Middle Miocene–Pliocene Provenance Evolution of the Yinggehai Basin, Northwestern South China Sea

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INTRODUCTION

As sandwiched by the Vietnamese and South China margins, the Yinggehai Basin preserves the Cenozoic unroofing sequences of surrounding source areas. It is a good entry point to study the regional geological evolution through the source-to-sink analysis. However, the current understanding of its provenance evolution is still limited, partially because of incomplete characterizations of potential sources and restricted sample coverage. Here we employ heavy mineral analysis and detrital zircon U–Pb geochronology on the Middle Miocene–Pliocene sediments to investigate the spatio-temporal provenance evolution.

PROVENANCE HYPOTHESIS

According to basin location, potential provenances include Hainan Island, the Red River and Central Vietnam. The sediment compositions generated from each provenance seem to show a great difference due to their distinct parent rock types. A detailed description of these three source areas can be found in Cao et al. (2015).

DATA AND METHODS

The heavy mineral data of 557 samples were acquired from China National Offshore Oil Corporation (CNOOC). Due to discrete analytical depths in commercial wells, the data were classified according to their corresponding series. Detrital zircon grains from 8 samples were conducted with LA-ICP-MS U–Pb dating at China University of Geosciences (Wuhan).

PROVENANCE EVOLUTION

One provenance during the Middle Miocene was Hainan Island, as suggested by the high zircon abundance in its southwestern margin. The detrital zircon U–Pb ages also show a comparable distribution, largely including the 70–190 Ma and 200–300 Ma. But the contribution from Hainan Island seems to be diluted by another provenance in the northern basin where the zircon content is relatively low. The occurrence of garnet and staurolite is most likely to represent the Red River Provenance. Its influence could possibly reach the central basin based on a multimodal zircon U–Pb age distribution, regardless of the obviously different peaks compared to the age data from the modern Red River sediments.

The sediment compositions in the eastern part of the basin generally remained unchanged over the Middle–Late Miocene, which can be exemplified by the very similar heavy mineral assemblages. But the provenances from the Red River and Hainan Island seem not to occupy the central basin, where both zircon and metamorphic minerals are scarce. Combined with a restricted zircon age range (200–500 Ma), we suggest that these unique fingerprints represent a provenance from Central Vietnam. It is worth noting that the U–Pb age signatures from Central Vietnam could be overlapped by the counterparts from the Red River.

The larger abundances of garnet, epidote and magnetite in most of the Pliocene samples explicitly reveal a provenance shift after the Miocene. A little titanite in the central basin was likely to be sourced from the Red River because of an association with staurolite.

CONCLUSIONS

The combined provenance analyses yield a well-defined relationship between the potential source areas and the Middle Miocene–Pliocene sediments. Hainan Island continuously delivered zircon-abundant sediments to the proximal areas, especially its southern margin. A representative contribution from Central Vietnam is witnessed in the Upper Miocene of the central basin. This remarkable progradation from the Central Vietnamese margin could result from a combination of the relative sea-level fall and accelerated onshore exhumation (Fyhn et al., 2009). The Red River seems to contribute much to the basin infill, but this provenance was not fixed in terms of both sediment composition and influence range. During the Middle Miocene, the Song Lo River probably stemmed from the Central Cathaysia and supplied the Neoproterozoic–Early Paleozoic-aged zircons to the basin. However, this interpretation still requires more robust evidence. Although the age spectra of the Upper Miocene–Pliocene strata from both the Red River drainage basin (van Hoang et al., 2009) and the Yinggehai Basin do not vary much, the widely distributed metamorphic minerals in this study suggest that the sediment contribution from the Red River had potentially strengthened since the Pliocene. This provenance shift is evidenced by the coeval river incision and accelerated offshore sediment accumulation (Clift and Sun, 2006).

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