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Research advance in sediment provenance of the Qiongdongnan Basin

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1 Introduction

Sediment provenance study, as an important part of basin analysis, is a key for source area definition, paleogeographic reconstruction, sediment transport route identification, and tectonic evolution (Haughton et al., 1991; Morton et al., 1999; Fontanelli et al., 2009; Cawood et al., 2012). The Qiongdongnan Basin (QDNB), lies in the northwestern passive continental margin of the South China Sea, neighbouring Hainan Island on the north and Yinggehai Bain on the west, is a hydrocarbon-rich Cenozoic extensional rifted basin. The basin orientating NE-SW, with length of 250-450 km and width of 150-200 km, and can be subdivided into four units, including the Central Depression, Central Uplift, Northern Depression and Southern Uplift. The investigation of the possible source terranes and transport pathways of sediments is of crucial factor in establishing reservoir presence and hydrocarbon exploration (Tsikouras et al., 2011; Chen et al., 2015). In this article, the research progress of sedimentary provenance is reviewed in details from the conventional methods transferred to advanced analysis in the QDNB.

In last decades, many methods have been used in provenance study of the QDNB, and concentrated in the Central Depression. Previous studies of provenance are mainly based on the traditional ways, including heavy minerals, seismic, mineralogical and geochemical studies (e.g. Yao et al., 2008; Cao et al., 2013; Li et al., 2015; Liu et al., 2015). These studies illustrated that several major source terranes were involved in the basin, including Hainan Island, southern Cathaysia and central Vietnam (eastern Indochina Blcok), several uplifts (e.g. Yongle, Shenhu, Xisha), and even Red River (southern Yangtze Block). Yao et al. (2008) based on the seismic data and depositional environment to recognize the source of northern QDNB. The study shows that a typical double provenance depositional model in deepwater area has been identified, and the provenance was probably derived mainly from the southern Xisha uplift and southwestern Indo-China Peninsula during rifting period, and just from Indo-China Peninsula during depression period. Shao et al. (2010) argued that there are differences in provenance between the eastern and western parts of the QDNB by using geochemical and paleoecological data. Different analysis were carried out for heavy minerals of the Neogene strata in QDNB by Cao et al. (2013) to understand the Neogene provenance evolution. The study suggests that both the Hainan Island and Red River are the main source terranes and provided detritus to the basin. Liu et al. (2015) using heavy minerals in core samples from eleven drillings, combined with paleontological, seismic and geochemical data, to investigate the evolution of provenance in the basin. The study proposed the basin has a principal feature of multi-sources, and evolving from local source to long distance source step by step since the Oligocene. During the Early Oligocene, sediments were mainly derived from Hainan, Yongle and Shenhu uplifts, Red River and Indochina Peninsula. The source from the Yongle and Shenhu uplifts most developed from Late Oligocene to Early Miocene and gradually subsided during Middle Miocene, whereas the Red River and Indochina developed since Late Miocene.

In recent years, sedimentary provenance study in the QDNB has been improved by single grain radiometric dating of grain populations, for example detrital zircon U-Pb dating, and changes from single to comprehensive. Cao et al. (2015) combined REE geochemistry, heavy minerals and detrital zircon U-Pb geochronology to reveal the provenance of the Upper Miocene sediments, and interpreted these sediments in the Central Depression

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were originated from the southern Yinggehai Basin through the submarine canyon. Li et al. (2015) using heavy minerals, REE geochemistry, zircon U-Pb ages to analyse provenance of QDNB, suggests that Red River was the main source to the Central Canyon. Chen et al. (2015) employing LA-ICP-MS U-Pb dating for detrital zircons to constrain the provenance of Upper Miocene Huangliu Formation in the western part of the Central Canyon. The zircons yield U-Pb ages ranging from 28 to 3285 Ma, and speculated they were fed dominantly from the Paleo-Red River system during the Late Miocene. Zuo et al. (2015) suggests that the Central Canyon is under the influence of various provenance including the Kontum Uplift in eastern Indochina and Hainan Island during the Late Miocene by combining the seismic profiles, heavy minerals and zircon U-Pb ages. Shao et al. (2016) made use of detrital zircon ages to determine the Paleogene sedimentary provenance in the northern South China Sea, and indicates that Hainan Island and Southern Uplift have the crucial influence on the basin during the Paleogene.

As discussed above, these studies provide an important framework for understanding the provenance and depositional process of the QDNB, and illuminates that Hainan Island, central Vietnam, Red River, and some uplifts surrounding all provided clastic material to the basin in different periods, but the contribution changes with the time and space. Even though there are many new data from different researchers, the provenance is still controversial because of the complexity of source regions, rock types and depositional environments. In addition, most of the studies focused on individual tectonic field (e.g. Central Canyon) or a stratigraphic unit, the systemic study for basin scale of sedimentary provenance is very lack, more advanced analysis methods are needed to apply in the basin to constrain the source terranes, to identify the transport pathways and to understand the source contributions, which will help to reduce the operational risks in drilling and reveal the evolution of the QDNB.

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