

Research Advances

Detrital Zircon U-Pb Geochronology: New Insight into the Provenance of Sanya Formation in the Yinggehai Basin

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Objective

The NNW-SSE trending Yinggehai Basin, located on the continental shelf at water depths of 50–200 m in the northwestern South China Sea, is a Cenozoic extensional basin. Over the past decades, a number of hydrocarbon reservoirs have been discovered in the deepwater area of the basin, including the Lingtou Formation (Eocene), Yacheng and Lingshui formations (Oligocene), Sanya, Meishan and Huangliu formations (Miocene) and Yinggehai Formation (Pliocene), which are covered by Quaternary sediments and underlain by pre-Paleogene strata. Traditionally, the strata underlying the first member of Yinggehai Formation are called middle-deep formation. The Lower Miocene Sanya Formation is an important exploration target in deep water area with a maximum thickness of 2950 m, which consists mainly of silty mudstone, mudstone, argillaceous siltstone and limestone, and has attracted much attention due to its gas potential and commercial value. Previous studies on the provenance of the Sanya Formation have focused on the heavy minerals, sedimentary facies and sequence stratigraphic analysis. However, the provenance of the Sanya Formation is still poorly understood because of its complex source areas and lacks of precise isotopic data. In last decades, U-Pb dating of detrital zircon in clastic sedimentary rocks has been widely used in provenance studies. The studies of river sediments around the basin show that zircon populations derived from the Red River are fundamentally different from those derived from the central Vietnam and Hainan Island, which makes the method of detrital zircon U-Pb geochronology be an effective way to constrain the source of the strata in the Yinggehai Basin. Up to now, detrital zircons have been only used to study the shallow strata. In this study, sandstone samples were collected from the drill cores in northern and eastern parts of the basin with aims to determine the provenance distribution of the Sanya Formation.

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Methods

Zircons were picked from heavy liquids and by a Frantz magnetic separator. After purified by hand sorting, zircon grains were mounted in epoxy and polished down to near half sections to expose the internal structures. Approximately 150 zircon grains were handpicked from each sample. U-Pb geochronologic analysis of detrital zircon grains extracted from three sandstone samples was conducted using a laser ablation inductively coupled mass spectrometer (LA-ICP-MS) at State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences. The $^{206}\text{Pb}/^{238}\text{U}$ ages younger than 1000 Ma are used, whereas $^{207}\text{Pb}/^{206}\text{Pb}$ ages are selected if the $^{206}\text{Pb}/^{238}\text{U}$ ages are older than 1000 Ma. For statistical purposes, ages with discordance greater than $\pm 10\%$ were rejected in this study.

Results

The morphology of the zircon grains shows a wide range from prismatic crystals to oval- and irregular-shaped with mostly rounded corners, indicative of long distance transportation for some zircons. Most grains show oscillatory growth zoning under CL. Integrated with the Th/U ratios of greater than 0.4, it is indicated that the majority of the analyzed zircons are of a magmatic origin. The results show that the characteristics of detrital zircon U-Pb ages are different among these samples, and that they might be derived from different source areas. The sample S1, located in northern Yinggehai Basin (Fig. 1), is diverse with a wide range of ages and multiple peaks at ca. 247 Ma, 432 Ma and 957 Ma, along with subordinate peaks at ca. 793 Ma, 1966 Ma and 2481 Ma. The sample S2 yields U-Pb ages ranging from Archean to Cenozoic, and has two major age peaks of ca. 156 Ma and 428 Ma, with three subordinate peaks at ca. 41 Ma, 239 Ma and 733 Ma. In contrast, the age spectra of sample S3 from the eastern Yinggehai Basin are comparatively simple, with two sharp and well-defined peaks at ca. 99 Ma and 238 Ma.

The youngest Cenozoic zircon grains with a small age peak at ca. 41 Ma correspond to the melting and exhumation triggered by motion on the Red River Fault Zone, implying that the Red River Fault Zone in southern Yangtze Block was a minor source for S2 during the Early Miocene. Late Jurassic-Cretaceous zircon grains with age peaks at ca. 99 Ma and ca. 156 Ma in S3 and S2, respectively, are consistent with the ages of Yanshanian granites present in the Hainan Island and could be regarded as the symbol of the Hainan. Coeval intrusive and volcanic rocks have been discovered in the western Hainan. Abundant ages around 234 Ma for these samples are consistent with the ages of the "Indosinian Movement". The ages ranging from 230 Ma to 250 Ma are well developed in the surrounding source areas (i.e. Yangtze, Indochina and Hainan), and are probably related to the collision between Indochina and South China. The early Paleozoic grains (ca. 430 Ma) related to "Caledonian Orogen" were poorly reported in Hainan but well distributed in South China. Neoproterozoic grains (700–1000 Ma) are consistent with the tectonic event termed "Jinningian Movement" which probably associated with the breakup of Rodinia and can be interpreted as a signature of the Yangtze Block. In addition, a number of older U-Pb ages with peaks at ca. 1966 Ma and 2481 Ma have been suggested to the basement sedimentary sequences of Yangtze. The samples S1 and S2 show strong similarities in age populations with the Yangtze Block,

whereas the ages of sample S3 are consistent with the Hainan, indicates that at least two source areas were contributed detritus to the Yinggehai Basin during early Miocene. In addition, S2 has a major age peak of ca. 156 Ma, suggesting that Hainan played an important role in contributing sediments to the position of the sample. The possible provenance directions of Sanya Formation are shown in Fig.1.

Conclusion

U-Pb geochronologic analysis of detrital zircon grains provides critical constraints on the provenance of the Lower Miocene Sanya Formation in the Yinggehai Basin. The study shows that detrital zircon U-Pb dating is a useful and powerful tool to identify the possible provenance in the basin. Comparison of the zircon ages with the potential source areas reveals that the clastic materials in the northern and eastern parts of the Yinggehai Basin were derived mainly from southern Yangtze and Hainan during the early Miocene.

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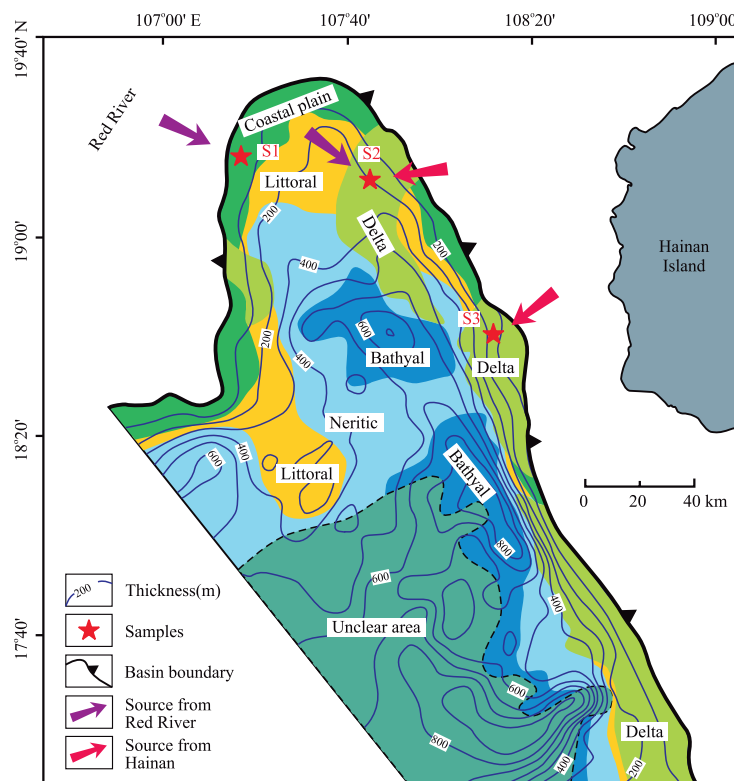


Fig. 1. Possible provenance directions of the Lower Miocene Sanya Formation in the Yinggehai Basin.