Stable isotope systematic of coalbed methane

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Stable carbon and hydrogen isotopes find useful applications in the exploration activities associated with Coalbed Methane (CBM), in particular the identification of different gas types and generation pathways. Isotopes provide critical information on the degree of gas saturation in coal seams. Kinetic isotope effects offer improved estimations of the "residual gas component", which is difficult and imprecise using conventional canister methods. The isotope signatures may also improve or replace the common canister desorption method to estimate "total gas".

We have conducted analyses on a base of over 1000 gas samples collected from 7 different coal-bearing basins with ranks ranging from sub-bituminous to anthracite.

These samples were taken 1) as time series during conventional desorption experiments and 2) from CBM production wells over a time span of several months. The analyses include gas molecular composition (C1 to C4, CO_2) and C-, H-isotope ratios of hydrocarbons.

Initial results reveal diagnostic trends in isotopic composition. The desorption experiments reveal consistent and systematic shifts in isotope ratio to increasing 13-C with time. In contrast, methane from production well samples grows isotopically 12-C enriched with time. Time series measurement of the gas composition recognize the point of incipient CO_2 desorption. They also provide information on the volume of coal in the subsurface that is influence by desorption. The same principles can be applied to monitoring the effectiveness of lithologic fracturing processes, i.e., the progress and success of the operation.

The application of thermal simulating experiment in gas-source correlation

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Experiment

6 samples from Kuche Depression of Tarim basin were collected and thermal simulated with a step of 40℃ and 8 stages from 260℃ to 540℃. The components, and ethane carbon isotopic compositions of simulated gases generated from mudstone, carbargilite and coal are analyzed. The drying coefficients ($C_1/(C_2+C_3)$) are caculated.

New method

Using drying coefficient of natural gas from well Ku-1 as parameter for interpolation method, relevant temperatures and thermal maturities of simulated samples are figured out (Table 1). According to geological background and the possible maturity range, the study showed that only the gas generated at about 420℃ from sample YM-4 of Jurassic coal measures is consistent with well Ku-1 both in hydrocarbon components and ethane isotopic composition. That means Jurassic coal is the main source rock of natural gas from well Ku-1.

Table 1 The interpolation temperature and Ro when the drying coefficent equals to that of gas from well Ku-1.

Samples		Low temperature stages		High temperature stages	
		T(℃)	Ro(%)	T(℃)	Ro(%)
Kuchehe13	T_{3t}	327.4	0.97	483	2.61
Kuchehe 16	T_{3t}	325	0.96	503	2.86
YM-1	T_{3t}	294	0.82	493	2.73
YM-2	T_{3t}	334.4	1	469	2.44
YM-3	J_{2kz}			477	2.54
YM-4	J_{2kz}	317	0.93	422	1.79
TS-1	J	282	0.76	504	2.87
TS-2	J	310	0.89	578	3.31

Conclusion

Combined with ethane carbon isotope, component and maturity data, the simulation gas drying coefficient can be used in gas-source correlation. The interpolation method overcomes the influence caused by organic thermal maturity and provides a new way for study of oil-gas source correlation.