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四川盆地东北部海、陆相储层沥青组成特征及来源

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摘要:

本研究系统采集了四川盆地东北部大普光、元坝地区上三叠统须家河组、下三叠统飞仙关组、上二叠统长兴组和鄂西渝东地区中石炭统黄龙组储层固体沥青样品,进行了岩石热解、有机元素、碳同位素和饱和烃、芳烃组分GC/MS的分析,以确定其成因、性质和来源。这些沥青总体上具有低溶性(多数氯仿抽提物/TOC<8%)、高反射率(换算的Ro>1.4%)、低H/C原子比(<0.6)的性质,属焦沥青类,是古油藏原油或运移烃经热裂解成气的残留物。其中,飞仙关组、长兴组碳酸岩储层沥青的S/C原子比值普遍较高(主要在0.025~0.085范围),且硫同位素 $\delta^{34}\text{S}$ 值(主要在12%~24%)接近硬石膏,说明可能包含有部分TSR成因的沥青。这些高热演化沥青中饱和烃生物标志物的组成和分布出现了异常变化,基本失去了其常规应用意义。芳烃中2,6-/2,10-DMP(二甲基菲)、1,7-/1,9-DMP和4-/1-MDBT(甲基二苯并噻吩)比值,可用来指示沥青烃源岩的有机质生源构成和沉积环境性质。须家河组陆相沥青中这些芳烃比值较高,表征其烃源母质中陆源有机质占优势,且形成于氧化性的环境;而飞仙关组、长兴组及黄龙组海相沥青中这些参数值低得多,意味着其烃源岩有机质生源应以水生生物为主,并沉积于还原性环境。经沥青/烃源岩的碳同位素和二苯并噻吩系列组成对比,认为须家河组储层沥青来源于本层位烃源岩,飞仙关组和长兴组沥青同源于一二叠系烃源层。鄂西渝东地区的黄龙组沥青碳同位素偏重($\delta^{13}\text{C}$ 值为-23.2%~-26.4%),原始烃源可能主要来自中、下志留统韩家店组及小河坝组地层。

英文摘要:

Solid reservoir bitumens collected from Xujiahe (Upper Triassic, T_3x), Feixianguan (Lower Triassic T_1f) and Changxing Formation (Upper Permian, P_2c) in Puguang and Yuanba gas fields and from Huanglong Formation (Middle Carboniferous, C_2h) in western Hubei-eastern Chongqing region, the northeast of Sichuan basin, were systematically analyzed for bulk and molecular compositions, to investigate their genesis, character and origin. These bitumens are primarily characterized by poor solubility (ratios of chloroform extract over TOC<8% mostly), high reflectance (equivalent Ro>1.4%) and low H/C atomic ratios (<0.6), suggesting that they are derived from their original reservoir oil or migrated hydrocarbon by thermal degradation into gas, belonging to a pyrobitumen. Most bitumens in carbonate reservoir of Feixianguan and Changxing formations exhibit relatively high atomic ratios of S/C (mostly in 0.025 to 0.085), with $\delta^{34}\text{S}$ values ranging mainly from 12% to 24%, indicating a proportion of them possibly resulted from TSR. Unusual biomarker composition and distribution, such as bimodal distribution in n-alkanes, reduced Pr/Ph value, undifferentiated distribution in steranes and terpanes and reversal isomerization in sterane, are observed in these over-mature bitumens, and thus their conventional geochemical significances appear lost. However, the ratios of 2,6-/2,10-DMP, 1,7-/1,9-DMP and 4-/1-MDBT in aromatic fraction are considered to be useful indicators for biological organic source and sedimentary environment of the source rocks from which the initial oils for the bitumens are derived. The aromatic ratios are relatively high in the bitumens of Xujiahe terrestrial reservoir, indicating a dominant terrigenous source input and oxic depositional environment for their source rocks. In contrast, they are significantly lower in the bitumens of Feixianguan, Changxing and Huanglong marine reservoirs, suggesting an organic source predominated by aquatic organisms and a reducing condition. According to correlation between bitumens and source rocks by carbon isotopes and relative composition of dibenzothiophene series, the reservoir bitumens in Xujiahe Formation are believed to originate from adjacent source rock within this sequence, and those in Feixianguan and Changxing formations both from Permian source rock. Since Huanglong solid reservoir bitumen studied is isotopically heavier ($\delta^{13}\text{C}$ values from -23.2% to -26.4%), the original hydrocarbon could be primarily sourced from Mid-Lower Silurian Hanjiadian and Xiaoheba source rocks, rather than Longmaxi Formation.

关键词: [储层固体沥青](#) [有机元素](#) [碳同位素](#) [生物标志物](#) [芳烃](#) [四川盆地东北部](#)

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