



四川盆地五峰组—龙马溪组海相页岩元素地球化学特征与有机质富集的关系

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A relationship between elemental geochemical characteristics and organic matter enrichment in marine shale of Wufeng Formation—Longmaxi Formation, Sichuan Basin

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摘要

选择四川盆地长宁县双河镇上奥陶统五峰组一下志留统龙马溪组新鲜露头剖面,对24个页岩样品进行了有机碳、硫含量和主、微量元素测试。分析了主、微量元素含量在剖面垂向上的变化特征及其与海盆古沉积环境的关系,讨论了控制四川盆地奥陶纪—志留纪页岩有机质富集的主要因素。研究表明:五峰组—龙马溪组底部约20 m的层段有机碳含量(TOC)较高,达2.2 % ~7.76 % ,向上有机碳含量变低(0.81 % ~1.83 %)并趋于稳定。页岩的主要成分为SiO₂(55.67 %)、Al₂O₃(10.13 %)和CaO(9.51 %)。TiO₂和Al₂O₃含量在剖面底部低,向上增大,指示陆源碎屑物质输入增加。富有机质页岩的SiO₂和CaO含量明显高于贫有机质页岩的含量,而Al₂O₃、Fe₂O₃和TiO₂含量较低;同时,在富有机质层段中氧化还原敏感元素Mo、U、V、Ni、Co、Cr和营养型元素Ba明显富集。Ni/Co、V/Cr、U/Th和黄铁矿矿化度(DOP_T)指示五峰组沉积时期水体氧化还原条件变化较大,以贫氧—厌氧环境为主,龙马溪组底部水体还原性比五峰组强,为具有一定H₂S含量的静海相环境,而中上部则为正常富氧环境。页岩中P和过剩钡(Ba_{XS})含量指示五峰组—龙马溪组沉积期具有高生产力特征,且TOC与氧化还原指标呈正相关关系,表明有机质含量的变化主要受控于氧化还原环境。Mo/TOC与DOP_T图解表明控制龙马溪组页岩微量元素富集的主要因素是氧化还原条件,而控制五峰组的则是水体滞留。龙马溪组有机质的富集主要是由海平面升降造成的海水缺氧程度所控制,而五峰组主要是水体滞留造成的海底缺氧使有机质得到了较好的保存。

关键词: 四川盆地, 沉积环境, 五峰组—龙马溪组, 有机质富集, 微量元素

Abstract:

In this study, a test was carried out on organic carbon, sulfur content, major and trace elements of 24 shale samples from fresh outcrop sections in Upper Ordovician Wufeng Formation—Lower Silurian Longmaxi Formation, Shuanghe Town, Changning County, Sichuan Basin. Moreover, this study analyzed the vertical variation characteristics of major and trace element contents and their relationship with sea-basin paleo-sedimentary environment and explored the major controlling factors for organic matter enrichment in Ordovician—Silurian shale of Sichuan Basin. Research results show that the organic carbon content is higher (2.2 % -7.76 %) in the reservoir intervals about 20 m above Wufeng Formation to the bottom of Longmaxi Formation, then decreased upwards to stable value of 0.81 % -1.83 % . Major components of shale include SiO₂ (55.67 %), Al₂O₃ (10.13 %) and CaO (9.51 %). The contents of TiO₂ and SiO₂ are lower at the bottom of profile and then increased upwards, indicating the increased input of terrigenous clastics. The SiO₂ and CaO contents of organic-rich shale are apparently higher than those of organic-poor shale, but the contents of Al₂O₃, Fe₂O₃ and TiO₂ are lower. Meanwhile, redox sensitive elements (Mo, U, V, Ni, Co, Cr) and nutritional elements Ba are significantly enriched in the organic-rich interval. Ni/Co, V/Cr, U/Th and the degree of pyritization (DOP_T) indicate that Wufeng Formation presents large changes in water mass redox conditions, dominated by suboxic and anoxic conditions. The water mass at the bottom of Longmaxi Formation has a higher reducibility than Wufeng Formation, indicating a euxinic environment with certain content of H₂S. However, normal oxygen enrichment environment exists in the middle and upper part. The contents of P and excess Ba (Ba_{XS}) in shale demonstrate a higher productivity in the sedimentary stage of Wufeng Formation—Longmaxi Formation, while TOC content has a positive correlation with redox proxies, suggesting that the changes in organic matter content is predominantly controlled by redox environment. The cross plots of Mo/TOC and DOP_T show that redox condition and water retention is the major controlling factor for trace element enrichment in Longmaxi Formation shale and Wufeng Formation, respectively. Organic matter enrichment in Longmaxi Formation is mainly controlled by the degree of seawater anoxic resulting from the rise and fall of sea level. However, anoxic environment in Wufeng Formation caused by water retention leads to favorable preservation of organic matter.

Key words: Sichuan Basin sedimentary environment Wufeng Formation—Longmaxi Formation organic matter enrichment trace element

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