

The main controlling factors and developmental models of Oligocene source rocks in the Qiongdongnan Basin, northern South China Sea

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Abstract: Coals developed in the Oligocene Yacheng and Lingshui formations in the Qiongdongnan Basin have high organic matter abundance, and the dark mudstones in the two formations have reached a good source rock standard but with strong heterogeneity. Through the analysis of trace elements, organic macerals and biomarkers, it is indicated that plankton has made little contribution to Oligocene source rocks compared with the terrestrial higher plants. The organic matter preservation depends on hydrodynamics and the redox environment, and the former is the major factor in the study area. During the sedimentary period of the Yacheng Formation, tidal flats were developed in the central uplift zone, where the hydrodynamic conditions were weak and the input of terrestrial organic matter was abundant. So the Yacheng Salient of the central uplift zone is the most favorable area for the development of source rocks, followed by the central depression zone. During the sedimentary period of the Lingshui Formation, the organic matter input was sufficient in the central depression zone due to multiple sources of sediments. The semi-enclosed environment was favorable for organic matter accumulation, so high quality source rocks could be easily formed in this area, followed by the Yacheng salient of central uplift zone. Source rocks were less developed in the northern depression zone owing to poor preservation conditions.

Key words: Hydrocarbon generation potential, paleoproductivity, preservation conditions, hydrodynamic conditions, redox conditions, Oligocene source rocks, Qiongdongnan Basin, northern South China Sea

1 Introduction

The formation of excellent marine source rocks depends on the living environment of the original source organisms and favorable preservation conditions for organic matter, and these factors are controlled by a good matching relationship of paleoproductivity, hydrodynamic and redox conditions, paleoclimate and sedimentation rate (Zhang et al, 2005; Chen et al, 2006). Among these factors, paleoproductivity and preservation conditions (including hydrodynamic and redox conditions) are much more important. Since the 1980s, there has been debate on whether the high organic matter abundance in marine sedimentary strata is dependent on preservation conditions or on production. Those who hold the former view believe that organic matter accumulates when the bottom water conditions are anoxic, and it has nothing to do with biologic productivity (Tyson, 1987; Tyson and Pearson, 1991). While others consider that organic matter

can accumulate at the water column with high biologic productivity, and it is the water depth rather than the dissolved oxygen that influences the abundance of organic matter (Calvert and Pedersen, 1992). However, in continental margin basins, the terrestrial organic matter input is also a significant factor influencing the formation of marine source rocks. For example, rift basins along the Atlantic Ocean where excellent marine source rocks formed were mainly located below the estuary of big rivers, and the big rivers and delta offered a good material base for the development of source rocks (Zhou et al, 2007; Li et al, 2012; Deng, 2012).

The present crude oil and gas in the Qiongdongnan Basin are mainly from transitional facies source rocks of the Oligocene Yacheng Formation (Dong and Huang, 2000; Huang et al, 2002; Chen et al, 2005; Xiao et al, 2006; Zhu et al, 2009; Li et al, 2011; Huang et al, 2012). Marine source rocks developed in the Lingshui Formation can also serve as gas source rocks and may have certain oil generation potential (Li et al, 2011). However, heterogeneity of source rocks is common in the study area, and the controlling factors are complex. There is still no relevant research on the controlling factors of Oligocene source rocks, which severely restricts

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