Orogen-parallel ductile extension and extrusion of the Greater Himalaya in the late Oligocene and Miocene

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[1] Predominant stretching structures in the Greater Himalayan Crystalline Complex (GHC) trend perpendicular to the belt and are linked to the southward exhumation or emplacement of the GHC between the South Tibet Detachment (STD) and the Main Central Thrust. However, our field investigations in southern Tibet reveal the widespread presence of gently dipping shear zones with a penetrative orogen-parallel stretching lineation, which separates the Tethyan Himalayan Sequence and the underlying GHC. The shear zones are well preserved in the upper part of the GHC, south to and structurally lower than the STD. Field criteria, microstructures, and quartz fabrics indicate top-to-the-east shearing in the Yadong shear zone (eastern GHC), coexistence of top-to-the-east and top-to-the-west shearing in the Nyalam shear zone (central GHC), but top-to-the-west shearing in the Pulan shear zone (western GHC). Characteristic microstructures and slip systems of quartz in the high-grade GHC rocks resulted from the lateral flow under upper amphibolite (up to 650–700 °C) to greenschist facies conditions. U-Pb ages of metamorphic zircon rims by sensitive high-resolution ion microprobe (SHRIMP) and laser ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS) analyses yield 28–26 Ma for the initiation of the Yadong and Nyalam shear zones and 22–15 Ma for the activation of the Pulan shear zone. In addition, $^{40}Ar/^{39}Ar$ cooling ages of biotite and muscovite suggest cessation of ductile sharing at 13–11 Ma on the Yadong shear zone, which is coeval with the activation of the STD. Combined with previous studies, we propose that initiation of orogen-parallel extension marks the transition from burial/crustal thickening to exhumation of the GHC. Due to lateral crustal thickness gradients in a thickened crust, orogen-parallel gravitational collapse occurred within the convergent Himalayan orogen in the late Oligocene-Miocene. This tectonic denudation triggered and enhanced partial melting and ductile extrusion of the GHC in the Miocene.

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1. Introduction

[2] Bounded by the north-dipping Main Central Thrust (MCT) below and the South Tibet Detachment (STD) above, the Greater Himalayan Crystalline Complex (GHC) forms the metamorphic core of the Himalayan orogen and represents the subducted northern margin of the Indian continent (Figure 1) [e.g., *Le Fort*, 1996; *Yin and Harrison*, 2000; *Yin*, 2006; *Guillot et al.*, 2008; *Yin et al.*, 2010a; *Webb et al.*, 2011a]. In the middle Eocene to Oligocene, the GHC experienced upper amphibolite to granulite facies prograde metamorphism due to subduction (burial/crustal thickening) [e.g., *Searle et al.*, 1992; *Hodges et al.*, 1994; *Vance and Harris*, 1999; *Ding and Zhong*, 1999; *Zhang et al.*, 2010]. Exhumation of the GHC in the context of the Indo-Asian collision is the key issue for understanding the evolution of the Himalayan orogen. The predominant stretching lineation in the GHC trends north to N30°E (orogen perpendicular), which has been attributed to the southward exhumation of these middle crustal rocks between the STD and MCT in wedge extrusion [e.g., *Burchfiel and Royden*, 1985; *Grujic et al.*, 1996] and channel flow models [e.g., *Beaumont et al.*, 2001; *Hodges et al.*, 2001; *Grujic et al.*, 2002] or to emplacement of the GHC between the MCT and STD in tectonic wedging models [*Yin*, 2006; *Webb et al.*, 2007, 2011a, 2011b].

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