Estuarine, Coastal and Shelf Science 169 (2016) 106–118

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

The distribution characteristics of rare metal elements in surface sediments from four coastal bays on the northwestern South China Sea

Shuhong Wang [a, b], Jin Li [a, c], Shuzhuang Wu [a, c], Wen Yan [a, *], Weixia Huang [a], Li Miao [a], Zhong Chen [a]

[a] CAS Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
[b] Key Laboratory of Marine Mineral Resources, Ministry of Land and Resources, Guangzhou 510075, China
[c] University of Chinese Academy of Sciences, Beijing 100049, China

ARTICLE INFO

Article history:
Received 27 April 2015
Received in revised form
6 November 2015
Accepted 2 December 2015
Available online 11 December 2015

Keywords:
Rare metal elements
Distribution and controlling factors
Mineralization potential
Coastal bay
Northwestern South China Sea

ABSTRACT

The distribution of rare metal elements (Zr, Sn, Ti, Y, Nb, Ta, Ce, La, Nd and Th) in surface sediments from four bays along the northwestern coast of the South China Sea allowed infer their main controlling factors and their mineralization potential as metals placer. The results revealed that their contents in surface sediments are very variable but show a clear geographic regularity. The average content of all elements in those areas decreases from the East to the West, with the minimum value of all elements in Leizhou Bay, the maximum value of Zr, Y, La, Ce, Nd and Th in Zhanjiang Bay, and the maximum values of Sn, Ti, Nb and Ta in Hailing Bay. The relative enrichment of these elements in two easternmost bays (Hailing Bay and Shuidong Bay) are attributed to the southwest alongshore current, which drain and transport terrigenous sediments from the granite region of the South China into these two bays. The correlation results between all element contents and fine sediment fraction (<63 μm) suggested that the main factors controlling the distribution of Ti, Nb and Sn should be the fine fraction of the sediment, but alternatively Zr, Y, La, Ce, Nd and Th are rich in heavy minerals and/or bioclasts, and Ta maybe affected by both. Detail analysis shows that sediments from Hailing Bay may contain abundant zircon, cassiterite, ilmenite (or rutile), xenotime, monazite, niobium tantalite and other rare metal minerals, with a good prospect as a rare metal placer resource, and the zircon, xenotime and monazite may also have good metallogenic prospects in Shuidong Bay and in the local area of Zhangjian Bay.

1. Introduction

Rare metal elements (RME) usually refer to those that are less abundant or of scattered distributing in nature, such as the titanium (Ti), vanadium (V), niobium (Nb), tantalum (Ta), zircon (Zr), hafnium (Hf), tungstern (W), molybdenum (Mo), lithium (Li), beryllium (Be), rare earth elements (REEs) and so on. RME are not the main component in minerals due to their low abundance in nature, and occur mainly dispersed and complex (Li et al., 2011). They occur often closely associated with other strategic metal deposits, for example, niobium, tantalum, yttrium, zirconium and titanium are often associated with some metal elements forming high utilization value minerals. RME are therefore often employed as indicators of metallic deposits (Murton, 2000).

Marine rare metal placer is a main raw material extracting rare metals, but there is little research on the rare metal elements in the marine environment. The ocean sediments are the carrier of a variety of metal elements and minerals. RME marine placers are one of the main types of marine placers that are formed in favorable coastal conditions, whenever local marine hydrodynamic and other factors promotes the re-concentration and deposition of some strategic metals (Ti, Zr, Nb, Ta and rare earth, etc.) (Rona, 2008). The exploitation of marine placers is one of the most important sources for RME worldwide (Rona and Lenoble, 2004). RME marine placers are found in continental shelves in all passive continental margins, and the most commercially valuable minerals are ilmenite, rutile, magnetite, cassiterite, ziron, monazite, xenotime, niobium tantalite, gold and platinum (Baturin, 2000; Murton, 2002; Rona, 2003,

* Corresponding author.
E-mail address: wyan@scsio.ac.cn (W. Yan).

http://dx.doi.org/10.1016/j.ecss.2015.12.001
0272-7714/

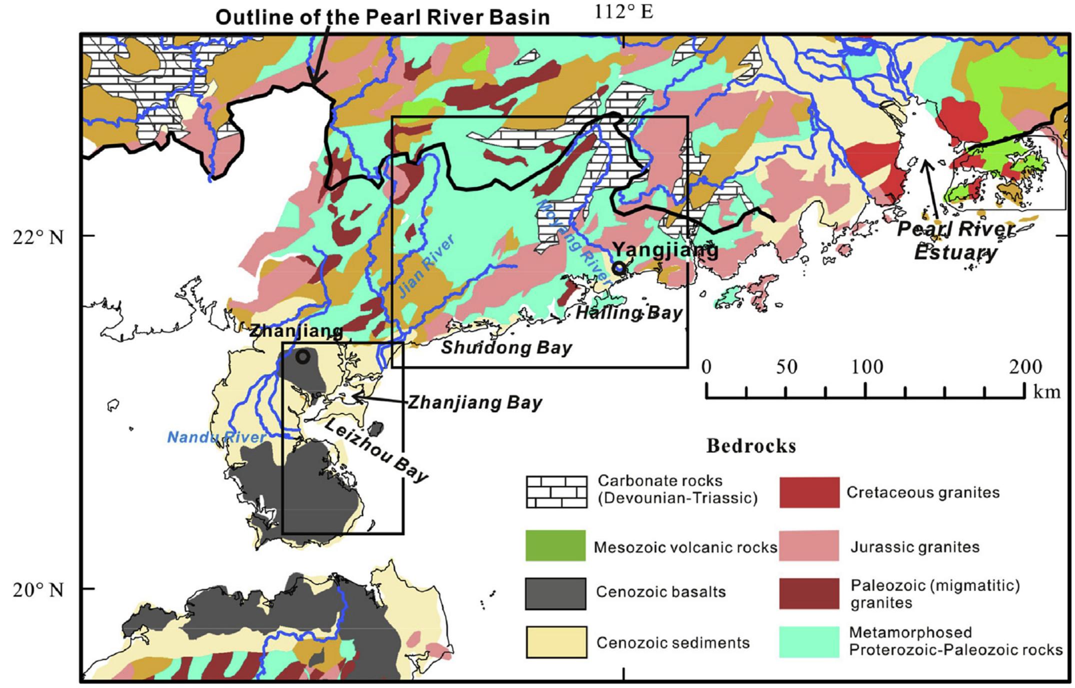

Fig. 1. Simplified bedrock geologic map of four coastal bays along the northwestern South China Sea (Ma, 2002).

2008; Chen et al., 2006). The controlling factors that constrain the mineralization, the source, transport, deposition and occurrence of RME in marine sediments is therefore very important to identify and evaluate the resource potential of marine RME placers.

The South China Sea (SCS) is one of the largest marginal seas in the Western Pacific, and the northern SCS has a long coastline with a wide shelf (Tamaki and Honza, 1991; Zhou and Yao, 2009; Franke et al., 2011). Some coastal RME-rich placers, such as ilmenite, rutile, cassiterite, zircon, monazite, xenotime and niobium tantalite, were identified in the northern SCS (Sun and Han, 1999; Huang, 2007). However, the evaluation of the potential for these metal placer resources in northern SCS continental shelf is still very low, and the knowledge of their distribution and genetic mechanism is unclear (Chen et al., 2006; Huang, 2007). Liang et al. (1988) has analyzed the geochemical characteristics of Zr and obtained the benefit area of zircon enrichment. Zhu et al. (2007) analyzed the distribution characteristics of Nb, Ta, Zr and Y in the surface sediments of continental shelf in the South China Sea. However, the samples number are insufficient, and the systematic and regularity are not obvious in this research, so the results can not reveal the distribution of rare metal placer. REEs have been widely used to investigate the chemical evolution of continental crust, tectonic setting, chemical weathering in drainage basins, and sediment sources (Wu, 1983; Zhao et al., 1990a, b; Li, 2001). But the RME study in the REEs is also rarely (Zhang, 2014). This shows that current research about RME still very weak. The continental shelf is characterized by the high frequency of near-shore bays that constitute important environmental units where strong interaction between land and sea controls coastal sedimentary processes and the occurrences and characteristics of the RME-rich placers (Yan et al., 2012). The investigation of the source transport and deposition controlling factors of RME in coastal bay sediments is fundamental to better understand the mineralization potential and resource perspective of the RME in continental shelf of the northern SCS. Some RME (Zr, Sn, Ti, Y, Nb, Ta, Ce, La, Nd and Th) in the surface sediments from four typical coastal bays in the northwestern SCS (also commonly known as the Western Guangdong) were analyzed in this study with the following main objectives: (1) understand the spatial distribution and variations of these elements in the surface sediments; (2) determine the key controlling factors responsible for the distribution of these elements; and (3) evaluate the mineralization potential of RME placer in the shelf sediments of those areas.

2. Geological setting, and materials and methods

2.1. Geological setting

In the western Guangdong Province, dominant bedrocks are the Jurassic granite rocks and the metamorphosed Proterozoic-Paleozoic rocks (Fig. 1). Carbonate rocks are sparsely distributed in the Basin of Moyang River. In the upper Moyang River, intermediate igneous rocks exposed in some rifted basins. In the west, metamorphic rocks are widely distributed, especially in the Basin of Jian River. The protolith is the Proterozoic and Paleozoic sedimentary rock and complex metamorphism occurred in the late Paleozoic and Mesozoic era. Cenozoic basalts cover the southern Leizhou Peninsula.

2.2. Sample collection

A total of 55 surface sediment samples were collected using a box-corer sampler along the northwestern coast of the SCS (Fig. 2) in autumn 2008, within the Guangdong Province 908 Special Project on Investigation and Research of Water Environment. Based on spatial distribution of the sampling sites, the sample region was divided in two areas (Fig. 1): Area I includes Leizhou Bay (LZ) and Zhanjiang Bay (ZJ); Area II includes Shuidong Bay (SD) and Hailing Bay (HL). Leizhou Bay is surrounded by the Chengyue River, Tongming River and Nandu River; Zhanjiang Bay is fringed by the Suixi River and other small streams; The Fengtou River and Moyang River are main rivers into the sea of the Hailing Bay. But the runoff effect of these rivers is very weak in these Bays. There is no big river