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Source tracing of rare earth elements: A case study of core 07 on the southern coast of Laizhou Bay

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ABSTRACT

Rare earth elements (REEs) have proven to be useful indicators of sediment sources. To identify the group of elements most suitable for provenance identification, coastal sediment samples collected from core 07 in Laizhou Bay were analyzed for the presence of REEs. In addition, a corresponding analysis of contributions that different source made to multi-source sedimentary system and provenance discrimination study were undertaken, with the twofold purpose of assessing the effectiveness of REEs as source indicators, and evaluating relative inputs to the sedimentary system on the southern coast of Laizhou Bay from near source and distant origin rivers (i.e. the Bailang River and Yellow River, respectively). The study revealed that various REEs displayed similar cyclic variation in the vertical direction in core 07, with obvious changes at marine–continental stratigraphic boundaries, which could be used as stratigraphic division index. According to chondrite-normalized REE distribution patterns, the Bailang River and Yellow River comprise the main provenance of sediments in core 07. REE discrimination diagrams and the Provenance Index (PI) reveal that the sediments in early stage (Qp_3^3~Qp_3^1, 49.15–80.00 m) were primarily derived from Yellow River, and the sediments in late stage (Qh_3~Qp_3^3 , 5.80–49.15 m) were stemmed from Bailang River. Following extensive analysis, it was concluded that the main provenance of core 07 was the Bailang River, which has played an important role in the sedimentary system of the southern coast of Laizhou Bay since the early Late Pleistocene. Sediment from the Yellow River, rechannelled frequently in geological history, had limited influence in this area.

1. Introduction

The chemical characteristics of clastic sediments have been widely used in provenance determination, as well as in the investigation of tectonics and weathering in sediment source regions (Bhatia, 1983; McLennan and Taylor, 1983; Cullers, 1988; Feng and Kerrich, 1990; Wu and Wang, 1991; Condie et al., 1992; Garver and Scott, 1995; Nesbitt and Young, 1996; Holail and Moghazi, 1998; Singh and Rajamani, 2001a, 2001b; Tripathi and Rajamani, 2003; Yang et al., 2003a, 2003b; Wang et al., 2007). In particular, immobile trace elements, which are known to be transported as particulate load, e.g. Th, Sc, Zr and the rare earth elements (REEs), have proven to be useful source indicators (Taylor and McLennan, 1985). The application of these immobile elements in provenance determination is based on the assumption that these elements undergo little geochemical fractionation during denudation. These elements (in particular, REEs) are commonly concentrated in fine-grained sediments for their host minerals, including accessory primary minerals as well as secondary minerals, generally weather to that size range. Therefore, during the process of sediment transport and deposition, these immobile elements tend to concentrate in suspended load of the river leaving the bed-load sediments depleted in them with higher proportions of quartz and feldspars. Because of the size and mineral fractionation, associated geochemical differentiation is expected.

The compositional characteristics of the parent rock are modified by multiple geochemical and physicochemical processes (e.g. coagulation, adsorption, flocculation, diagenetic remobilization, and resuspension) during the transport or temporary storage of sediments in riverine, estuarine and coastal systems (Sholkovitz, 1976; Hoyle et al., 1984; Sholkovitz, 1995; Johannesson et al., 1996; Censi et al., 2004; Marmolejo-Rodriguez et al., 2007; Wang and Liu, 2008). On account of their intrinsic chemical properties, rare earth

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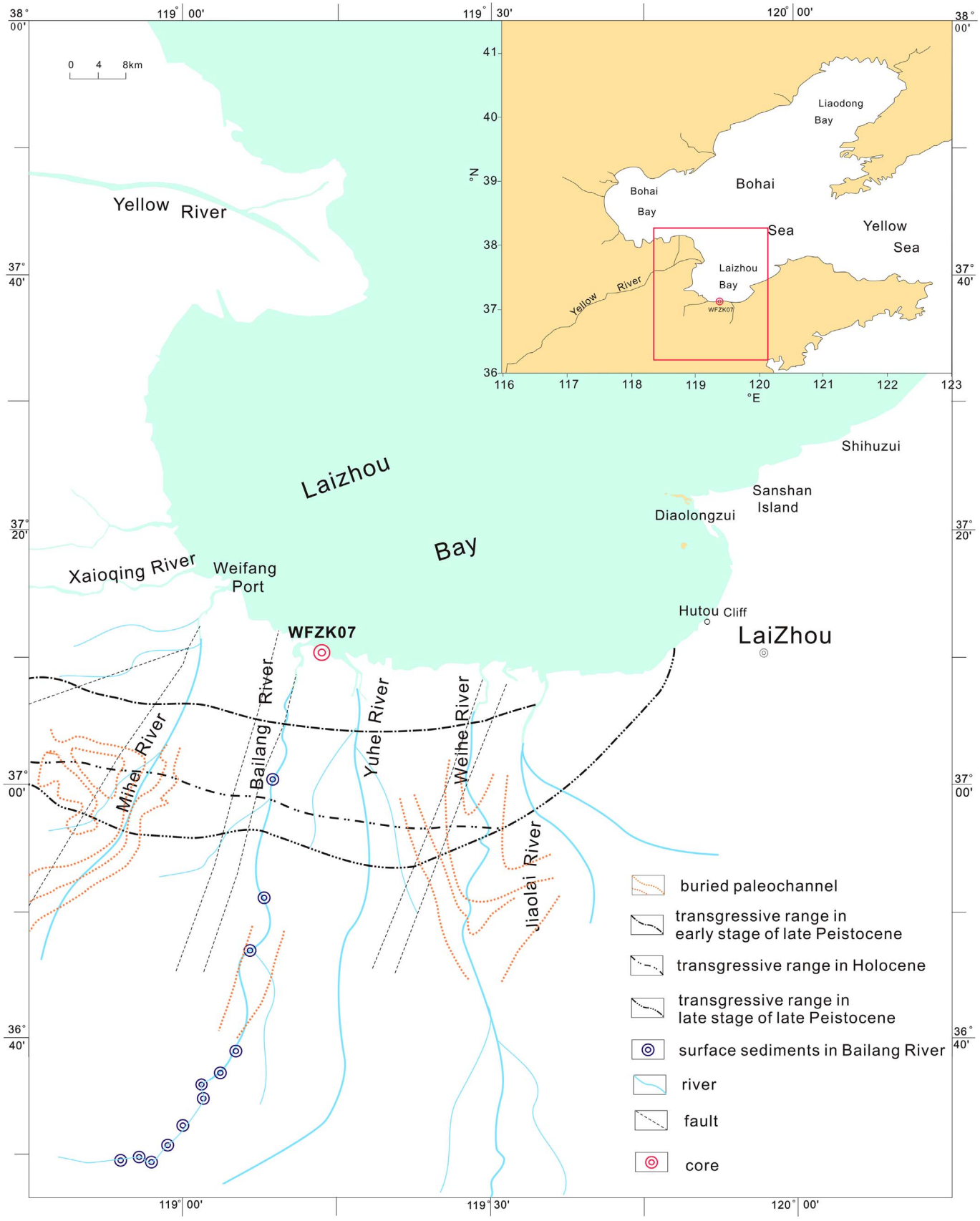

Fig. 1. The location of core 07 and sampling of sediments in Bailang River.