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Proterozoic tectonics of Hainan Island in supercontinent cycles: New insights from geochronological and isotopic results

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ABSTRACT

Hainan Island in southwestern south China has 1.43 Ga crystalline rocks as part of the Proterozoic basement rocks for the Cathaysia Block. Understanding Proterozoic tectonics of the island is thus essential for constraining the paleogeographic positions of the Cathaysia Block in Precambrian supercontinents. We report here new geochronological and Hf–O isotopic results for Mesoproterozoic gneisses, metavolcanic and metasedimentary rocks, and quartz sandstones from Hainan Island. Together with published data from the region, we divide Hainan Mesoproterozoic rocks into three major tectonostratigraphic units: (1) the amphibolite-facies Baoban Complex, consisting mainly of 1.43 Ga volcanic/plutonic rocks and sedimentary rocks formed in a continental rift setting but subsequently experienced high-grade metamorphism during 1.3–1.0 Ga; (2) the greenschist-facies Shilu Group, consisting of 1.43 Ga rift sediments with 1.44 Ga tuff in the "fifth layer" that are coeval with the protolith of the Baoban Complex, and ca. 1.0 Ga foreland basin sediments in the "sixth layer", all underwent upper greenschist-facies metamorphism soon after the deposition of the "sixth layer"; (3) the Shihuiding Formation that unconformably overlies the Shilu Group, consisting of <1.1 Ga (most likely ⩽1.0 Ga) coastal marine to lagoon sediments deposited in a post-orogenic setting. Inter-continental provenance and magmatic comparisons suggest a united Tasmania-Cathaysia-Laurentia landmass during the Mesoproterozoic, likely all received similar-sourced rifting sediments from Cathaysia-like basements during the Nuna breakup at ~1.43 Ga. The 1.3(?)–0.9 Ga Grenville-aged Sibao orogeny welded the Yangtze Block with the Cathaysia-Laurentia landmass, bringing Tasmania, Yangtze and the Cathaysia-Laurentia landmass together. Sedimentary detritus were shed from the orogen to basins covering Hainan Island, western Yangtze, Tasmania and western Laurentia during the assembling of Rodinia.

1. Introduction

The East and Southeast Asia region is tectonically one of the most complex regions on Earth (e.g., Metcalfe, 1996; Li et al., 2002a), being a collage of allochthonous continental blocks/terranes with variable Archean to Proterozoic crystalline basements. These include the North China, South China, Tarim, Indochina, Sibumasu, Qiangtang and Lhasa blocks (Fig. 1A inset). These terranes were mostly part of Gondwana during the early Paleozoic, but rifted apart and drifted northwards during the late Paleozoic to the Mesozoic (Metcalfe, 1996, 2013). Understanding the nature and evolution of these terranes are not only important for understanding the tectonic history of the region, but also crucial for establishing the various supercontinent cycles through Earth's history.

The study region, Hainan Island, is situated at the southern Cathaysia Block adjacent to the Indochina Block (Fig. 1A inset). Poor understanding on the geotectonic evolution of this island led to competing models regarding the assembly of the Asian continent and even supercontinent reconstructions. Some researchers divided Hainan Island into a northerly Qiongzhong terrane and a southerly Yaxian terrane (Fig. 2A) with both being Gondwana-affiliated but not amalgamated until either the Ordovician (Xu et al., 2014) or the mid-Cretaceous (Yang et al., 1989; Yu et al., 1990) along the east-west-trending Jiusuo-Lingshui Fault. Others divided Hainan Island into two Gondwana-affiliated terranes (the northwestern and southeastern Hainan terranes), which sutured along the northeast-southwest-trending Baisha Fault during the

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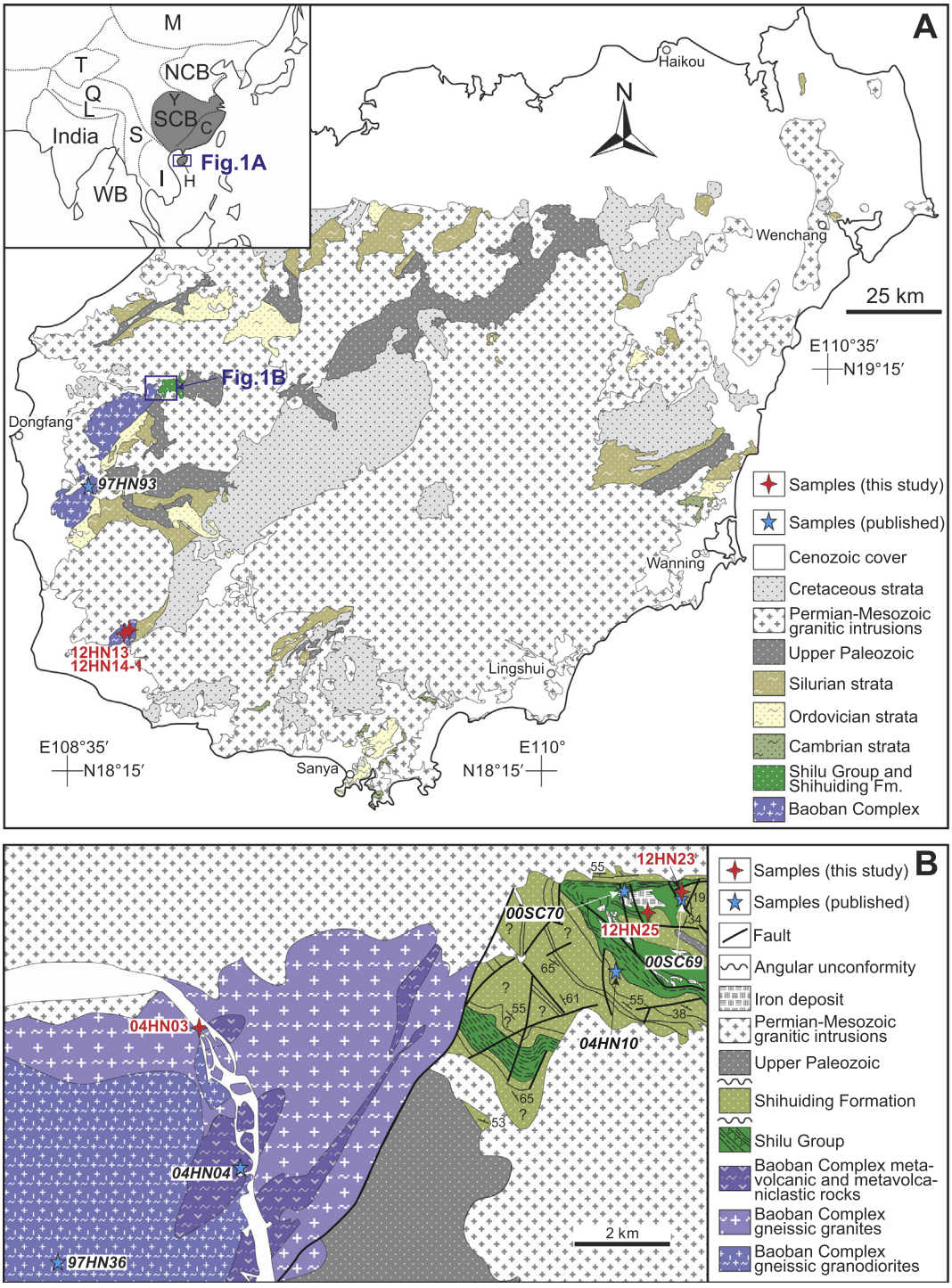

Fig. 1. (A) Simplified geological map of Hainan Island showing distribution of Mesoproterozoic crystalline basement rocks and Phanerozoic rock units. Published samples are from Li et al. (2002b, 2008d). Inset figure shows the current geographic sketch of major continental blocks/terranes of Southeast Asia, in which: NCB – North China Block, SCB – South China Block, Y – Yangtze, C – Cathaysia (including Hainan Island, shown as "H"), M – Mongolian terrane, T – Tarim, L – Lhasa, S – Sibumasu (including Qiangtang terrane, shown as "Q"), I – Indochina, WB – West Burma. (B) An enlarged geological map of western Hainan Island shows detailed contacting relationships between three Mesoproterozoic units and younger rocks, and sampling localities (after unpublished 1:50,000 geological maps for the Changjiang, Chahe and Dongfang sheets).

late Paleozoic (Fig. 2B; Metcalfe, 1994, 1996). Yet another group of researchers (Hsü et al., 1990; Chen et al., 1992; Li et al., 2002a) suggested that Hainan Island consists of a northern section as part of the coastal continental block (they called the Huanan block) and a southerly Gondwana-derived Dongnanya Block (eastern extension of Sibumasu?), the two of which collided during the Mesozoic along the so-called "Shilu mélange" belt (Fig. 2C). A major shortfall for all these models is that all the suggested suture zones (Fig. 2A-C) are interpreted fault zones based on geophysical data with little geological confirmation apart from relatively minor Cenozoic fault reactivation (Wang et al., 1991). The proposed Mesozoic "Shilu mélange" (Chen et al., 1992; Fig. 2C) was later proved to be a Mesoproterozoic metasedimentary and metavolcanic package (the Shilu Group; see Li et al., 2008d), therefore discrediting such Mesozoic collisional models (Hsü et al., 1990; Chen et al., 1992; Li et al., 2002a).