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Geochemistry and petrogenesis of volcanic rocks from Daimao Seamount (South China Sea) and their tectonic implications

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ABSTRACT

The South China Sea (SCS) experienced three episodes of seafloor spreading and left three fossil spreading centers presently located at 18°N, 17°N and 15.5°N. Spreading ceased at these three locations during magnetic anomaly 10, 8, and 5c, respectively. Daimao Seamount (16.6 Ma) was formed 10 my after the cessation of the 17°N spreading center. Volcaniclastic rocks and shallow-water carbonate facies near the summit of Daimao Seamount provide key information on the seamount's geologic history. New major and trace element and Sr–Nd–Pb isotopic compositions of basaltic breccia clasts in the volcaniclastics suggest that Daimao and other SCS seamounts have typical ocean island basalt-like composition and possess a 'Dupal' isotopic signature. Our new analyses, combined with available data, indicate that the basaltic foundation of Daimao Seamount was formed through subaqueous explosive volcanic eruptions at 16.6 Ma. The seamount subsided rapidly (>0.12 mm/y) at first, allowing the deposition of shallow-water, coral-bearing carbonates around its summit and, then, at a slower rate (<0.12 mm/y). We propose that the parental magmas of SCS seamount lavas originated from the Hainan mantle plume. In contrast, lavas from contemporaneous seamounts in other marginal basins in the western Pacific are subduction-related.

1. Introduction

The origins of marginal or backarc basins in the western Pacific and the many features of these basins are still poorly understood (Hall, 2002; Karig, 1971). For example, volcanic seamounts near fossil spreading centers are common in the Oligocene to Miocene South China Sea (SCS), Shikoku and Sea of Japan basins, but their origin and geodynamic importance are still debated (e.g., Ishizuka et al., 2009; Tu et al., 1992; Yan et al., 2008a, b, 2014). In the Shikoku and Sea of Japan basins, seamounts were formed immediately after the cessation of seafloor spreading (e.g., Ishizuka et al., 2009; Kaneoka et al., 1990; Klein et al., 1978; Pouclet et al., 1995). In the SCS, however, three fossil spreading centers and a number of seamounts were formed ~6–12 my after the cessation of spreading (Briais et al., 1993; Yan et al., 2008b). Studies on their petrogenesis and geodynamic significance have been limited because of the dearth of samples and the fact that these had been dredged from relatively imprecise locations (e.g., Shi and Yan, 2011; Tu et al., 1992; Wang et al., 1984; Yan et al., 2008a, b, 2014).

Here we present new observations as well as major-trace element and Sr–Nd–Pb isotopic analyses of individual basaltic lava breccias as well as bulk volcaniclastic rocks. These rocks have recently been sampled *in situ* from Daimao Seamount through shallow core drilling by *R/V Ocean No. 6*, Guangzhou Marine Geological Survey, Ministry of Land and Resources of the People's Republic of China. We combined our new analyses with available geochemical data for samples previously dredged from SCS seamounts and geophysical data for the SCS to constrain the origin and evolution of Daimao and other seamounts in the SCS. Our results are highly consistent with the recently proposed regional tectonic evolution of the SCS region (Yan et al., 2014).

2. Geological setting and sample description

The SCS is one of the largest marginal basins in the western Pacific (Fig. 1). It was formed by the southeastward rifting of several microcontinental blocks and subsequent seafloor spreading from ~37 Ma to ~16 Ma (Briais et al., 1993; Cande and Kent, 1995; Hsu et al., 2004). During the Cenozoic, the SCS underwent three episodes of seafloor spreading (Briais et al., 1993). Spreading ceased at present day 18°N (magnetic anomaly 10) in the northwest sub-basin and commenced at present day 17°N (magnetic anomaly 8) in the east sub-basin at ~30 Ma. Spreading ceased again at 17°N and commenced at present day 15.5°N in the east sub-basin and in the southwest sub-basin at ~26–24 Ma. Spreading finally stopped at 16 Ma (magnetic anomaly 5c) (Cande and Kent, 1995; Hsu et al., 2004), leaving three fossil spreading centers within the basin (Fig. 1).

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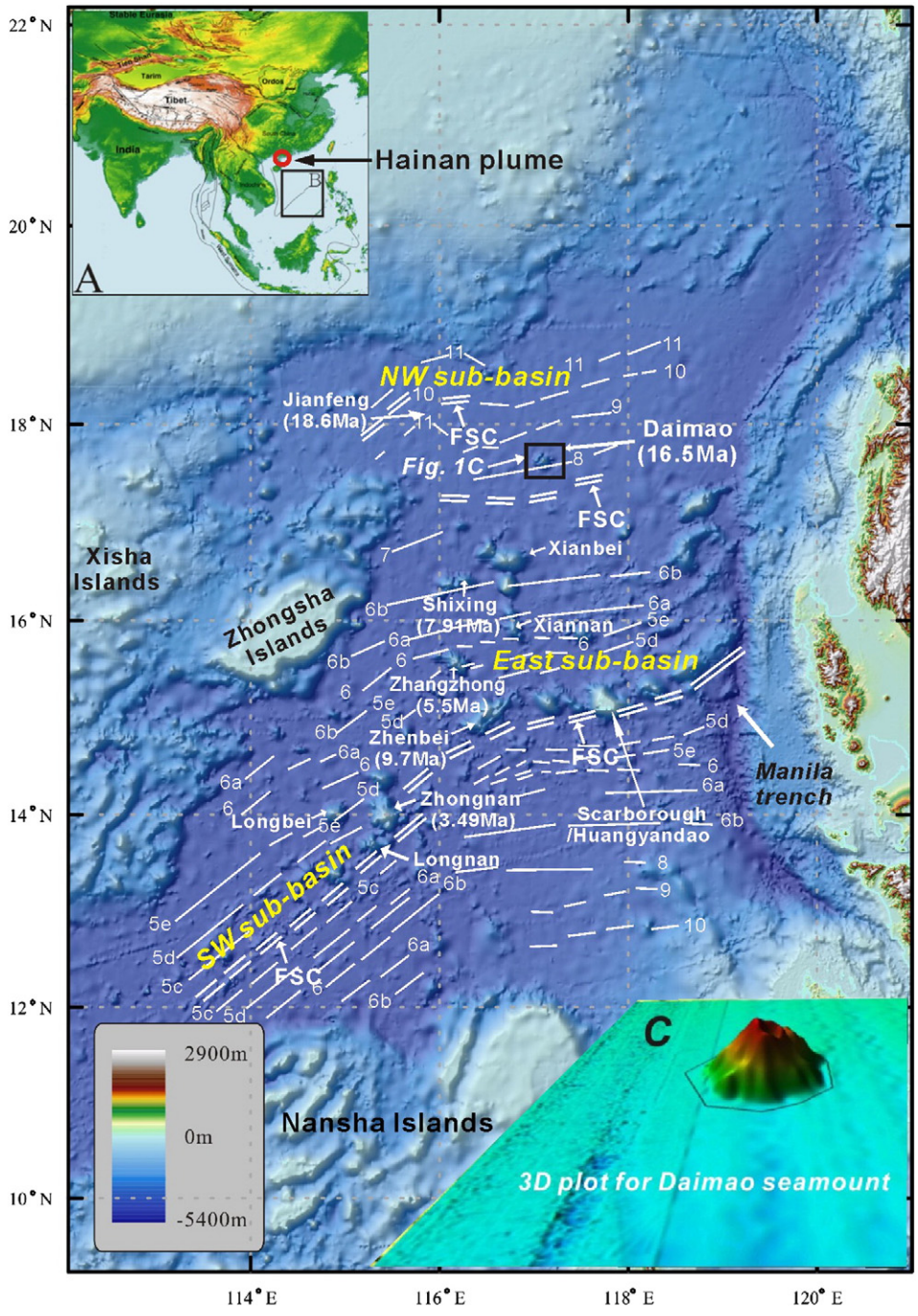

Fig. 1. (A) Tectonic location of the SCS, and (B) geological map of the South China Sea (SCS) and drilling location in Daimao Seamount. The magnetic anomaly lines are gray lines and spreading axes are white double lines. There are three fossil spreading centers: the first one is oriented E–W in the northwest (NW) sub-basin; the second one is oriented E–W in the east sub-basin (near the present 17°N); and the third one is also in the east sub-basin (15.5°N) but extends southwestward into the southwest (SW) sub-basin. Data are from Briais et al. (1993). The ages of seamounts obtained by previous dating investigations (Yan et al., 2008b) are also shown. (C) 3-D plot of Daimao Seamount.

In addition to seafloor spreading magmatism, within plate magmatism is also associated with the history of the SCS basin. Prior to Cenozoic spreading (60–43 Ma or 32 Ma), bimodal volcanics formed along the northern margin of the SCS (e.g., Chung et al., 1997; Zhou et al., 2009). After the cessation of spreading, intraplate volcanism occurred around the SCS (e.g., Pearl River Mouth Basin, Leiqiong Peninsula, Beibu Gulf, Indochina block — Flower et al., 1992; Hoang and Flower, 1998; Lee et al., 1998; K.L. Wang et al., 2012; X.-C. Wang et al., 2012; Zhou and Mukasa, 1997; Zou and Fan, 2010; Zou et al., 1995; along the coastal areas of the Fujian Province — Ho et al., 2003; Zou et al., 2000, 2004), near and/or along the 15.5°N fossil spreading center (Tu et al., 1992; Yan et al., 2008a), and in Nansha islands (Kudrass et al., 1986). Based on a limited amount of age data (Wang et al., 1984; Yan et al., 2014), the seamounts generally show a younging trend from the northwest sub-basin to the Scarborough (Huangyandao in Chinese) seamount chain, approximately corresponding to the age of the underlying oceanic crust (inferred from magnetic anomalies; Fig. 1B). Consequently, the igneous rocks from SCS seamounts and volcanoes in the surrounding areas contain a record of the source and evolution of intraplate or post-spreading volcanism that commenced as early as ~18 Ma and still is currently active at the northern margin of the SCS and in the Indochina block.

Daimao Seamount is located near the 17°N fossil spreading center between the east and northwest sub-basins (Fig. 1) and was formed at 16.6 Ma (Table 1). It occupies an area of ~1400 km^2; its radius