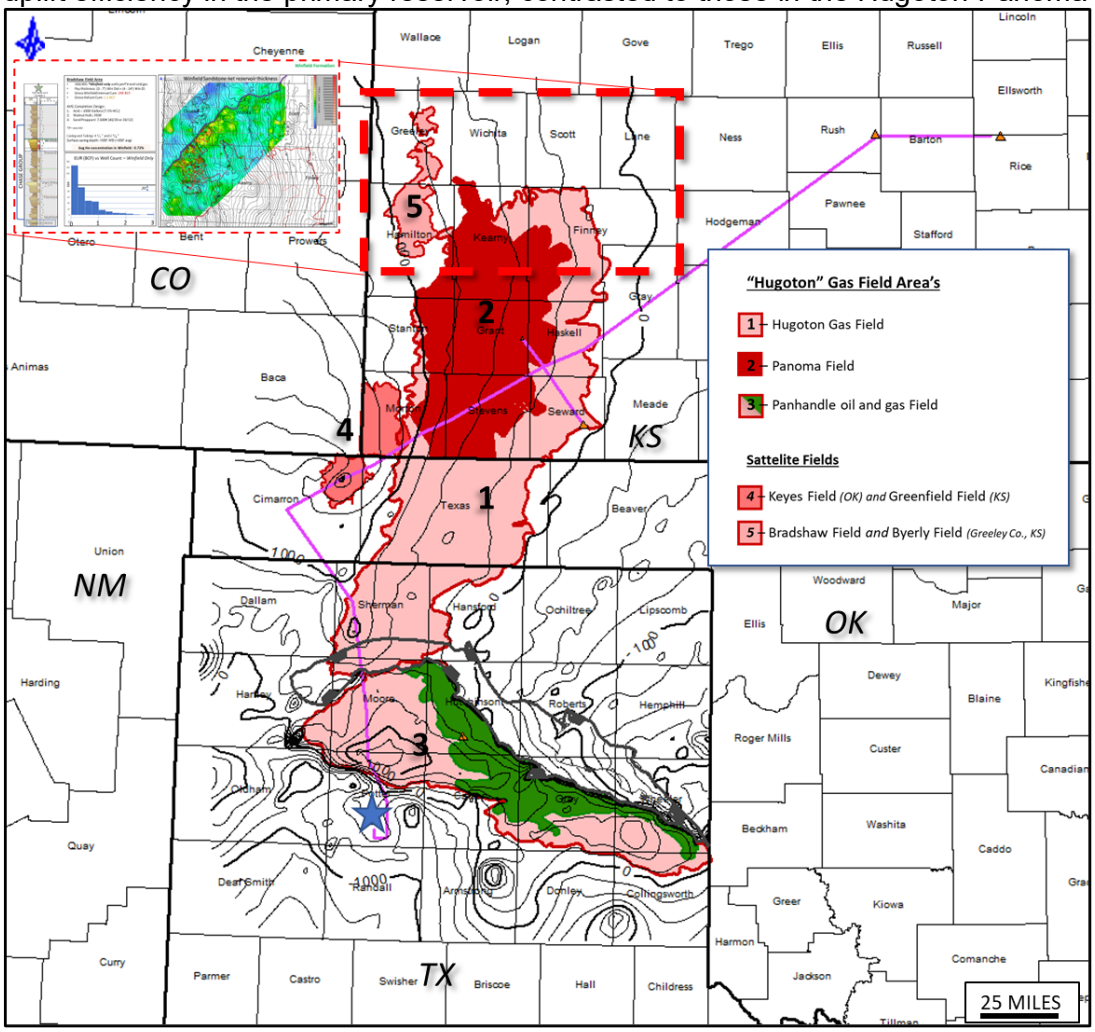

Figure – Map showing Hugoton-Panhandle Gas Fields distribution. Structure contours on top of Chase Group with a contour interval of 250 feet, 1000 feet bold contour interval. Red shaded regions are natural gas and helium productive, green is oil (unique to Panhandle Field) Pink line highlights Federal Govt's BLM Pipeline, starts at Bush Dome/Cliffside Reserve (blue star) in Potter

Co., TX and ends in Rice County ,KS. 425 miles of pipeline and infrastructure that define the skeleton of the world's Helium Corridor. The area outlined in the red dashed line is the area of investigation.

Theory / Method / Workflow

Detailed sequence stratigraphic correlation/mapping of reservoir/flow units and integrating their engineering history to understand how the helium commingled natural gas reservoir is most economically exploited. More specifically, this study will show a well-defined subfield in one of the Hugoton's northwest satellite fields, the Bradshaw Field. The goal is to apply the detailed stratigraphic well-log analysis to the engineering results, to observe which reservoir parameters and completion techniques are driving well economics in the Permian's Chase Group's natural gas and helium gas reservoirs.

Results, Observations, Conclusions

From the limitless historical data publicly available, as well as the robust literature review dating back to the 1920s, the Hugoton Field provides a centuries worth of development in petroleum systems analysis and petroleum detection/exploitation technologies. However, operators lost interest in helium and the low btu natural gas after the Federal Helium Reserve was filled with more than 40 billion cubic feet of gas in the early 1970s and new technologies were discovering new ways and areas to exploit natural gas more efficiently. By integrating the results, observations, and conclusions of the Hugoton's initial exploration and developments prior to the 1970s, with modern geo-analytical techniques (sequence stratigraphy, plate tectonics, salt tectonics etc.) allows for a more granular understanding of the Hugoton's northern satellite fields, which were beginning to be developed in the late 1950s and early 1960s. The US has been the global leader in helium, as 149 billion cubic feet have been produced, processed, and marketed in the US alone, and the world has collectively (US included) only marketed 189 billion cubic feet of helium, as of 2022 (Bureau of Mines - AMY 1967-1993; BLM/USGS MCS 1991-2022). Taking a closer look at the fields' most responsible for America's share of helium and understanding their development history provides context for the exploration and discovery of the most economic recovery methods for helium, as proven by the Bureau of Land Management with their Helium Reserve and that filling process. More specific to geo-analysis, this study will observe the coincident correlation of facies changes within both the reservoirs and their overlying seals, with their relative fluid saturation compositions, between the Hugoton and its northern satellite fields.

Novel/Additive Information

Regardless of a defined trapping mechanism or newly refined petroleum systems timing analysis, which are both critically important concepts to understanding and predicting any reservoir's saturation/economic potential, the Hugoton fields' production purports that the Permian Chase Group's economically viable gas reservoirs are available either in the high-stand marine reservoirs' or in their northwesterly correlative lowstand terrestrial and marginal marine reservoirs'; therefore delineating their internal stratigraphic marine-terrestrial boundaries' (shorelines) have profound economic consequences on planning new drills' or field infill wells' locations and their associated completion styles'.

Acknowledgements

BLM/DOI
AAPG
KGS/WDL
KGS.KU.EDU
Bandit Exploration
Geoscience and Petroleum Research Inc.

References

Babcock, J. A., T. M. Olson, K. V. K. Prasad, S. D. Boughton, P. D. Wagner, M. H. Franklin, and K. A. Thompson, 2001, Reservoir characterization of the giant Hugoton gas field, Kansas, in K. S. Johnson, ed., Pennsylvanian and Permian geology and petroleum in the southern mid-continent, 1998 symposium: Oklahoma Geological Survey Circular 104, p. 143–159.

Buchanan R.S., Kiowa County, Colorado: Pre-Permian Handbook of the Hugoton Embayment, Liberal Geological Society – 1956, p. 7-10.

Caldwell, C. D., 1991, Cyclic deposition of the Lower Permian, Wolfcampian Chase Group, western Guymon-Hugoton field, Texas County, Oklahoma, in W. L. Watney, A. W. Walton, C. D. Caldwell, and M. K. Dubois, eds., Midcontinent core workshop—integrated studies of petroleum reservoirs in the midcontinent: Lawrence, Kansas, Kansas Geological Survey, p. 57–80.

Dubois, M. K., A. P. Byrnes, G. C. Bohling, and J. H. Doveton, 2006, Multiscale geologic and petrophysical modeling of the giant Hugoton gas field (Permian), Kansas and Oklahoma, U.S.A., in P. M. Harris and L. J. Weber, eds., Giant hydrocarbon reservoirs of the world: From rocks to reservoir characterization and modeling: AAPG Memoir 88/SEPM Special Publication, p. 307 – 353.

Foster R.J., Clarke T.G., Tully P.C., Davis C. L., Leachman W. D., Balazik R. F., Koelling G. W., Thomasson E. W., Moore B. J., Bureau of Mines, Mineral Yearbooks 1967-1993: Metals and Minerals 19xx, Volume I Year 1967-1993: Helium. University of Wisconsin Ecology and Natural Resources Collection URL:http://digicoll.library.wisc.edu/EcoNatRes/ (accessed January 3, 2022).

Hemsell, C. C, 1939, Geology of Hugoton gas field of southwestern Kansas: Am. Assoc. Petroleum Geologists Bull., v. 23, no. 7, p. 1054-1067.

Johnson, K. S., 1989, Geologic evolution of the Anadarko basin, in K. S. Johnson, ed., Anadarko basin symposium: Oklahoma Geological Survey Circular 90, p. 3–12.

Mazzullo S. J., 1996, Stratigraphic Architecture of Lower Permian, Cyclic Carbonate Reservoirs (Chase Group) in the Mid-Continent USA, Based On Outcrop Studies: AAPG Bulletin, V. 82, No. 3 (March 1998), P. 464–483.

Olson T. M., Babcock J. A., Wagner P. D., 1996, Geologic Controls on Reservoir Complexity, Hugoton Giant Gas Field, Kansas: Copyright © TGS, 2006 – Transactions of the 1995 AAPG Mid-Continent Section Meeting, 1996.

Peterson J. B., Pacheco N., Hamak J. E., Thomas D. S., Hayes, Jr. D. V., Madrid P. J., Helium: Bureau of Land Management and U.S. Geological Survey, Mineral Commodity Summaries ("MCS") – Helium, January 1996 – 2022. URL:https://www.usgs.gov/centers/national-minerals-information-center/helium-statistics-and-information (accessed January 3, 2022).

Pippin, L., 1970, Panhandle-Hugoton Field, Texas-Oklahoma-Kansas—the First Fifty Years, in M. T. Halbouty, ed., Geology of giant petroleum fields: AAPG Memoir 14, p. 204–222.

Rascoe Jr., B., 1968, Permian system in western mid-continent: The Mountain Geologists, v. 5, no. 3, p. 127–138.

Rascoe Jr., B., 1988, Permian system in western mid-continent, in W. A. Morgan and J. A. Babcock, eds., Permian rocks of the midcontinent: Midcontinent SEPM Special Publication 1, p. 3–12.

Sorenson, R. P., A dynamic model for the Permian Panhandle and Hugoton fields, western Anadarko basin: AAPG Bulletin, v. 89, no. 7 (July 2005), pp. 921–938.

Wagner, C. R., 1955, The Keyes Gas Field, Cimarron County, Oklahoma: The Panhandle Geonews Vol. 2, No. 3 p. 4-39.