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Review

The late Mesozoic–Cenozoic tectonic evolution of the South China Sea: A petrologic perspective

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ABSTRACT

This paper presents a review of available petrological, geochonological and geochemical data for late Mesozoic to Recent igneous rocks in the South China Sea (SCS) and adjacent regions and a discussion of their petrogeneses and tectonic implications. The integration of these data with available geophysical and other geologic information led to the following tectono-magmatic model for the evolution of the SCS region. The geochemical characteristics of late Mesozoic granitic rocks in the Pearl River Mouth Basin (PRMB), micro-blocks in the SCS, the offshore continental shelf and Dalat zone in southern Vietnam, and the Schwaner Mountains in West Kalimantan, Borneo indicate that these are mainly I-type granites plus a small amount of S-type granites in the PRMB. These granitoids were formed in a continental arc tectonic setting, consistent with the ideas proposed by Holloway (1982) and Taylor and Hayes (1980, 1983), that there existed an Andean-type volcanic arc during later Mesozoic era in the SCS region. The geochonological and geochemical characteristics of the volcanics indicate an early period of bimodal volcanism (60–43 Ma or 32 Ma) at the northern margin of the SCS, followed by a period of relatively passive style volcanism during Cenozoic seafloor spreading (37 or 30–16 Ma) within the SCS, and post-spreading volcanism (tholeiitic series at 17–8 Ma, followed by alkali series from 8 Ma to present) in the entire SCS region. The geodynamic setting of the earlier volcanics was an extensional regime, which resulted from the collision between India and Eurasian plates since the earliest Cenozoic, and that of the post-spreading volcanics may be related to mantle plume magmatism in Hainan Island. In addition, the nascent Hainan plume may have played a significant role in the extension along the northern margin and seafloor spreading in the SCS.

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1. Introduction

The South China Sea (SCS) is one of the largest marginal basins in the western Pacific. Since the Paleozoic era, the SCS and adjacent regions (henceforth termed the SCS region) experienced a complex tectonic evolution. As an important part of southeast Asia, the SCS region has been the focus of numerous Paleozoic and Mesozoic palaeogeographic reconstructions (e.g., Karig, 1971; Hamilton, 1979; Taylor and Hayes, 1983; Tapponnier, 1986; Yan and Shi, 2007; Hall et al., 2008; Zhou et al., 2008; Metcalfe, 2010; Morley, 2012; and references therein). Based on tectonostratigraphic, palaeobiogeographic and palaeomagnetic data, Metacalfe (1996, and references therein) suggested that the various pre-Cretaceous continental terranes of east and southeast Asia were all derived directly or indirectly from Gondwanaland and the northward drift of these terranes was accompanied by the opening and closing of three successive oceans - the Palaeo-Tethys, Meso-Tethys and Ceno-Tethys. In his tectonic evolution model, there existed a marginal basin (named the Proto-South China Sea) in late Cretaceous time that finally closed at the northwest Palawan trough by its subduction towards the Philippines and Borneo (Cullen, 2013).

During the Cenozoic era, the tectonic evolution of the SCS region was influenced by the collision between Indo-Australian and Eurasian plates and the ocean-ward retreat of the subduction zone of the Pacific plate (Lee and Lawver, 1994; Honza, 1995; Honza and Fujioka, 2004; Hall, 1996, 2002; Hall et al., 2008, 2009). Based on seafloor magnetic anomalies, Taylor and Hayes (1980, 1983) suggested that the seafloor spreading period in the SCS was at 32–17 Ma, but this was subsequently adjusted to 32–15.5 Ma by Briais et al. (1993), and further revised to 30–16 Ma based on the time scale of Cande and Kent (1995). Barckhausen and Roeser (2004) interpret cessation of SCS spreading at 20.4 Ma. A recent study, however, showed that the time for initial spreading could be as old as 37 Ma (magnetic anomaly C17) (Hsu et al., 2004). The spreading mode and dynamic setting of the SCS is currently still in debate (e.g., Karig, 1971; Taylor and Hayes, 1980, 1983; Tapponnier, 1986; Briais et al., 1993; Li et al., 1998; Yan and Shi, 2007).

Igneous activity plays an important role in plate reconstruction and regional tectonic evolution. In previous reconstructions of the SCS region, however, few petrological data were included. Zhou et al. (2005) and Yan et al. (2006) systematically summarized the temporal–spatial distribution of Mesozoic–Cenozoic magmatism in the region, but detailed petrogenetic discussions were not presented. The publication of new petrological data can provide a better understanding of the igneous activity in the region. The objective of this paper is to review recently published petrological