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Elemental compositions of crab and snail shells from the Kueishantao hydrothermal field in the southwestern Okinawa Trough

Zhigang Zeng [a,b,c,d,*], Yao Ma [a,c], Xiaoyuan Wang [a,b], Chen-Tung Arthur Chen [e], Xuebo Yin [a], Suping Zhang [f], Junlong Zhang [f], Wei Jiang [f]

[a] Seafloor Hydrothermal Activity Laboratory of the Key Laboratory of Marine Geology and Environment, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China
[b] Laboratory for Marine Mineral Resources, Qingdao National Laboratory for Marine Science and Technology, Qingdao, 266071, China
[c] University of Chinese Academy of Sciences, Beijing 100049, China
[d] Qingdao Collaborative Innovation Center of Marine Science and Technology, Qingdao 266061, China
[e] Department of Oceanography, National Sun Yat-Sen University, Kaohsiung 80424, Taiwan, China
[f] Marine Biological Museum, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China

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ABSTRACT

To reveal differences in the behavior of benthic vent animals, and the sources and sinks of biogeochemical and fluid circulations, it is necessary to constrain the chemical characteristics of benthic animals from seafloor hydrothermal fields. We measured the abundances of 27 elements in shells of the crab *Xenograpsus testudinatus* and the snail *Anachis* sp., collected from the Kueishantao hydrothermal field (KHF) in the southwestern Okinawa Trough, with the aim of improving our understanding of the compositional variations between individual vent organisms, and the sources of the rare earth elements (REEs) in their shells. The Mn, Hg, and K concentrations in the male *X. testudinatus* shells are found to be higher than those in female crab shells, whereas the reverse is true for the accumulation of B, implying that the accumulation of K, Mn, Hg, and B in the crab shells is influenced by sex. This is inferred to be a result of the asynchronous molting of the male and female crab shells. Snail shells are found to have higher Ca, Al, Fe, Ni, and Co concentrations than crab shells. This may be attributed to different metal accumulation times. The majority of the light rare earth element (LREE) distribution patterns in the crab and snail shells are similar to those of Kueishantao vent fluids, with the crab and snail shells also exhibiting LREE enrichment, implying that the LREEs contained in crab and snail shells in the KHF are derived from vent fluids.

1. Introduction

Hydrothermal vents associated with volcanic arcs, back-arc basins (BABs) and mid-ocean ridges (MORs) host diverse organisms including crabs, clams, mussels, shrimps, tube worms, limpets, cyclopoid copepods, and snails (e.g., Rio et al., 1992; Company et al., 2006; Cravo et al., 2007; Cravo et al., 2008; Cunha et al., 2008; Lietard and Pierre, 2009; Marchand et al., 2009; Jacobson et al., 2012; Forget and Juniper, 2013; Mantha et al., 2013). Characterizing the chemical compositions of the benthic animals that inhabit seafloor hydrothermal fields is essential for understanding their biomineralization processes, any changes in the physico-chemical conditions of the seafloor environment, the bioaccumulation of metals, and the chemical transport of global hydrothermal systems (e.g., Hongo and Nozaki, 2001; Bau et al., 2010; Demina et al., 2012). Only a few organisms are able to survive in the low-pH, high-sulfur and metal-enriched environment of the Kueishantao hydrothermal field (KHF) (Chen et al., 2005a, Chen et al., 2005b; Zeng et al., 2007, 2011, 2013; Peng et al., 2011). These include the snail *Anachis* sp. and the crab *Xenograpsus testudinatus* (Ng et al., 2000). The concentrations of metals in the tissues and shells of hydrothermal crabs have been determined in previous studies (e.g., Colaço et al., 2006; Peng et al., 2011). However, very little is known about the ecology of the KHF, and the biological and chemical characteristics of the seafloor hydrothermal vent crab *Xenograpsus testudinatus* (Jeng et al., 2004; Hwang et al., 2008). Peng et al. (2011) reported bioaccumulation of

* Corresponding author at: Key Laboratory of Marine Geology and Environment, Institute of Oceanology, Chinese Academy of Sciences, 7 Nanhai Road, Qingdao 266071, China.
E-mail address: zgzeng@ms.qdio.ac.cn (Z. Zeng).

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trace metals in the crab. They found that the metal concentrations varied significantly with the type of crab tissue; the Al, Cd, Co, Cu, Fe, Ni, and Zn concentrations were highest in the gills, which suggested metal accumulation via the respiratory system, rather than by the uptake of food, whereas the Mn concentration was highest in the exoskeleton. The distribution patterns of metals varied between the gills and the exoskeleton due to the different pathways of metal utilization in the different crab tissues (Peng et al., 2011). Furthermore, the crabs showed high digestive capacities of major digestive enzymes, and particularly high activities for proteolytic enzymes, which are likely to be adaptations to irregular food availability (Hu et al., 2012).

Despite these previous studies, little is known about the role of host-rock and fluid and/or plumes in the life history of vent crabs and snails, and the biological and chemical characteristics of snails in the KHF. In this study, we have determined the major, trace, and rare earth element (REE) compositions of shells of the crab *X. testudinatus* and the snail *Anachis* sp. from the KHF, in an effort to understand the compositional variations between individual vent organisms, and reveal the sources of the rare earth elements (REEs) that are incorporated into the shells of seafloor hydrothermal vent crabs and snails. In addition, this is the first geochemical study of *Anachis* sp. from the KHF.

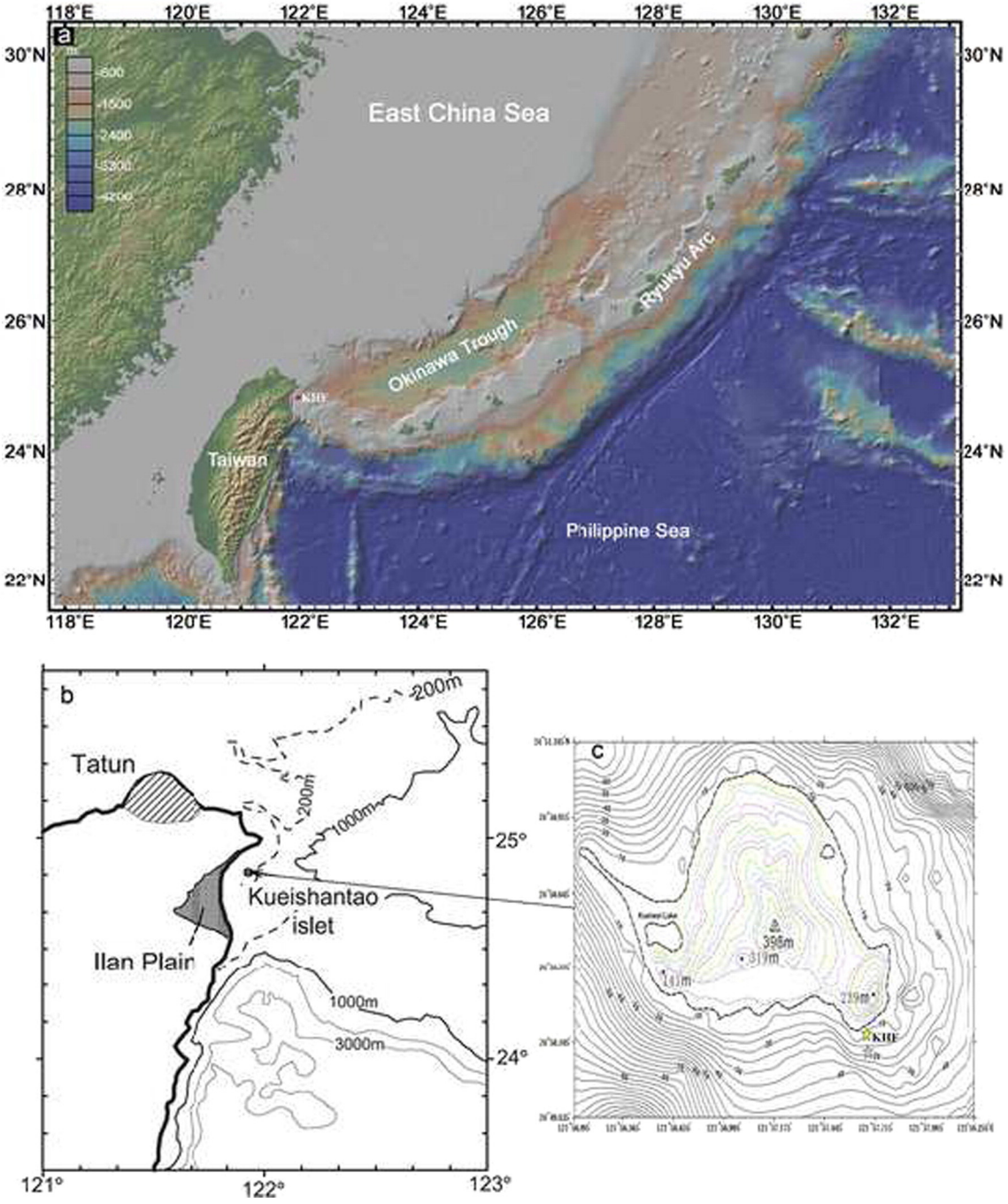

Fig. 1. (a) Map showing Taiwan and the location of the Okinawa Trough (bathymetric map and data from http://www.geomapapp.org/index.htm). (b) Bathymetric map showing the tectonic setting and location of Kueishantao Islet (from Chen et al., 2005a). (c) Locations of springs in the Kueishantao hydrothermal field (KHF). The yellow star indicates a yellow-spring site (108 °C) and the white star indicates a white-spring site (51 °C) (based on Zeng et al., 2013).

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