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GEOLOGICAL AND GEOCHEMICAL CONTROLS ON COAL-SOURCED NATURAL GAS ACCUMULATIONS IN THE UNITED STATES AND CHINA

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Introduction

Worldwide consumption of natural gas is forecast to increase by 50 percent by 2040 (Energy Information Agency, 2016), with the largest demand coming from the US and China. While much of the new supply to meet this demand is projected to come from shale gas, natural gas derived from coal is expected to contribute a significant portion. This study examines the primary geological and geochemical controls on known coal-sourced gas accumulations in the US and China. The geochemistry and maceral content of coals, as well as the molecular and isotopic composition of coal-sourced gases, have been characterized for all coal-bearing basins in the US and China. Detailed studies involving laboratory pyrolysis experiments and basin modeling have also been conducted for two basins (Piceance Basin, US and Ordos Basin, China).

Results

All coals examined predominantly contain vitrinite with secondary contributions of inertinite. The carbon isotopic composition of kerogen in US and Chinese coals generally ranges between -26 to -22‰, which is distinct from Type I and Type II kerogen found in lacustrine and marine shales that typically ranges from -33 to -26‰ (VPDB) (Lewan, 1986). However, Type II kerogens with significant C4 plant input which are present after the Eocene, and Ordovician kerogens that contain a significant contribution of *G. prisca* do not follow this trend (Lewan, 1986; Pancost et al., 1999; Pancost et al., 2013). The thermal maturity of the examined coals ranges from 0.5 to 2.1%R_o, and the majority are mature to overmature with respect to gas generation.

Coal-sourced gases in the US and China are predominantly composed of hydrocarbons, with N_2 and CO_2 each generally accounting for <5% of the total gas. Gas wetness and stable isotopic composition of the hydrocarbons are both correlated with thermal maturity of the source. The covariation of the molecular and stable carbon isotopic composition of C_2, C_3, and C_4 follows well-established kinetic models for hydrocarbon generation and isotopic fractionation. Notable exceptions to these relations occur in the Ordos Basin where high-maturity gases exhibit the isotopic rollover (Figure 1) seen in many North American shale gases (Zumberge et al., 2012), and in the Uinta Basin where biogenic gases contain significant amounts of C_2. Calibrated hydrocarbon generation kinetics incorporated into 1-D basin models predict natural gas generation of 5600 scf/ton and 4200 scf/ton for the Cameo Coal (Piceance Basin, US) and Ordos Coal (Ordos Basin, China), respectively.

Conclusions

Unique features of the geologic settings of coal-sourced gas accumulations in the US and China lead to distinct differences in the relative resource potential in each of these nations. Spatially extensive, thermally mature, organic-rich marine shales in tectonically stable basins are more abundant in the US compared to China. This leads to greater shale-gas resource potential in the US, and a greater relative importance of coal-sourced gas in China. Moreover, the ubiquity of marine-sourced gases in US basins complicates the assessment of conventional coal-sourced gas resources.

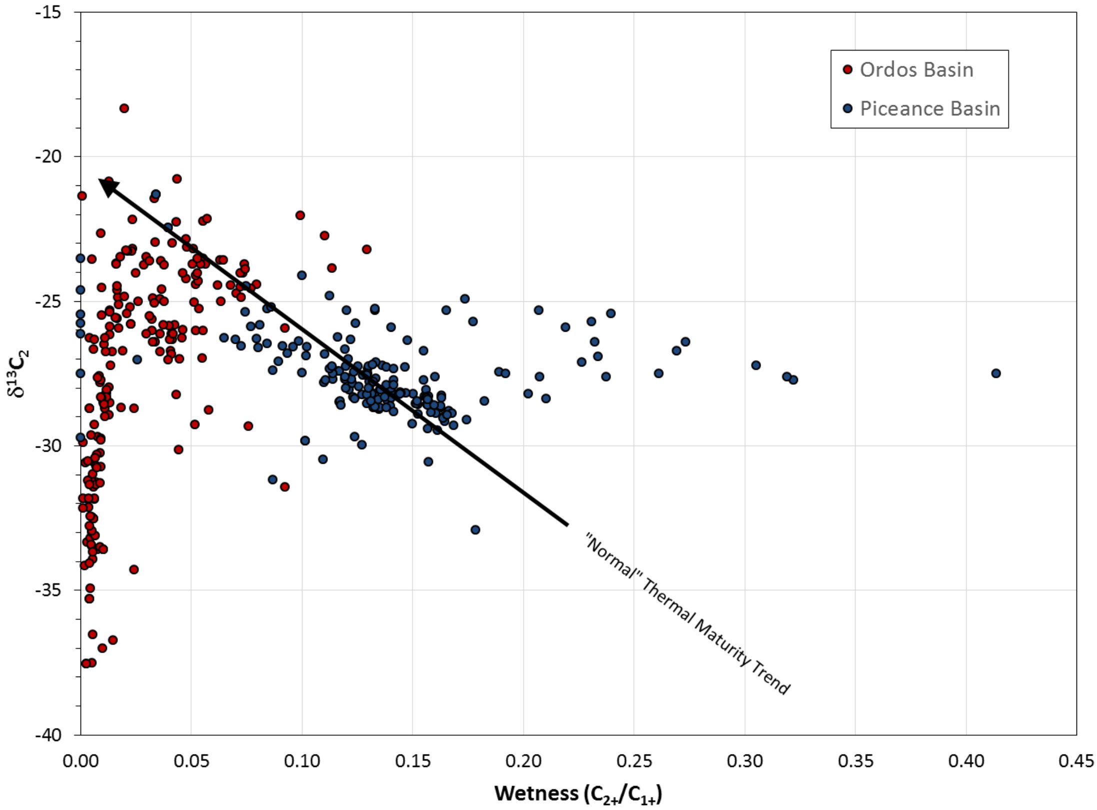

Figure 1 *The $\delta^{13}C$ of ethane vs. gas wetness for coal-sourced gases from the Ordos Basin, China show the "isotope rollover", which is not seen in other basins such as the Piceance Basin, USA.*

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