Earth-Science Reviews 115 (2012) 37–75

Contents lists available at SciVerse ScienceDirect

Earth-Science Reviews

journal homepage: www.elsevier.com/locate/earscirev

Late Cretaceous–Early Palaeogene tectonic development of SE Asia

C.K. Morley

PTTEP, 27th Floor, Enco Building, Soi 11, Vibhavadi-Rangsit Road, Bangkok, Thailand, 10900

ARTICLE INFO

Article history:
Received 7 December 2011
Accepted 1 August 2012
Available online 9 August 2012

Keywords:
Cretaceous
Palaeogene
Strike–slip
Khorat Group
Subduction
SE Asia

ABSTRACT

The Late Cretaceous–Early Palaeogene history of the continental core of SE Asia (Sundaland) marks the time prior to collision of India with Asia when SE Asia, from the Tethys in the west to the Palaeo-Pacific in the east, lay in the upper plate of subduction zones. In Myanmar and Sumatra, subduction was interrupted in the Aptian-Albian by a phase of arc accretion (Woyla and Mawgyi arcs) and in Java, eastern Borneo and Western Sulawesi by collision of continental fragments rifted from northern Australia. Subsequent resumption of subduction in the Myanmar–Thailand sector explains: 1) early creation of oceanic crust in the Andaman Sea in a supra-subduction zone setting ~95 Ma, 2) the belt of granite plutons of Late Cretaceous–Early Palaeogene age (starting ~88 Ma) in western Thailand and central Myanmar, and 3) amphibolite grade metamorphism between 70 and 80 Ma seen in gneissic outcrops in western and central Thailand, and 4) accretionary prism development in the Western Belt of Myanmar, until glancing collision with the NE corner of Greater India promoted ophiolite obduction, deformation and exhumation of marine sediments in the early Palaeogene. The Ranong strike–slip fault and other less well documented faults, were episodically active during the Late Cretaceous–Palaeogene time. N to NW directed subduction of the Palaeo-Pacific ocean below Southern China, Vietnam and Borneo created a major magmatic arc, associated with rift basins, metamorphic core complexes and strike–slip deformation which continued into the Late Cretaceous. The origin and timing of termination of subduction has recently been explained by collision of a large Luconia continental fragment either during the Late Cretaceous or Palaeogene. Evidence for such a collision is absent from the South China Sea well and seismic reflection record and here collision is discounted. Instead relocation of the subducting margin further west, possibly in response of back-arc extension (which created the Proto-South China Sea) is preferred. Lying between the two subduction related arcs, the Khorat Basin is of predominantly Late Jurassic–Early Cretaceous age but stratigraphic and apatite fission track data also indicates deposition of 1–2 km of Late Cretaceous sediments. The synformal basin geometry probably arose due to the dynamic topography created by converging Tethyan and Palaeo-Pacific subduction zones. The Aptian-Albian slowing of basin subsidence and onset of evaporite deposition coincides with collision of the Mawgyi and Woyla island arcs. Extensive Palaeogene deformation and exhumation (3+ km in places) affected all margins of the Khorat Plateau. Deformation includes folds of the Phu Phan uplift, and strike–slip faults, thrusts and folds on the southern and eastern margins. South of the Khorat Plateau outcrop, and seismic reflection data from the Ton Le Sap Basin (Cambodia), and the Gulf of Thailand, indicate syn-depositional fault-controlled subsidence was important during Cretaceous deposition. The hot, thickened crust developed during the Late Cretaceous–Palaeogene events follows the weak (Indosinian), crustal-scale Inthanon and Sukhothai zones, which persistently guided the location of later structures including Cenozoic extensional, and post-rift basins, and influenced the widespread occurrence of low-angle normal faults, metamorphic core complexes, and eastern Gulf of Thailand super-deep post-rift basins.

Contents

E-mail address: chrissmorley@gmail.com.

0012-8252/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.earscirev.2012.08.002

1. Introduction

Late Cretaceous–Palaeogene tectonic events within, and surrounding the Gulf of Thailand mark an important period in the development of the continental core of SE Asia (Sundaland) continental crust (Fig. 1). Yet the story remains fragmentary and dating of events is commonly ambiguous. Recently a number of different geological studies and geophysical surveys enable a more coherent picture of the tectonic setting and events affecting the area to be established. This paper reviews the regional publications, publically available data, and presents new data to develop an up-dated tectonic model for the Late Cretaceous–Palaeogene history of the circum-Gulf of Thailand region up to about 40 Ma. This time period is one of significant tectonic activity in central Indochina (Thailand, Laos, Cambodia, Malaysia), which at present is poorly described. The Late Cretaceous–Early Palaeogene period is bracketed by episodes of extensive basin development: i.e. deposition of the Khorat Group, and Phuqoc Group during the Jurassic–Cretaceous (Racey et al., 1996; Racey and Goodall, 2009; Fyhn et al., 2010), and the regional development of rift basins in SE Asia from the Late Eocene onwards (Hall and Morley, 2004).

To understand the Late Cretaceous–Paleogene tectonic development of Sundaland, also requires knowledge of the tectonic development in adjacent areas. The history, in general, is one of subduction of the Tethys and Palaeo-Pacific oceans and associated accretionary events on the western, southern, and eastern margins of Sundaland (Hall et al., 2009; Metcalfe, 2009, 2011). But the details of collision events involving island arcs, continental blocks and smaller fragments remains highly uncertain, and a number models with some contradictory elements have been proposed (e.g. Charusiri et al., 1993; Barber and Crow, 2003, 2009; Hall, 2009; Hall et al., 2009; Fyhn et al., 2010; Wang et al., 2008, 2011). This paper discusses the main plate tectonic models and their compatibility with our present understanding of the Late Cretaceous–Early Palaeogene stratigraphic, sedimentary, structural and tectonic development of Sundaland. The tectonic development is discussed in the context of three geographical regions: 1) the western and southern boundaries of Sundaland, which comprises the story of the subduction of the Tethyan realm beneath Eurasia, the approach of India with Eurasia, and the collision of continental fragments rifted from Australia and island arcs with Sundaland. 2) The continental area of Sundaland, (i.e. Thailand, Laos, Cambodia, Vietnam, Malaysia, Borneo, Myanmar, Sumatra, western Java, Western Sulawesi), and the tectonics of the plate interior, and 3) the eastern boundary of Sundaland, which involves the subduction of the Palaeo-Pacific oceanic crust beneath Southern China, Vietnam and southern Borneo, and the putative collision of continental fragments during the late Cretaceous and Palaeogene (e.g. Hall et al., 2009; Hall, 2012; Fyhn et al., 2010).

The Late Cretaceous to early Palaeogene period is also important for understanding the subsequent development of Cenozoic tectonics during the Himalayan stage of deformation. There is a widespread impression that the significant Cenozoic tectonics of Indochina began with the effects of escape tectonics during the Oligocene (e.g. Tapponnier et al., 1986; Leloup et al., 2001; Replumaz and Tapponnier, 2003; Fyhn et al., 2009). However, is this really the case? For example it has been proposed by many workers (e.g. Leloup et al., 2001; Replumaz and Tapponnier, 2003; Fyhn et al., 2009) that opening of the South China Sea spreading centre (Fig. 1) is linked with displacement on the Ailao Shan-Red River Fault zone. Yet, as reviewed by Morley (2002) the development of extension

Fig. 1. A) DEM of the SE Asia region, ETOPO1 data (Amante and Eakins, 2009). B) Regional location map showing Terranes accreted in the Late Palaeozoic, in part based on Sone and Metcalfe 2008b, Barber et al. (2011), and Metcalfe (2011).