

Enrichment Patterns of Natural Gas in the Archaeozoic Metamorphic Buried-Hill of Deep Oil-Type Continental Rift Basins in the Bozhong Depression, Offshore Bohai Bay Basin, China

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Abstract

Bohai Bay Basin is a typical oil-type basin located on the east coast of China, with the characteristics of more oil and less gas. The statistic shows that oil reserves can be greater than 130×10^8 tons (851.5×10^9 bbl.), gas reserves 500×10^8 m³ (12360.2×10^9 cuft). Gas was previously paid little attention as source rocks (Es3, Es1 and Ed members) of Bozhong depression, which is considered to be mainly dominated by I-II2 kerogen, and the thermal maturity is not high enough for a great amount of gas generation, the vitrinite reflectance ranges from 0.56 to 1.72. No systematic investigations on the enrichment patterns of natural gas origin in the Archaeozoic (Ar) metamorphic buried-hill have been conducted. However, a condensate gas reservoir named Bozhong 19-6 was discovered recently. It's proved that the gas-bearing area is 118 km² (45.6sq.mi) and the height of the gas column is 1569m (5147.6ft), proven gas reserves is more than 100 billion m³. Its distribution area is up to 7000km²(2702sq.mi), the accumulated thickness reaches up to 1500m(4921ft). Based on Rock-Eval pyrolysis, natural gas composition, isotope data of the gas and source rock, core inclusion chromatography, adamantane, hydrocarbon inclusion, and light hydrocarbon fingerprint comparison data of 362 samples, enrichment patterns of natural gas origin in the Ar metamorphic buried-hill were analyzed for the first time. According to carbon isotope value and light hydrocarbon index of Alkane gas, which range from -39.1‰ to -38.5‰, and the proportions of

dimethylcyclopentane and methylcyclohexane to C7 light hydrocarbons are 13% and 37% respectively, the Es3 Formation is the significant source rock. We conduct a thermal simulation experiment of hydrocarbon generation by using samples from Es3 source rock (TOC content is 3.07%, hydrocarbon index is 694mg/g), and find it has relatively high activation energy of hydrocarbon generation 220KJ/mol, in contrast to 202-213KJ/mol in the Dongying depression, which indicates that the Bozhong depression has massive gas generation in high thermal evolution, and the gas generation potential is as high as 38% of the total hydrocarbon generation potential. What's more, residual asphalt seen in the microscope slice indicates a large amount of hydrocarbon gas invasion. We finally analyzed the enrichment patterns of natural gas in the research area. The condensate gas reservoir experienced three stages: the formation and adjustment of the early reservoir, and the filling of kerogen pyrolysis gas into the late reservoir. Dark-brown and yellow-green oil inclusions, which are medium to low maturity, record the stage of oil accumulation. The blue-white light oil and gas inclusions are highly mature and record the second stage of oil accumulation. What's more, deep-gray gas inclusions record the latest phase of gas accumulation.