PETROLOGIC CONTROLS ON THE CARBON SEQUESTRATION AND ENHANCED RECOVERY POTENTIAL OF COAL

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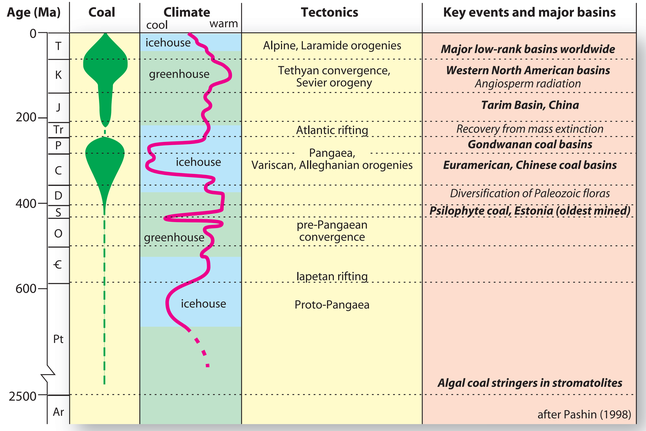
ABSTRACT

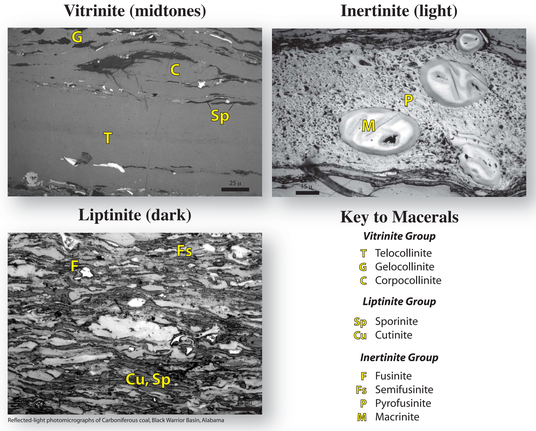
Economic coal resources range in age from Silurian to Pleistocene, and the petrology of these resources is diverse, reflecting the spectrum of geologic factors associated with the accumulation and transformation of peat to coal. Along with thickness, depth, and permeability, the petrology of coal can determine the viability of carbon sequestration and CO_2-enhanced coalbed methane recovery technology. Rank, grade, and maceral composition are the principal petrologic factors influencing the sequestration potential of coal, and the relative importance of each of these factors varies depending on the composition of the original peat deposit and the geochemical changes associated with burial and thermal history.

Gas adsorption capacity correlates positively with coal rank in most basins, but CH_4 capacity is more rank-sensitive than CO_2 capacity, which favors enhanced gas recovery in high-rank coal. Mineral matter, principally quartz, clay, pyrite, and carbonate, dilutes the nanoporous organic matrix of coal, thereby decreasing adsorption capacity on a simple volumetric basis. Storage capacity is highest in vitrinite group macerals and correlates most strongly with telovitrinite content. However, gas capacity is severely limited in perhydrous vitrinite because potential sorption sites are occupied by long-chain hydrocarbons. Perhydrous vitrinite is facies-dependent, is associated with sapropelic organic matter in the oil generation window, and is most common in Permian, Cretaceous, and Tertiary strata. In Permian strata, perhydrous vitrinite is associated with specific seams, whereas in younger strata, perhydrous vitrinite is widespread. Accordingly, coal petrology is a powerful tool for assessing and screening sequestration opportunities in coal basins around the globe.

COAL THROUGH GEOLOGIC TIME

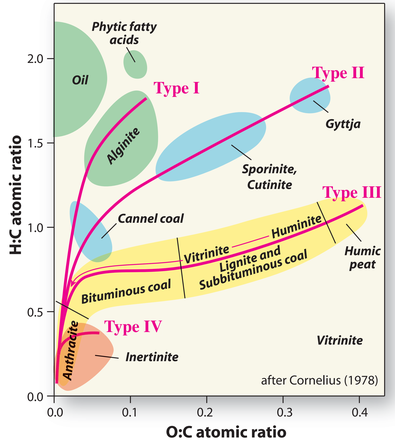


COAL MACERALS



Reflected light photomicrographs of Carboniferous coal, Black Warrior Basin, Alabama

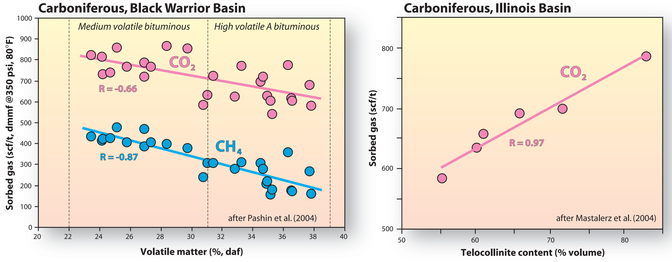
VAN KREVELEN DIAGRAM



ORIGIN, SOURCE-ROCK, AND STORAGE POTENTIAL

Maceral	Origin	Source-rock potential	Gas-storage potential
Vitrinite Group Telinite Gelinite Corpocollinite	Woody tissue Gelified woody tissue Gelified woody tissue	Gas-prone; can be oil-prone	High adsorption capacity; low free-storage capacity
Liptinite Group Alginite Sporinite Cutinite Resinite	Algae Spores and pollen Cuticles (bark, leaves, etc.) Sap, resin	Oil-prone	Low adsorption capacity; low free storage capacity
Inertinite Group Fusinite Semifusinite Pyrofusinite Sclerotinite Macrinite/Micrinite	Oxidized woody tissue Partially oxidized woody tissue Burnt plant tissue Fungi Oxidized resin, gel, etc.	Low potential	Variable adsorption and free storage capacity

ADSORPTION VS. RANK, MACERAL COMPOSITION

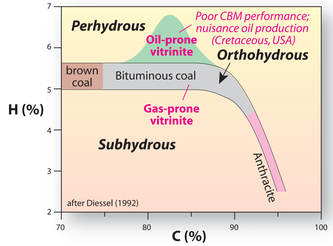


MINERAL MATTER

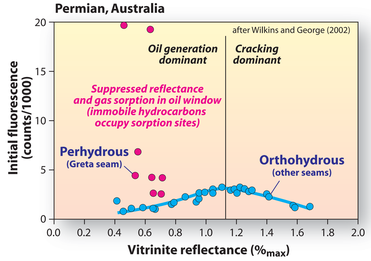
Pyritized coal, Black Warrior Basin, Alabama

Weakly sorptive mineral matter dilutes strongly sorptive organic matter, thereby reducing total sorption capacity

OIL-PRONE (PERHYDROUS) VITRINITE



VITRINITE FLUORESCENCE VS. REFLECTANCE



CONCLUDING THOUGHTS

1) Coal is heterogeneous in terms of maceral composition, rank, and mineral matter content.
2) This heterogeneity reflects spatial and secular changes in plant communities and peat composition, as well as the thermal and burial history of sedimentary basins.
3) Rank, maceral content, and mineral matter can have a strong influence on the adsorption capacity of coal, and hence the applicability of CO_2 sequestration and CO_2-enhanced recovery technology.
4) Oil-prone (perhydrous) vitrinite can affect reservoir performance adversely, especially where coal is within the oil generation window. Perhydrous vitrinite is abundant in some Carboniferous and Permian coal seams and is widespread in Cretaceous and Tertiary seams.
5) Accordingly, petrologic screening of coal beds can be useful for predicting reservoir performance and for selecting coal beds for gas production, sequestration, and enhanced recovery.