Continental Shelf Research 88 (2014) 185–202

Contents lists available at ScienceDirect

Continental Shelf Research

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

Research papers

The surface sediment types and their rare earth element characteristics from the continental shelf of the northern south China sea

Shuhong Wang [a], Nan Zhang [a,b], Han Chen [a,b], Liang Li [a,b], Wen Yan [a,*]

[a] Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China;
[b] University of Chinese Academy of Sciences, Beijing 100049, China

ARTICLE INFO

Article history:
Received 6 January 2014
Received in revised form
11 August 2014
Accepted 12 August 2014
Available online 23 August 2014

Keywords:
Rare earth element (REE)
Sediment types
Provenance analyses
Continental shelf
Northern South China Sea

ABSTRACT

The grain size as well as some major and trace elements, including rare earth element (REE), for 273 surface sediment samples collected from the continental shelf of the northern South China Sea were analyzed in this study. The sediment types are mainly sandy silt and silt, making up 60% of the whole samples, and secondly are mud, sandy mud, muddy sand and silty sand, making up 28% of the whole samples, based on grain-size in which the Folk's classification was used. The total REE content (ΣREE) show a wide variation from 21 ppm to 244 ppm with an average value of 155 ppm, which similar to the average ΣREE of the China loess, but much different from that in deep-sea clay, showing a significant terrigenous succession. The REE contents in different sediment types vary greatly, mainly enriching in silt, sandy silt, mud and sandy mud. The REE distribution contours parallel to the coastal, presenting like strips and their contents gradually reduce with increasing distance from the coast. The high content of the western Pearl River Mouth, Shang/Xiachuan Islands and Hailing Bay might be regarded to the coastal current developed from the east to the west along to the Pearl River Mouth in the northern South China Sea. But the chondrite-normalized REE patterns in various sediment types have no difference, basically same as those of coastal rivers and upper crust. They all show relative enrichments in light rare earth element (LREE), noticeable negative Eu anomaly and no Ce anomaly, indicating that those sediments are terrigenous sediments and from the same source region. Further analysis suggest that the sedimentary environment in the study area is relatively stable and granite widely distributed in the South China mainland is the main source of REE, which are transported mainly by the Pearl River. The late diagenesis has little effect on the REE.

1. Introduction

Rare earth element (REE, from La to Lu) are a coherent group of trace elements, which have similar chemical and physical properties including low solubility and they have been widely used to investigate the geochemical evolution of the continental crust as well as chemical weathering in drainage basins (Taylor and McLennan, 1985; McLennan, 1989; Delgado et al., 2012). In the study of oceanic sediments, the REE have become accepted as a reliable tool for determining depositional processes and sediment provenance (Elderfield et al.,1990, Prego et al., 2009; Liu et al.,2013), also for understanding paleoenvironmental changes in more detail, because of their conservative behavior (especially their immobility in water) during sediment formation (Taylor and McLennan, 1985). However, the REE compositions can also be affected by post-depositional diagenetic processes including changes in redox conditions and the formation of authigenic minerals (Piper, 1974; Murray et al., 1991; Haley et al., 2004), which restrict their usage as provenance tracers in deep sea sediments. In the early time, there are only a few studies about the REE geochemistry of sediments in the South China Sea (Gu et al., 1989; Zhao et al., 1990; Liu et al., 1999). Gu et al., (1989) analyzed the REE content of 94 samples from the whole South China Sea and found that the REE average value was 152 ppm and the high levels and sub-high levels of the REE mainly distributed in the inner shelf and sea basin, which primarily related to fine-grained sediments, whereas the middle levels and low levels distributed in the fine-grained sediments of the southeastern central basin and Zhongsha and Xisha, which probably related to volcanic material mixed. They suggested the Mesozoic granitoids debric widely distributed in the coastal surface sediments of the South China was the main source of the REE. Zhao et al., (1990) used 23 representative samples of continental shelf sediments from the Bohai Sea, Yellow Sea, East Sea and South China Sea to discuss the REE content and characteristics of the China Seas. The results showed that the REE average values was 156 ppm, the ΣREE of the

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

http://dx.doi.org/10.1016/j.csr.2014.08.005
0278-4343/

Bohai Sea and South China Sea was higher, and the REE content increased with the grain size from coarse to fine. Liu et al., (1999) researched the distribution characters and model of REE in surface sediments from Lingdingyang area of Pearl River Estuary and showed that the REE content change widely with average value 272 ppm, which is far higher than the REE average content in crust and in granite of the South China area. They suggested the high REE content was related to watershed material sources. While in recent years, focusing on the South China Sea sedimentary environments and processes, and resource exploration, some researches have been carried out in different perspectives on the REE geochemical characteristics of sediments from different areas, including the whole South China Sea (Zhu et al., 2007; Liu et al., 2010; Liu et al., 2013), southwestern South China Sea (Cai et al., 2010), Shenhu area of South China Sea (Zhao et al., 2010), bays along the coast of Guangdong Province (Yan et al., 2012), Nandu River of Hainan (Ma et al., 2010), high-standing island of Taiwan (Li et al., 2013), and so on. All results showed that the terrigenous input is the main source of the South China Sea sediment, the REE distribution are controlled by volcanic and biological sedimentary and sediment transport and sorting effected by coastal rivers and ocean currents.

The continent shelf of the northern South China Sea is relatively flat and wide, accepting the weathering and erosion product from the Pearl River and the surrounding land. And its complex provenance and the hydrodynamic conditions make it play an important role in analyzing the source, migration and accumulation of sediments in the South China Sea. However, most of researches related to REE are currently limited to a specific region or geographical environment and there is almost no detailed analysis on REE characteristics of different sediment types. Thus, the comprehensive understanding of the REE distribution of the whole continental shelf and their possible implication in the geological environment are very lacking.

In this study, the high density sediment samples were collected in the mid-western continental shelf of the northern South China Sea where the water depth is less than 100 m. In order to get deeper understanding about the sediment provenance and sediment environment of the continental shelf in the northern South China Sea, the general characteristics of the REE geochemistry and the REE characteristics in the different sediment types are systemically discussed based on the sediment grain size analysis and the sediment types discrimination.

2. Materials and methods

2.1. Sample collection

A total of 273 surface sediments (0–5 cm) from the continental shelf (19°∼23°N, 110°∼116°E) of the northern South China Sea were collected by the 20 cm × 20 cm grab, and the upper 5 cm of the sample were collected for analysis of grain size and elements. The station distribution is shown in Fig. 1. The sampling sites chosen in this study are less influenced by human disturbance and shallower than 100 m depth contour and mainly distribute in the coastal water of the western Guangdong and the eastern Hainan Island. The study area is relatively flat terrain and distributes many rivers. The northern and western of the study area are surrounded by strongly eroded land area and the continent is very rich in material supply (Liang et al., 1986).

2.2. Grain size

The grain size is determined in CAS Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences. Sediment samples were pre-treated in a solution of 10% H_2O_2 prior to granulometric analysis using a Mastersizer2000 analyzer. As the range of grain size measurement was 0.02–2,000μm, at 1ϕ intervals, the samples were separated into two parts according to the grain size. Samples within this range were measured directly, while the samples with coarse particle (> 2,000μm) were sieved with a sieve meth of 1 mm, and then the part over the sieve was analyzed with standard sieving methods, and the part below the sieve was measured directly, then using simulated program of Mastersizers2000 to combine the two parts data and get the whole grain size. Triplicate analyses were performed on each sample, and the mean values of each parameter were calculated, the associated standard deviations were < 3%.

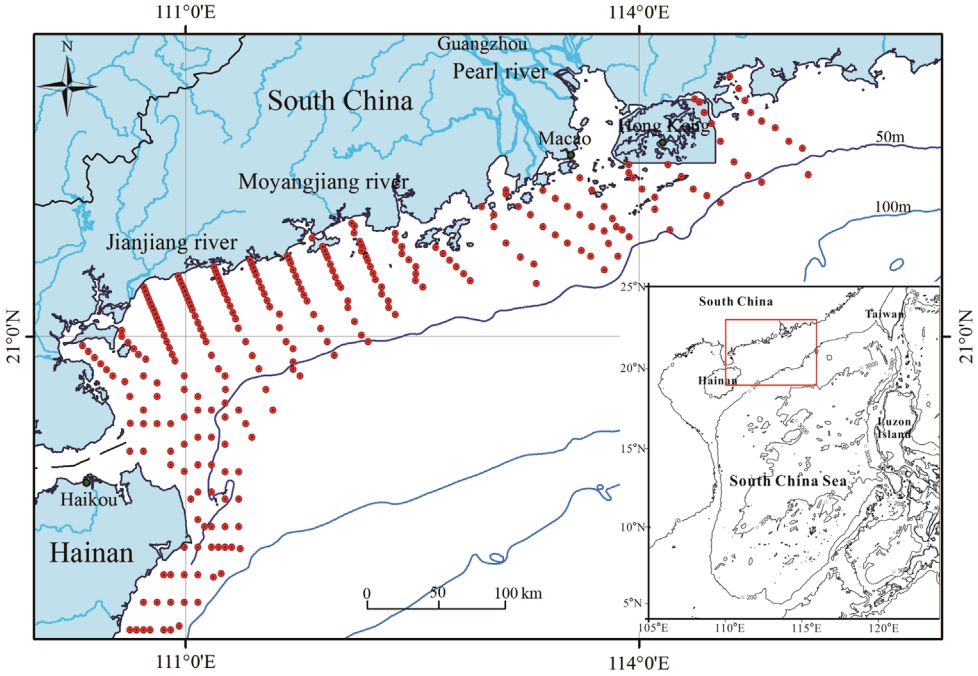

Fig.1. Sample location for surface sediments of the continental shelf of the northern South China Sea.