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Basaltic dykes of the Eastern Belt of Peninsular Malaysia: The effects of the difference in crustal thickness of Sibumasu and Indochina

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ABSTRACT

Basaltic dykes of Peninsular Malaysia are confined to the Eastern Belt (Indochina/East Malaya block) as compared with the Western Belt (Sibumasu Block). The dyke intruded through a crustal fracture formed by stress developed from the evolution of two offshore basins (Malay and Penyu basins) east of Peninsular Malaysia. The Ar–Ar dating from the present study combined with the previous geochronological data indicate that the ages of dykes range from 79 ± 2 Ma to 179 ± 2 Ma. Thus it is difficult to correlate the dykes with the closure of Tethys during Permo-Triassic time because of the younger age of the dykes. The majority of the dykes exposed in the Eastern Belt may have been attributed to the difference of crustal thickness between the Eastern and Western belt of Peninsular Malaysia. A thicker Western Belt crust (13 km more than both Eastern and Central belts) is difficult to rupture with normal plate tectonic stress and therefore serves to contain the rise of a mantle derived melt. The chemistry indicates the basalts are olivine to quartz normative and are of the continental within-plate category.

1. Introduction

Indochina, Thailand and Peninsular Malaysia and its offshore region of South East Asia located at the relatively stable Sundaland (Metcalfe, 2011). Sundaland is made up of several tectonic blocks such as South China block, Indochina–East Malaya block, Sibumasu block and SW Borneo block. These blocks originate from the India–Australian margin of eastern Gondwana and assembled by the closure of multiple Tethyan and back-arc ocean basins now represented by suture zones. Among the sutures are Song Ma, Nan Uttaradit, Bentong Raub and Sra Kaeo (Metcalfe, 2000, 2001, 2002, 2011). One of the common expressions of mantle magma generation related to crustal fracturing during extensional tectonics is the presence of basaltic dykes. Despite being abundant in many parts of the Southeast Asia, these dykes have been neglected to-date in regional models.

In Peninsular Malaysia, mafic dykes, intruding into both intermediate to felsic igneous rocks and older layered rocks, are found widely not only on the mainland, but also on several islands off the east coast of the peninsula (Fig. 1) (Lee, 1977; Haile et al., 1983; Ghani, 2000a,b, 2001a). Previous geochemical studies on basaltic dykes of the Peninsula are found in Haile et al. (1983) on the Kuantan dolerite as well as Ghani (2000a,b) and Ghani et al. (2002) on the dykes from Perhentian, Redang Islands and mainland Terengganu. Ghani (2000a,b) divided the dykes in into two main groups based on their relative age. These are: (1) the older dykes which are syn-plutonic, and (2) the younger dykes, which are post-plutonic to the host rock. The younger dykes constitute about 98% of the total dykes found in the Eastern Belt.

This paper will focus on the geochemistry of the younger dykes and its implication to regional tectonics. A comprehensive geochemical based study that includes all data for the younger dykes in this region and their correlation does not, as yet, exist. This paper reports an ongoing research of the basaltic to intermediate dyke magma that was emplaced throughout the latter half of the Mesozoic in Peninsular Malaysia. The dykes were not only restricted to the Cretaceous age but were also emplaced during the middle Jurassic. The study helps in understanding the characteristics of mafic magma emplaced during that time.

2. Tectonic setting and general geology

Peninsular Malaysia is traditionally subdivided into two north–south trending zones based on differences in magmatism, stratigraphy, mineralization and structure (Cobbing et al., 1992). The Peninsula is made up of two blocks, Sibumasu (Continental block derived from Gondwana) and Indochina (Arc terranes derived from Southchina or Indochina) blocks (Metcalfe, 2011). Sibumasu terrane of Peninsular Malaysia is part of the Sibumasu continental lithospheric terrane which also includes western

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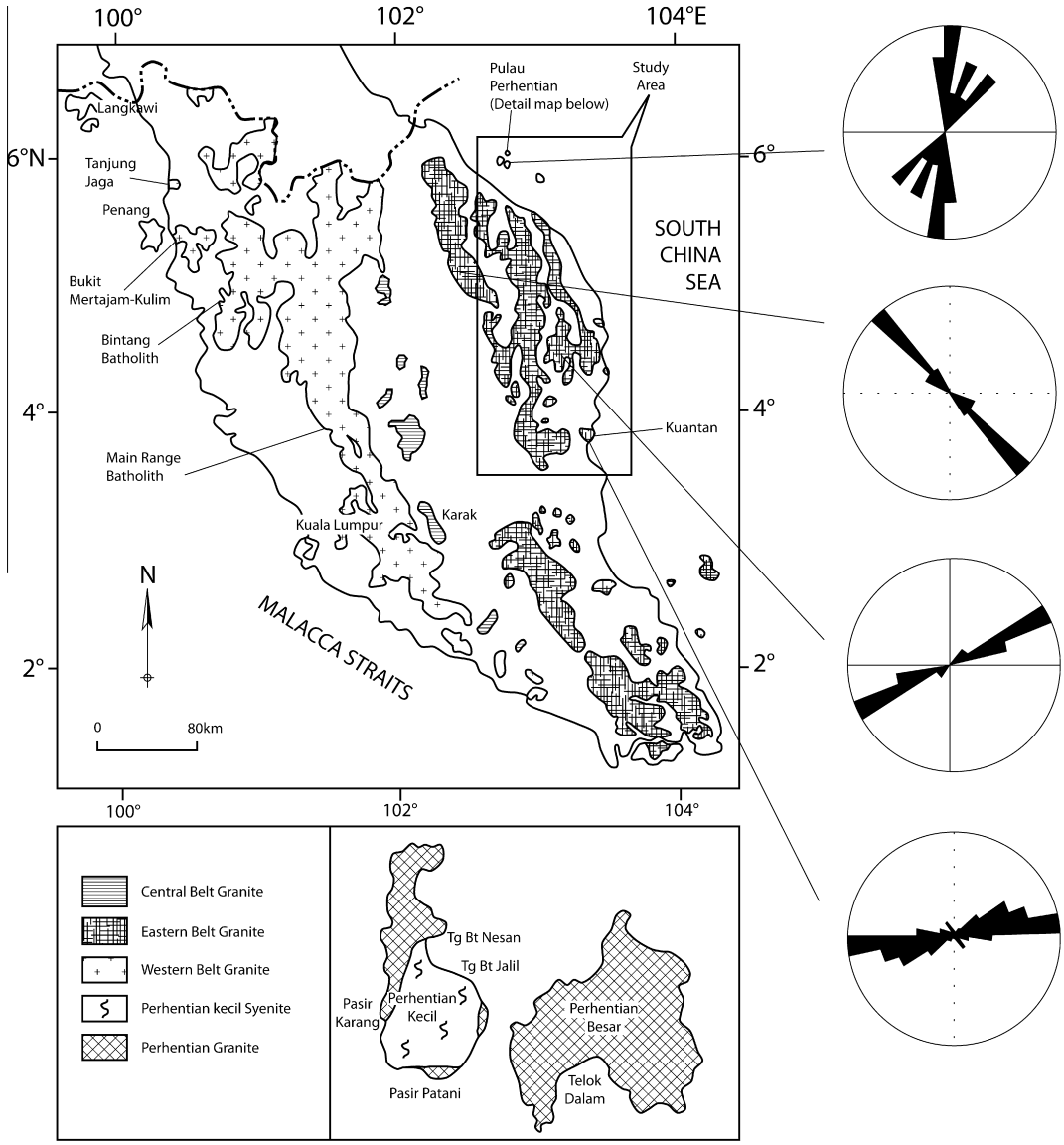

Fig. 1. Map of Peninsular Malaysia showing the study area where most of the dyke samples were collected. Also shown is the distribution of the granitic rocks from Peninsular Malaysia where most of the dykes intruded granites. The main trends of the dykes are shown in the Rose diagrams. Note the two different trends of northern and southern part of the study area.

Yunnan (Baoshan and Tenchong Blocks), the Shan States of Burma, northwest Thailand Peninsular Burma and Thailand (Metcalfe, 1986, 1988). The Indochina terrane of Peninsular Malaysia was interpreted as an arc terrane derived from South China or Indochina in the Carboniferous. These two terranes started to collide in lower Permian to middle Triassic which marked the closure of the Tethys Ocean (Metcalfe, 2000). These two terranes are separated by the Bentong-Raub suture that represents the main Devonian to Middle Triassic Paleo-Tethys Ocean (Metcalfe, 2000, 2011). The suture zone is a result of subduction of the Palaeo-Tethys ocean beneath Indochina during the early Permian and Triassic collision of the Sibumasu terrane with the Indochina block (Metcalfe, 2000).

The Sibumasu terrane, west of the Bentong Raub suture, is characterized by tin bearing, continental collision S-type granites, emplaced at around 200–220 Ma (Searle et al., 2012; Ghani et al., 2013a; Cottam et al., 2013). They have been interpreted as granites formed by crustal thickening and melting of the Sibumasu terrane following collision with Indochina and closing of the Bentong-Raub suture zone (Mitchell, 1977; Hutchison, 1978; Metcalfe, 2000; Searle et al., 2012). The main granite type is coarse megacrystic biotite granite and two-mica granite with SiO_2 content more than 67%. To the east of the suture in Indochina block, granites are older compared to those from the Western Belt, emplaced approximately at about 220–290 Ma and are mainly I-type granitic comprise of extended compositional spectrum from gabbro (±syenites) through granodiorite to monzogranite, usually forming small batholiths and plutons (Cobbing et al., 1992; Ghani, 2001b, 2009; Ghani et al., 2013b). The Eastern granite batholiths intrude into deformed, metamorphosed Carboniferous to Triassic sediments and volcanics. Mafic rocks associated with the Permian to Triassic granite constitute less than 5% of the total surface exposures. Rare occurrences of alkali series rock (syenite, monzonite and alkali gabbro) occur in Perhentian Island and Benom Complex (Ghani, 2001b; Mustafa and Ghani, 2003).

The granites, as well as sedimentary and metamorphic rocks of the Eastern Belt, have been intruded by a series of basaltic dykes with average thicknesses ranging from 10 cm to 20 m. The dykes do not occur only at the northeastern part of the Eastern Belt but are also found abundantly in the southeastern part of the Eastern