Oil and Gas Generation, Migration, Production Forecast, and Geochemical Reservoir Characterization of the Northern Denver Basin: Implication from the Total Petroleum Systems Analysis.

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Summary

The Denver-Julesburg (Dj) basin (Fig.1) is an asymmetric basin with thrust contact on the western margin against the Laramide- orogeny (Rocky Mountains). It is situated in eastern Colorado, southeastern Wyoming, the southwestern corner of South Dakota, and the Nebraska Panhandle. Thousands of oil and gas wells had been drilled and completed in this basin since the first completion of an oil well in 1881 in the Florence field (Higley and Cox, 2007). There are multiple oils and gas producing conventional and unconventional reservoirs including several major cretaceous source rocks (e.g., Niobrara, Carlile Shale, Graneros Shale, and Mowry Shale), and many reservoir rocks (e.g., Codell, Muddy Sandstone etc.). The oil-source-reservoir correlation of hydrocarbon from these reservoirs are not very well fingerprinted through detail organic geochemistry including gas chromatography, biomarkers, oil and gas molecular composition, compounds specific isotopes and their thermal maturity equivalent data. It is very important to determine the origin of hydrocarbon (oil and gas) to properly estimate the hydrocarbon phase, gas-to-oil ratio (GOR) and production prediction. Many reservoir/petroleum engineering parameters vary based on type of source rock (Type I/II/III) and nature of its expulsion in varying pressure temperature volume (PVT) conditions. This study focuses on the detail geochemical analysis from source rock, extracted oil, mud gas, and production gas and oil geochemistry to determine the origin of the hydrocarbon stored in different Cretaceous stratigraphic horizons from Denver basin and their production equivalent hydrocarbon phases.

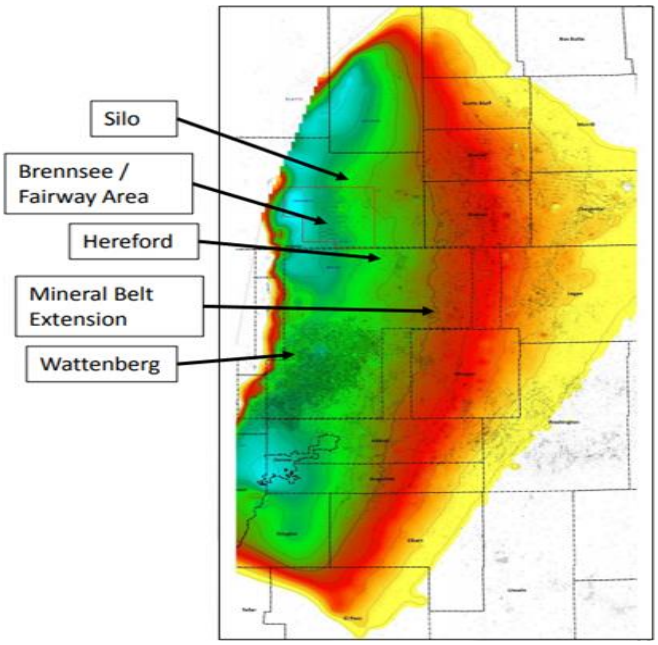

Figure 1: The figure on the left shows the Dj basin reginal structure on the top of Niobrara Formation. It also shows the major oil and gas fields in the basin.

Theory / Method / Workflow

Geochemistry data were generated from cored rocks, cuttings, mud gas, extracted oils and compared with the produced gas and oils from the Denver basin. This article included source rock analysis through Rock-Eval pyrolysis on cored and cuttings rocks, Leco-TOC, gas composition and compound specific isotopes via GC-IRMS, thermal extract gas chromatography (TEGC), high resolution gas chromatography, Gas Chromatography-Mass Spectrometry (GCMS) biomarker analysis on MPLC(medium pressure liquid chromatography) separated saturates and aromatics, bulk carbon isotope analysis on extracted oil and produced oil (Peters et al., 2005; Rahman et al., 2016; Rahman et al., 2017).

Results, Observations, Conclusions

Clayton and Swetland (1980) concluded that all the Cretaceous oils are compositionally similar throughout the basin. But the extracted oils from cored rock and cuttings and associated gas and oil data from several intervals from this study clearly depict there are significant differences in oils found in these Cretaceous reservoirs. Geochemistry data from source rock suggests that most of the organic matter in different Cretaceous source rocks are of Type II kerogen. However, the source rock differs in chemistry because of depositional environment associated with marine shale vs carbonate. It is evident from the pyrolysis, mud gas, and extracted oil chemistry data from the Denver basin that there are distinct differences in origin of oil and gas in these reservoirs.

Novel/Additive Information

The major highpoints of this study are as follows: 1) the novel organic geochemistry data should be used to better characterize any basin for conventional and unconventional exploration and development; 2) this approach helps to model better petroleum systems, basin evaluation, and overall understanding of the quality of petroleum, expulsion histories, migration pathways and type of petroleum stored in rocks.

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