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Kinematics, fabrics and geochronology analysis in the Médog shear zone, Eastern Himalayan Syntaxis

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ABSTRACT

The uplift history and tectonic evolution of the Eastern Himalayan Syntaxis (EHS) have been extensively studied in the last several decades. The Médog shear zone, the eastern boundary of the EHS, has preserved considerable significant information on the structural and tectonic evolution of the EHS. In this study, we report kinematics, fabrics and geochronology data of the Médog shear zone in the EHS. Analyses of the crystallographic preferred orientation (CPO) of quartz (EBSD analysis) demonstrated that there are three major slip systems: (1) basal < a > slip, (2) prism [c] slip, and (3) prism < a > slip. These slip systems are consistent with microstructures of low-temperature shearing, medium-temperature shearing and high-temperature shearing, respectively. Zircons from the two gneiss samples possess inherited magmatic cores and metamorphic overgrown rims, yielding a metamorphic age of 29.4–28.6 Ma. It is suggested that the dextral shearing along the Médog shear zone was not earlier than the Early Oligocene. The $^{40}Ar/^{39}Ar$ analysis indicates that the Médog shear zone experienced three thermo-tectonic events from the Late Oligocene to the Pliocene, e.g., ~23.4 Ma, 16.9–12.6 Ma and ~5.3 Ma. We correlate the Oligocene metamorphic event and the Late Oligocene to the Pliocene multi-stage thermo-tectonic events that resulted from subduction of the northeast corner of the India plate.

1. Introduction

The Himalaya orogen is a classic example of an orogenic system created by continent–continent collision (Dewey and Burke, 1973; Yin and Harrison, 2000). Although there are many studies concerning collision time, tectonic evolutionary history, metamorphism and deformation, our understanding of the orogen belt remains incomplete (Aitchison et al., 2011; Argand, 1924; Beaumont et al., 2001; Dewey and Burke, 1973; Harrison et al., 1992; Hodges, 2000; Molnar and Tapponnier, 1975; Royden et al., 2008; Tapponnier et al., 1986; Xu et al., 2012; Yin and Harrison, 2000). The Himalayan orogen is bordered by four large boundaries: the Yarlung–Tsangpo suture to the north, the Main Frontal Thrust (MFT) to the south, the left-slip Chaman fault to the west, and the right-slip Sagaing fault to the east (Yin, 2000). The EHS represents the east termination of the main Himalayan arc. Understanding the tectonics of the EHS plays a key role in constructing the origin and evolution of the Himalaya orogen belt. Thus, the kinematics, microstructure, geochronology and fabric analyses of the deformation structures are critically important.

The EHS, structurally below the Gangdese magmatic belt, is a high-grade metamorphic terrane. This terrane primarily consists of orthogneiss and paragneiss with high amphibolite–granulite facies that are often interlayered with high-pressure granulites and mantle-derived mafic–ultramafic xenoliths (Liu and Zhong, 1997). These rocks experienced high grade metamorphism in the upper green schist to upper amphibolite or granulite facies (Liu and Zhong, 1997; Zhong and Ding, 1996). The EHS is confined by boundary faults, including the sinistral-shearing Dongjiu–Milin fault to the west and the dextral-slipping Médog Shear zone to the east (Burg et al., 1998; Xu et al., 2008, 2012; Zhang et al., 1992, 2004).

The kinematics, deformation, geochronology and tectonic implications of the western boundary have been extensively studied over the past few decades (Booth et al., 2004; Ding et al., 2001; Lee et al., 2003; Lin et al., 2009; Palin et al., 2015; Xu et al., 2012; Zhang et al., 2004). By contrast, the eastern boundary has not been thoroughly elucidated, partially because of inaccessibility caused by dense vegetation. It is essential to understand the sheared rocks' deformation histories and the Namche Barwa massif's exhumation mechanisms by structural, microstructure and fabric analysis.

In this study, we present a series of new results from detailed geological, structural and geochronological investigations of the Médog shear zone and adjacent areas, which provide new data, including field observations, deformation and fabric kinematics, and new zircon

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LA-MC-ICP-MS U–Pb and $^{40}Ar–^{39}Ar$ dates on a range of rocks. The data presented could also enable us to improve the current geodynamic models for the uplift of the EHS, particularly during the later stages of the Indian–Eurasian plate collision.

2. Geological setting

The EHS is the eastern termination of the Himalayan collisional orogen (Fig. 1). The intensive tectonic compression caused the Yarlung–Tsangpo suture to bend suddenly, making a 'U-turn' syntaxis in the uplifted area at the Namche Barwa (Geng et al., 2006; Sun et al., 2004a,b; Zheng et al., 2003a,b). The EHS can be divided into three major tectonic units (Geng et al., 2006): (1) the Yarlung–Tsangpo suture zone, (2) the Gangdese magmatic belt and (3) the Namche Barwa group. The western and eastern contacts between the Namche Barwa group and the Gangdese magmatic belt are the sinistral Dongjiu–Milin shear zone and dextral Médog shear zone respectively (Burg et al., 1997, 1998; Ding et al., 2001; Xu et al., 2012; Zhang et al., 1992, 2004).

2.1. The Yarlung–Tsangpo suture zone

The Yarlung–Tsangpo suture zone represents the remnants of the Neo-Tethyan ocean located between the Namche Barwa group and the Gangdese magmatic belt (Burg et al., 1998) and primarily comprises green-schist facies to low amphibolite facies metamorphic rocks and sporadic ophiolites (Geng et al., 2006; Liu and Zhong, 1998; Xu et al., 2012). In the EHS, the Yarlung–Tsangpo suture zone forms an inverted U-shape around the Namche Barwa massif (Burg et al., 1998; Geng et al., 2006). It was previously shown to be offset by the two margin faults for approximately dozens of kilometers (Burg et al., 1998; Geng et al., 2006; Zhang et al., 1992; Zheng et al., 2003a,b) because of the intensive northeast indentation of the Indian plate. The Dongjiu–Milin shear zone is characterized by strong mylonitization that produced a steep, west-dipping foliation and a variably oriented stretching lineation. From north to south, it can be divided into three segments: (1) The northern segment of the Dongjiu–Milin shear zone is a NE–SW trending, left-lateral, transpressional shear zone. (2) The central segment of the Dongjiu–Milin shear zone is a nearly N–S trending, left-lateral, strike–slip shear zone with horizontal or subhorizontal (plunging generally less than 10–15° to SSW) stretching lineation. (3) The southern segment of the Dongjiu–Milin shear zone is a NE–SW trending, left-lateral, transtensional shear zone with SW-plunging (40–60°) stretching lineation (Xu et al., 2012).

2.2. The Gangdese magmatic belt

The Gangdese magmatic belt consists of Precambrian metamorphic basement, Paleozoic cover and massive Mesozoic-Cenozoic granitoids (Burg et al., 1997; Dong et al., 2015; Zhang et al., 1992). The basement comprises banded migmatite, amphibolite, felsic gneiss, and garnet-bearing two-mica gneiss, whereas the cover is mainly dominated by paragneiss, sandstones and limestones.

2.3. The Namche Barwa group

The Namche Barwa group, which is in fact the eastward extension of the Greater Himalayan Unit, can be divided into three tectonic units: the Paixiang formation (II_1), the Zhibai high-pressure (HP) complex (II_2) and the Duoxiong–La migmatite (II_3) (Geng et al., 2006; Liu et al., 2007; Xu et al., 2012; Fig. 2a). The Paixiang formation mainly comprises felsic gneiss, forsterite-bearing marble, clinopyroxenite, and diopsidite. The Zhibai HP complex mainly consists of felsic and mafic granulites (Geng et al., 2006; Guilmette et al., 2011; Liu and Zhong, 1997; Xu et al., 2010; Zhong and Ding, 1996). The peak timing of HP granulite-facies metamorphism has been variably estimated from 50 Ma to 24 Ma (Ding and Zhong, 1999; Ding et al., 2001; Liu et al., 2007; Xu et al., 2010, 2012; Zhang et al., 2007, 2010, 2015). The Duoxiong–La

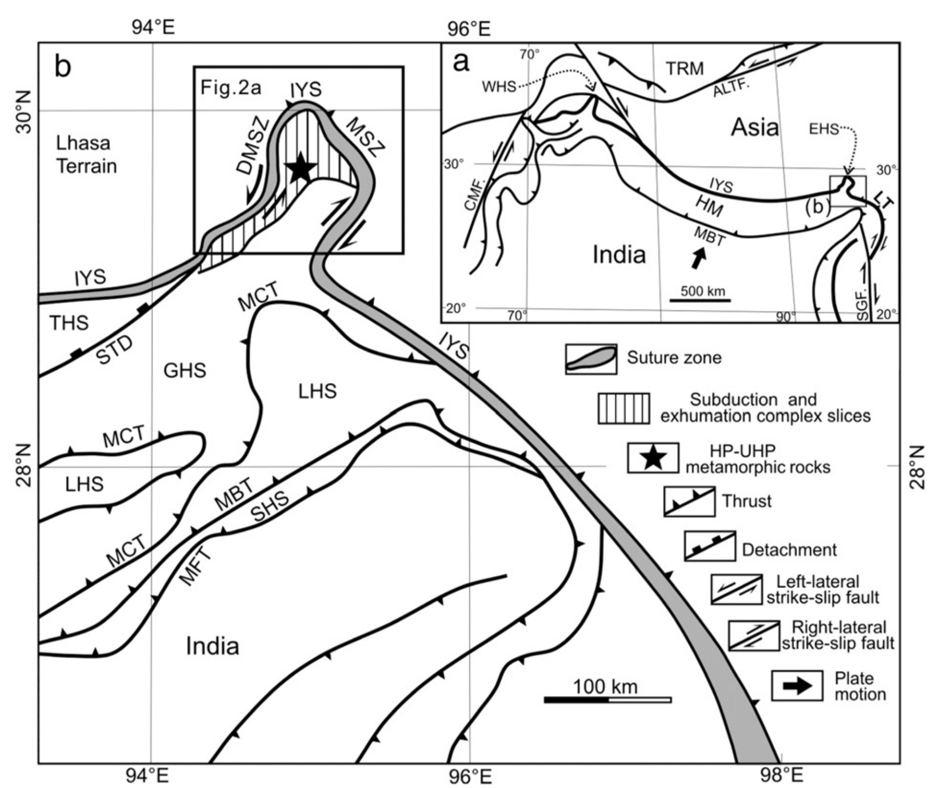

Fig. 1. (a) Simplified tectonic maps of the Himalayan orogenic belt; (b) geological sketch map of the Eastern Himalayan Syntaxis and surrounding regions (after Ding et al., 2001). Abbreviations: WHS: the Western Himalayan Syntaxis; EHS: the Eastern Himalayan Syntaxis; ALTF: Altyn Tagn Fault; IYS: Indus–Yarlung Suture Zone; HM: Himalaya; MBT: the Main Boundary Thrust; STDS: South Tibet Detachment System; DMSZ: Dongjiu–Milin Shear Zone; MSZ: Médog shear zone.