Geochemical characterization of solid bitumen in the Upper Sinian gas reservoir, Sichuan Basin: Implications for its origin and source rock

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Introduction

The Anyue gas field is a recently discovered giant gas field in the Sichuan Basin, southwest China. Its most important gas reservoirs occur in the carbonate deposits of the Upper Sinian Dengying Formation. Solid reservoir bitumens were widely observed in these carbonate reservoirs. Some studies have been performed on these solid bithmens (Cui et al., 2008; Tian et al., 2013). However, their origin and source rock have not yet been well defined. In this study, an investigation on molecular compositions of extracted hydrocarbons from these solid bitumens was conducted, aiming at providing insight into their formation processes and source rock characteristics.

Results and conclusions

Ten core samples with extensive occurrence of solid bitumens from the second member of the Dengying Formation in the Anyue gas field were investigated. The yields of hydrocarbons obtained by Soxhlet extraction of rock powder are relatively low. Major classes of hydrocarbons identified in extracted materials from the Upper Sinian solid bitumen samples consist of n-alkanes, mid-chain monomethyl alkanes, cyclohexyl alkanes, acyclic isoprenoids, tricyclic terpanes, pentacyclic triterpanes and steranes. Secondary alteration processes including microbial alteration and thermal alteration affected the Upper Sinian gas reservoirs. Initially charged oils in the reservoirs were severely biodegraded and later burial coupled with thermal alteration and probably gas deasphalting transformed biodegraded oils into solid reservoir bitumens. Occurrence of a series of 25-norhopanes and various amounts of unresolved complex mixture (UCM) indicate severe biodegradation of the initially charged oils. Low extracted yields, predominance of low molecular weight n-alkanes in the major resolvable hydrocarbons, and terpane and sterane maturity parameters support high degree of thermal alteration of biodegraded oils. Several parameters including ratios based on various tricyclic terpanes and hopanes (e.g., C_{22}/C_{21}, C_{24}/C_{23} and C_{26}/C_{25} tricyclic terpane, C_{29}/C_{30}, $C_{31}R/C_{30}$ and $C_{35}S/C_{34}S$ hopane), dibenzothiophene/phenanthrene and C_{27} diasteranes/ (diasteranes + regular steranes) suggest that the Upper Sinian solid bitumens were mainly derived from marine shale source rocks. These marine shales were deposited in an anoxic, hypersaline environment evidenced by low pristane/phytane ratios, high gammacerane index and high R_{22} index and received a significant organic-matter input from prokaryotic organisms and a much lower contribution from eukaryotic algal. The Upper Sinian solid bitumen samples have different distributions of steranes and carbon isotopic compositions of saturated and aromatic hydrocarbons compared to other late Proterozoic–early Cambrian origin organic materials, e.g. the Siberian oils (Fowler and Douglas, 1987; Summons and Powell, 1992), which could be attributed to organic facies variations that differ in their source rocks.

References

Cui, H.Y., Zhang, L., Wei, G.Q., Hu, G.Y., Liang, F., Xiang, J., 2008. Characteristics of the Sinian reservoir bitumen in Weiyuan–Ziyang areas of the Sichuan Basin and its significance. Petroleum Geology & Experiment 30, 489–493. (in Chinese with English abstract)

Tian, X.W., Hu, G.Y., Li, W., Li, X.Q., Su, G.P., Xu, Y.C., Cai, D., Wei, H.P., 2013. Geochemical characteristics and significance of Sinian reservoir bitumen in Leshan–Longnvsi paleo-uplift area, Sichuan Basin. Natural Gas Geoscience 24, 982–990. (in Chinese with English abstract)

Fowler, M.G., Douglas, A.G., 1987. Saturated hydrocarbon biomarkers in oils of Late Precambrian age from Eastern Siberia. Organic Geochemistry 11, 201–213.

Summons, R.E., Powell, T.G., 1992. Hydrocarbon composition of the Late Proterozoic oils of the Siberian Platform: Implications for the depositional environment of source rocks. In: Early Organic Evolution: Implications for Mineral and Energy Resources (Schidlowski, M., ed.), Springer-Verlag, NewYork, pp. 296–307.