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The kinematic history of the Khlong Marui and Ranong Faults, southern Thailand

Ian Watkinson*, Chris Elders, Robert Hall

SE Asia Research Group, Department of Earth Sciences, Royal Holloway University of London, Egham, Surrey TW20 0EX, United Kingdom

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ABSTRACT

The Khlong Marui Fault (KMF) and Ranong Fault (RF) are major NNE-trending strike-slip faults which dissect peninsular Thailand. They have been assumed to be conjugate to the NW-trending Three Pagodas Fault (TPF) and Mae Ping Fault (MPF) in Northern Thailand, which experienced a diachronous reversal in shear sense during India–Eurasia collision. It follows that the KMF and RF are expected to show the opposite shear sense and a slip sense reversal at a similar time to the TPF and MPF. New field data from the KMF and RF reveal two phases of ductile dextral shear separated by Campanian magmatism. Paleocene to Eocene post-kinematic granites date the end of this phase, while a brittle sinistral phase deforms the granites, and has exhumed the ductile fault rocks. The timing of these movements precludes formation of the faults in response to Himalayan extrusion tectonics. Instead, they formed near the southern margin of a Late Cretaceous–Paleocene orogen, and may have been influenced by variations in the rate of subduction ahead of India and Australia. North-south compression prior to reactivation of the subduction zone around southern Sundaland in the Eocene caused widespread deformation in the overriding plate, including sinistral transpression on the KMF and RF.

1. Introduction

Widespread intraplate deformation within mainland Southeast Asia is conspicuously expressed by northwest trending strike-slip faults which originate near the eastern Himalayan syntaxis. These include the Ailao Shan–Red River Fault (ASRR), the Mae Ping Fault (MPF), and the Three Pagodas Fault (TPF) (Fig. 1), which are interpreted to have played a key role in the eastwards movement of fault-bounded blocks during indentation of the Indian continent into the Eurasian plate (e.g. Gilley et al., 2003; Lacassin et al., 1997; Leloup et al., 1995; Tapponnier et al., 1982, 1986). They record a history of sinistral motion under medium to high metamorphic conditions followed by a diachronous reversal in shear sense and a change to brittle deformation during the Oligocene on the TPF and MPF, and the Miocene on the ASRR (Gilley et al., 2003; Lacassin et al., 1997; Leloup et al., 1995, 2001; Wang et al., 1998). Northward-younging slip sense reversal is believed to result from northward migration of the Himalayan deformation front and lateral extrusion of successive fault-bounded blocks (Lacassin et al., 1997).

The northeast-trending Khlong Marui Fault (KMF) and Ranong Fault (RF) (Fig. 2) cut across the Thai Peninsula south of the NW-trending faults, and are orientated about 100° anti-clockwise from the TPF (Fig. 1). Although they have not been traced offshore, the two fault zones appear to intersect in the northern Gulf of Thailand. As a result, the KMF and RF have been interpreted to be conjugate to the TPF and MPF (Lacassin et al., 1997; Tapponnier et al., 1986), an assumption which has become entrenched in subsequent references to the Cenozoic deformation of the area. Their kinematics are therefore modeled as ductile dextral motion during the early stages of India–Eurasia collision, changing to brittle sinistral at the same time as the change from sinistral to dextral on the TPF and MPF (e.g. Hall, 1996, 2002; Lee and Lawver, 1995; Replumaz and Tapponnier, 2003; Tapponnier et al., 1986).

Development of the South China Sea, and Cenozoic basins of offshore Vietnam, Cambodia and in Northern Thailand, have also been attributed to movement on the NW-trending strike-slip faults (Briais et al., 1993; Polachan et al., 1991; Tapponnier et al., 1986), and offshore extensions of the KMF and RF have been linked to extension in the Andaman Sea and the Gulf of Thailand (e.g. Packham, 1993; Pigott and Sattayarak, 1993; Polachan, 1988). However, the timing and extent of deformation on the NW-trending structures is still under debate (e.g. England and Houseman, 1986; Hall and Morley, 2004; Rangin et al., 1995; Searle, 2006), and recent workers have favoured processes such as subduction rollback (Morley, 2001), lower crustal flow (Morley and Westaway, 2006), and changing intraplate stresses as a result of edge forces (Hall and Morley, 2004), as principal controls on extension in the basins, reducing the importance of large strike-slip faults in the evolution of Southeast Asia.

The KMF and RF have undoubtedly played a part in this evolution. Early work on the KMF identified a phase of brittle

* Corresponding author.
E-mail address: i.watkinson@gl.rhul.ac.uk (I. Watkinson).

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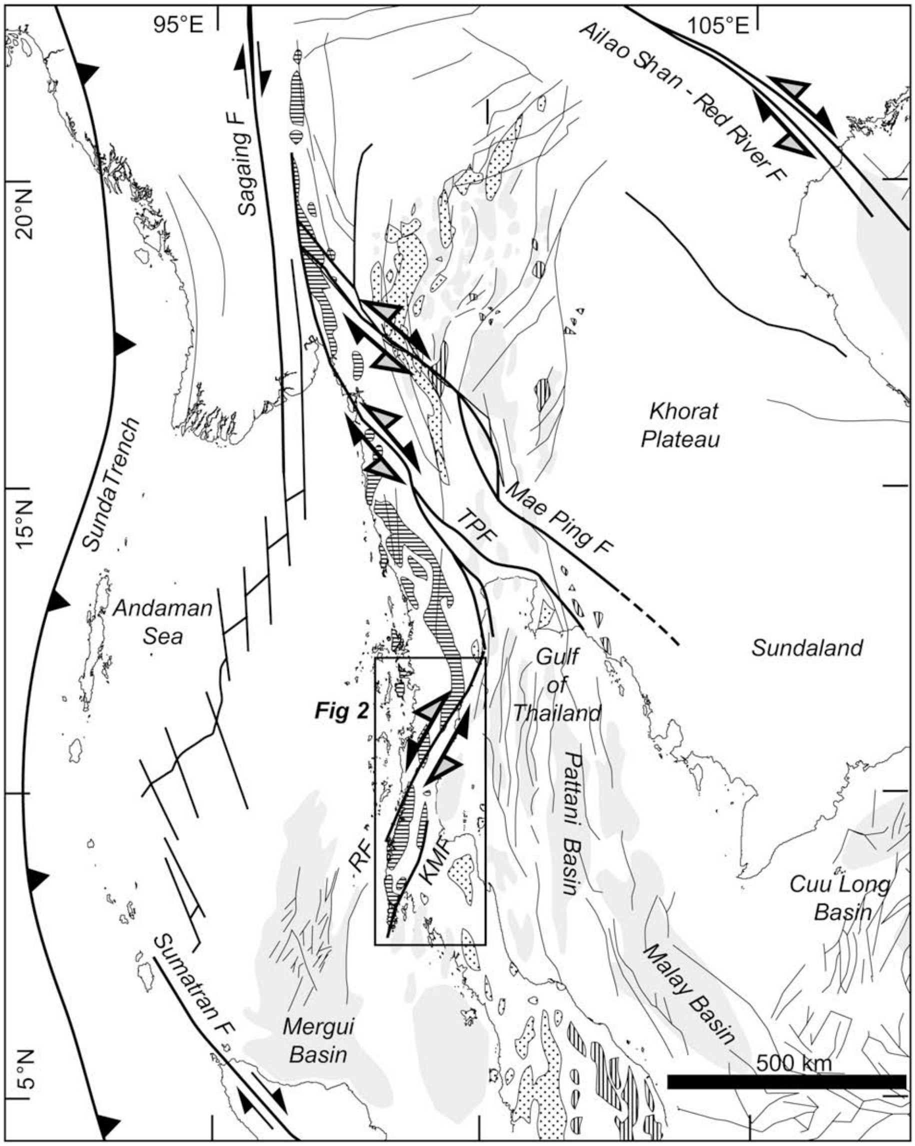

Fig. 1. Regional tectonic elements of mainland Southeast Asia. Horizontal line ornament, Western Province granites; dotted ornament, Main Range granites; vertical line ornament, Eastern Province granites; pale grey, Cenozoic basins; black lines, brittle faults; grey half arrows, ductile shear sense; black half arrows, brittle shear sense. After Cobbing et al. (1986), Morley (2002), and Polachan (1988).

sinistral strike-slip deformation, based on the apparent offset of granites across the fault (Garson and Mitchell, 1970). Detailed field-based studies of fault kinematics have been notably lacking, until Intawong (2006) recognised an additional, older, ductile phase.

This paper presents new field evidence supporting these events on the KMF, and a similar change from ductile dextral to brittle sinistral shear on the larger, less well studied RF. Integrating this new field data with existing isotopic ages shows that the ductile phase pre-dates Himalayan deformation, and therefore the connection to the northern faults is more complicated than previously assumed.

2. Geological setting

2.1. The Thai Peninsula

The structural geology of the N–S trending Thai Peninsula is dominated by the KMF and RF: broadly linear NNE-trending strike-slip fault zones centered around elongate slivers of ductile fault rocks (Fig. 2). These are bounded and overprinted by brittle strands, which are part of a population of parallel and branching sinistral faults which are localised into the two similar but discrete fault zones. The smaller KMF passes from Ko Phuket in the south towards Surat Thani in the north, while strands of the RF can be traced from Takua Pa in the south to Pran Buri in the north, crossing the peninsula entirely. A relatively undeformed block with a strike-normal width of no more than 50 km lies between the two faults.

Rocks in and around the fault zones are dominantly Late Palaeozoic marine sediments deposited at mid-southern latitudes (Metcalfe, 2002, 2006). Most prominent are siliciclastic deposits of the Permo-Carboniferous Kaeng Krachan or Phuket Group, the oldest exposed rocks in the fault zone, which occupy a broad area of the central Thai Peninsula (Department of Mineral Resources, 1982). They comprise grey mudstone, siliceous shale, sandstone, and conglomeratic sequences between 2 and 3 km thick. Distinctive pebbly mudstones, interpreted as diamictites (Bunopas et al., 1991),