PETROLEUM GENERATION POTENTIALS AND KINETICS OF COALY SOURCE ROCKS IN KUQA DEPRESSION OF TARIM BASIN, NORTHWEST CHINA

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The Kuqa depression in the northern Tarim Basin is a major gas producing province of China. A number of large (giant) and medium gasfields have been found in this depression with total in-place gas reserves over 1×10¹² m³. Gaseous hydrocarbons for these reservoirs were mainly derived from coaly source rocks within the Triassic-Jurassic strata (e.g. Liang et al., 2003; Zhao et al., 2005). Confined pyrolysis experiments (gold capsules) were performed to determine the yields and kinetic features for petroleum formation for seven coals from coal pits in the depression with lower maturities (%Ro 0.58–0.74). The maximum yields of oil and gaseous hydrocarbons (ΣC₁–₅) range 46.39–87.50 and 107.20–120.94 mg/g TOC, respectively, for the four coals TTC1, TTC4, TTC11 and TTC18 within the Upper Triassic Taliqike Formation (T₃t) having hydrogen index (HI) ranging 223–278 mg HC/g TOC while they range 14.31–39.78 and 70.11–95.06 mg/g TOC, respectively for the three coals JKC1, JKC2 and JKC3 within the Middle Jurassic Kezilenuer Formation (J₂k) having HI ranging 57–183 mg HC/g TOC. The result of mass balance demonstrates that the total yield of oil and gaseous hydrocarbons in confined pyrolysis at EASY%Ro 1.19–1.50 only occupies a portion of 38–53% of the releasable moieties in Rock-Eval pyrolysis, suggesting that the other portion of 47–62% of these moieties was rearranged and incorporated to polyaromatic nuclei in residual solid within oil generative window for the seven coals. At highly post mature stage with EASY%Ro >1.87, the residual solid of the seven coals have very similar gas generative potentials (ΣC₁–₅, Figure 1a), which are substantially higher than their quality index (QI = (S₁+S₂)/TOC) with differences ranging 20–40 mg/g TOC. This result demonstrates that, at highly post mature stage with EASY%Ro >1.87, coals still have the capability to generate a significant amount of methane with maturity further increasing even if they have very low S1+S2 values (QI<15 mg HC/g TOC).

For the four Triassic coals which are effective oil source rocks with maximum oil yield >40 mg/g TOC, the weighted average activation energies for oil generation range 51.64–52.96 kcal/mol with frequency factors ranging from 9.61×10¹² s⁻¹ to 1.69×10¹³ s⁻¹. The distributions of activation energies for oil generation from these four coals are highly concentrated, demonstrating that the precursors for oil generation are highly homogeneous. This feature can be also partly ascribed to that only a limited portion of the bound alkanes in the initial coal can be released as oil components.

The weighted average activation energies for gas generation range 64.72–65.33 kcal/mol with frequency factors ranging from 8.25×10¹³ s⁻¹ to 1.22×10¹⁴ s⁻¹ for the three Jurassic coals and range 62.78–65.02 kcal/mol with frequency factors ranging from 8.21×10¹³ s⁻¹ to 1.67×10¹⁴ s⁻¹ for four Triassic coals. Only minor portion of gaseous hydrocarbons, i.e. about 30% and 44%, respectively for the Jurassic coals and Triassic coals is generated at EASY%Ro up to 2.19 while the major portion is generated at higher maturities (Figure 1b).

Kinetic parameters for the generalized coals JKC and TTC for oil and gas generation were determined from the average oil and gas yields of the three Jurassic coals and four Triassic coals, respectively. Under natural condition at heating rate of 5 °C/My, the generalized
Jurassic coal JKC and Triassic coal TTC could be effective gas source rocks with gas yield ($\Sigma C_{1-5}$) >20 mg/g TOC at EASY%Ro >1.76 and 1.59, respectively. The abundant gaseous hydrocarbons found in Kuqa Depression can be mainly ascribed to high maturities of coal source rocks (%Ro >2.0), especially Triassic coal source rocks, in combination with excellent seal of thick salt and gypsum for the gas reservoirs.

![Figure 1](image)

*Figure 1* Gas yields ($\Sigma C_{1-5}$) of the seven coals at highly post mature stage (EASY%Ro 1.87–4.44) at a heating rate 2 °C/h (a), and the predicted cumulative amounts of oil generated and expelled, and total gaseous hydrocarbons ($\Sigma C_{1-5}$) generated in closed and semi open systems for both the generalized coals JKC and TTC under geological conditions at 5 °C/my versus EASY%Ro (b). $S_O$-G: the cumulative amount of oil generated; $S_O$-E: the cumulative amount of oil expelled.

**References**
