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Timing of metamorphism of the Lansang gneiss and implications for left-lateral motion along the Mae Ping (Wang Chao) strike-slip fault, Thailand

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ABSTRACT

The Mae Ping fault (MPF), western Thailand, exhibits dominantly left-lateral strike-slip motion and stretches for >600 km, reportedly branching off the right-lateral Sagaing fault in Myanmar and extending southeast towards Cambodia. Previous studies have suggested that the fault assisted the large-scale extrusion of Sundaland that occurred during the Late Eocene–Early Oligocene, with a geological offset of ~120–150 km estimated from displaced high-grade gneisses and granites of the Chiang Mai–Lincang belt. Exposures of high-grade orthogneiss in the Lansang National Park, part of this belt, locally contain strong mylonitic textures and are bounded by strike-slip ductile shear zones and brittle faults. Geochronological analysis of monazite from a sample of sheared biotite-K-feldspar orthogneiss suggests two episodes of crystallization, with core regions documenting Th–Pb ages between c. 123 and c. 114 Ma and rim regions documenting a significantly younger age range between c. 45–37 Ma. These data are interpreted to represent possible magmatic protolith emplacement for the Lansang orthogneiss during the Early Cretaceous, with a later episode of metamorphism occurring during the Eocene. Textural relationships provided by in situ analysis suggest that ductile shearing along the MPF occurred during the latter stages of, or after, this metamorphic event. In addition, monazite analyzed from an undeformed garnet-two-mica granite dyke intruding metamorphic units at Bhumipol Lake outside of the Mae Ping shear zone produced a Th–Pb age of 66.2 ± 1.6 Ma. This age is interpreted to date the timing of dyke emplacement, implying that the MPF cuts through earlier formed magmatic and high-grade metamorphic rocks. These new data, when combined with regional mapping and earlier geochronological work, show that neither metamorphism, nor regional cooling, was directly related to strike-slip motion.

1. Introduction

A prominent tectonic model proposed to explain the structural evolution of Tibet and SE Asia following the India–Asia collision is that of 'continental extrusion', which hypothesizes that large tracts of thickened continental crust have been extruded to the east and southeast away from the northward-moving Indian indenter via systems of lithospheric-scale strike-slip faults (Tapponnier et al., 1986; Armijo et al., 1989; Leloup et al., 1995). In this model, the eastward extrusion of Tibet has purportedly occurred along the right-lateral Karakoram and Jiale faults, in Pakistan and southern China respectively, and by left-lateral motion along the Altyn Tagh fault in northern China (e.g. Tapponnier et al., 1986). By contrast, the extrusion of Sundaland to the southeast is reported to have largely occurred as a result of right-lateral motion along the Sagaing fault in Myanmar and the left-lateral Ailao Shan–Red River (AS–RR) shear zone passing through Yunnan and Vietnam (Leloup et al., 1995 and others). By contrast, some recent studies of major strike-slip faults in Tibet and along the AS–RR shear zone refute the large-scale extrusion hypothesis (e.g. Searle, 2006; Yeh et al., 2008; Searle et al., 2010, 2011). These studies have shown that the total geological offsets are generally much less than previously thought and that strike-slip motion was largely not coincident with the initial India-Asia collision (c. 50 Ma; Green et al., 2008).

The extent of Quaternary and recent (active) motion along a fault system is readily determined by interpreting geomorphological offsets, GPS motion and interferometric synthetic aperture radar (InSAR). However, elucidation of the pre-Quaternary history is often more problematic and requires accurate determination of geological offsets and obtaining ages on the formation of such

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features. As such, metamorphic and magmatic rocks exposed within ductile shear zones involved in the continental extrusion model have been targeted in the past for detailed geochronological analyses, as these lithologies provide the best opportunity to constrain the timing of pre-Quaternary fault motion. In and around Tibet these include the Karakoram fault (e.g. Searle et al., 1998; Phillips and Searle, 2007; Robinson, 2009), the Jiale fault (e.g. Lee et al., 2003) and the Red River fault (e.g. Leloup et al., 1995; Searle, 2006; Searle et al., 2010). In SE Asia high-grade metamorphic rocks are also exposed along the Sagaing fault in Myanmar (e.g. Barley et al., 2003; Searle et al., 2007) the Mae Ping fault (Lacassin et al., 1997; Morley et al., 2007) and the Khlong Marui and Ranong faults (Watkinson et al., 2008; Morley et al., 2011). The occurrence of high-grade metamorphic and magmatic rocks in these lithospheric-scale strike-slip shear zones is under debate. Some studies suggest that metamorphism is directly related to strike-slip shear heating (cf. the Red River fault in Leloup and Kienast (1993) and Leloup et al. (1995)), whereas others suggest that transpressional uplift merely exhumes older (and therefore) unrelated metamorphic rocks (cf. the Karakoram and Red River fault in Searle et al. (1998, 2010), Searle and Philips (2007) and Streule et al. (2009)).

In this paper we address this issue in consideration of the prominent Mae Ping fault (MPF) in western Thailand. Geochronological analysis of monazite within a sample of mylonotized orthogneiss provides constraints upon the timing of peak metamorphism and ductile shearing within Sundaland in relation to the India–Asia collision. Our new U–Th–Pb monazite age data are combined with published structural and geochronological results along other major strike-slip faults in Thailand to show that the latest metamorphic episode in the mid-Eocene pre-dated left-lateral motion along the MPF. Furthermore, we suggest that widespread Late Cretaceous leucogranite dykes exposed away from the fault zone record a regional anatectic event prior to the collision of India with the Myanmar microplate, and the subsequent collision of both these welded terranes with Asia.

2. Geological background

Strike-slip fault complexes in SE Asia show orientations that infer an intimate relation to the northward-progression of the Indian plate and clockwise rotation of Asian plate blocks around the Eastern Himalayan Syntaxis (Huchon et al., 1994). Two prominent and well documented examples outside of Thailand include the N–S trending right-lateral Sagaing fault in Myanmar and the NW–SE trending left-lateral AS–RR fault zone in Yunnan–Vietnam (Fig. 1). Although comparable large-scale fault zones in Thailand

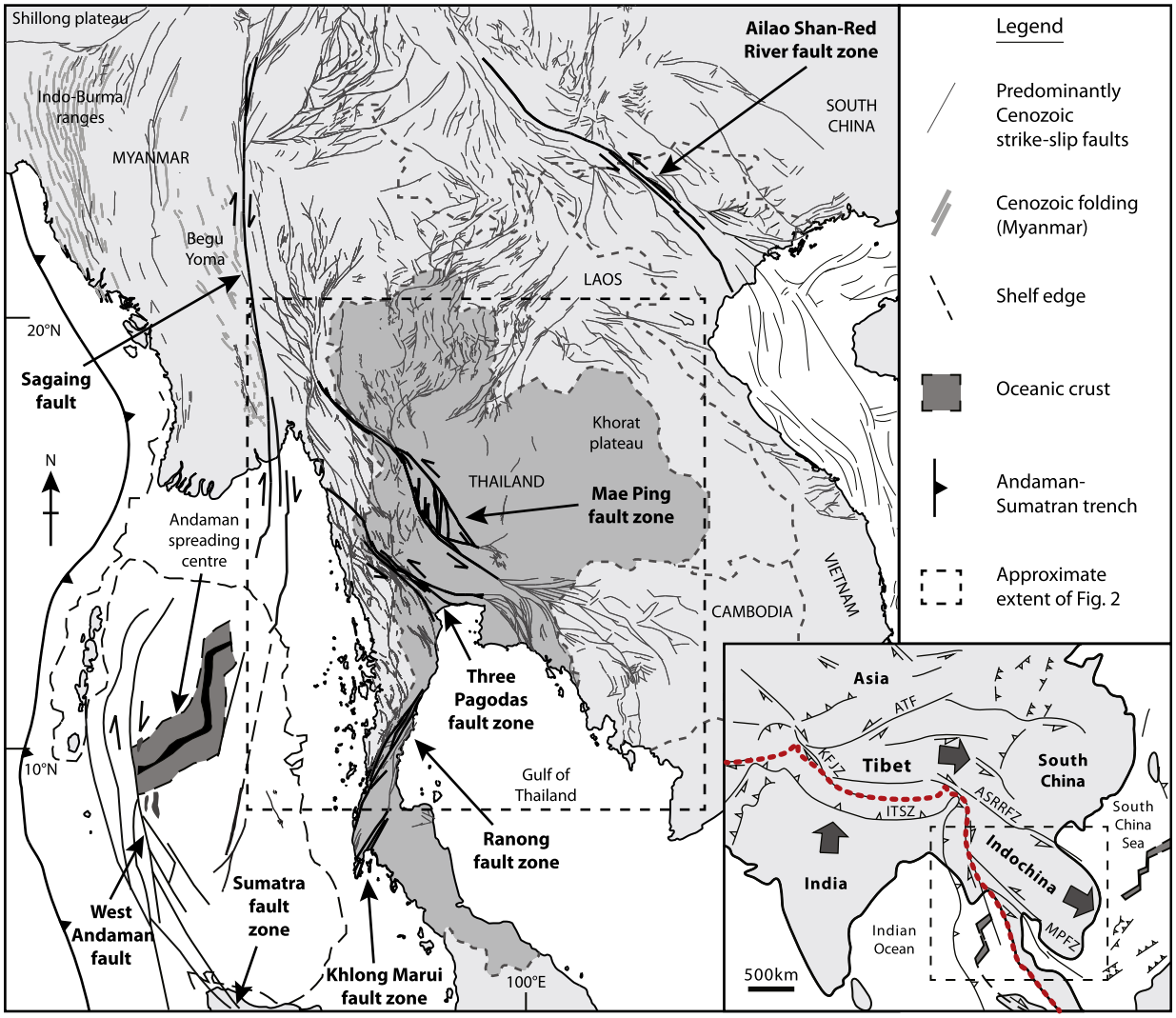

Fig. 1. Simplified tectonic map of SE Asia showing regional fault patterns (modified from Watkinson et al. (2011) and Morley (2012)). Inset figure is after Tapponnier et al. (1982): ITSZ, Indus–Tsangpo suture zone (approximate position marked by bold dashed line); ATF, Altyn Tagh fault; KFJZ, Karakoram–Jiale fault zone; ASRRFZ, Ailao Shan–Red River fault zone; MPFZ, Mae Ping fault zone. Dashed box in inset shows approximate location of main figure.