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Interplay of deformation and magmatism in the Pangong Transpression Zone, eastern Ladakh, India: Implications for remobilization of the trans-Himalayan magmatic arc and initiation of the Karakoram Fault

Koushik Sen [a,*], Barun K. Mukherjee [a], Alan S. Collins [b]

[a] Wadia Institute of Himalayan Geology, Dehradun 248001, India
[b] Centre for Tectonics, Resources and Exploration (TRaX), School of Earth and Environmental Sciences, University of Adelaide, Adelaide, SA 5005, Australia

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ABSTRACT

In the eastern part of Ladakh, the right-lateral Karakoram Fault Zone (KFZ) bifurcates into two strands called the Pangong Strand and the Tangtse Strand. These two strands bound a region called the Pangong Transpression Zone (PTZ), which consists of migmatitic dioritic gneiss, calc-silicates and the Durbuk Pluton; a pluton of two-mica leucogranite. Outcrop scale observations suggest pervasive migration of leucogranitic melt through the existing tectonic structures of the gneiss. Magnetic fabric from both the tectonized and undeformed parts of the Durbuk Pluton show parallelism with the tectonic fabric of the host gneiss, which, along with pervasive melt migration, indicates syn-kinematic relationship between deformation along the KFZ, leucogranite magmatism and emplacement of the Durbuk Pluton. U–Pb geochronology of zircons from the dioritic gneiss yields a crystallization age of 63.6 ± 1.5 Ma and also shows younger zircon growth down to ~13 Ma, which suggest arc magmatism at ~65 Ma followed by partial melting and leucogranite magmatism in the KFZ till ~13 Ma. One two-mica leucogranite sample from the Durbuk Pluton gives a crystallization age of 22.7 ± 0.5 Ma. As the Durbuk Pluton is syn-tectonic with deformation along KFZ, it is inferred that the KFZ initiated at least ~23 Ma ago.

1. Introduction

The dextral strike-slip trans-Himalayan Karakoram Fault Zone (KFZ) is believed to be the manifestation of India-Asia collision-related crustal thickening giving way to eastward directed escape of the thickened Tibetan crust (Peltzer and Tapponnier, 1988; Armijo et al., 1989; Tapponnier et al., 1996). Its timing of initiation and motion are pivotal for understanding the tectonics related to the history of the India-Eurasia collision. Two clearly distinct hypotheses exist regarding the age of initiation of the KFZ with respect to metamorphism and leucogranite magmatism. Phillips et al. (2004) used two sets of leucogranite dikes to infer the timing of initiation of KFZ: one mylonitized, with a tectonic fabric concordant with the Karakoram Fault and another one much younger, relatively undeformed and one that cross-cuts the regional foliation. They obtained a crystallization age of 15.68 ± 0.52 Ma for the older deformed leucogranite dykes and 13.73 ± 0.28 Ma age for the younger cross-cutting one. Based on this evidence, they argued that the KFZ is post-tectonic to the older one and pre-tectonic to the younger one, so it initiated between these two ages (see also Phillips and Searle, 2007; Searle and Phillips, 2007; Wang et al., 2012). On the other hand, outcrop-scale field relationships and metamorphic evidence provided by Weinberg and Mark (2008), Valli et al. (2008), Weinberg et al. (2009), Sen et al. (2009), Rolland et al. (2009), Leloup et al. (2011, 2013), Mukherjee et al. (2012) and Boutonnet et al. (2012) were used to infer that metamorphism, felsic magmatism and dextral shear in the KFZ are synchronous and this syn-magmatic deformation of the KFZ started at ~20–23 Ma.

Calc-alkaline granitoids of the Karakoram Batholith, many of which have undergone solid-state deformation, have yielded ages of 75–70 Ma indicating active magmatism in the region of the KFZ (Jain and Singh, 2008). Yet the relationships of these early litho-units (e.g. the Pangong migmatite-granodiorites and calc-alkaline granitic gneisses, Fig. 1) to deformation along the KFZ is not clear. The timing of initiation of the KFZ and relationship with melt generation remain controversial. Here we, 1) investigate the relationship between melt migration and deformation by analysing

* Corresponding author.
E-mail address: koushik.geol@gmail.com (K. Sen).

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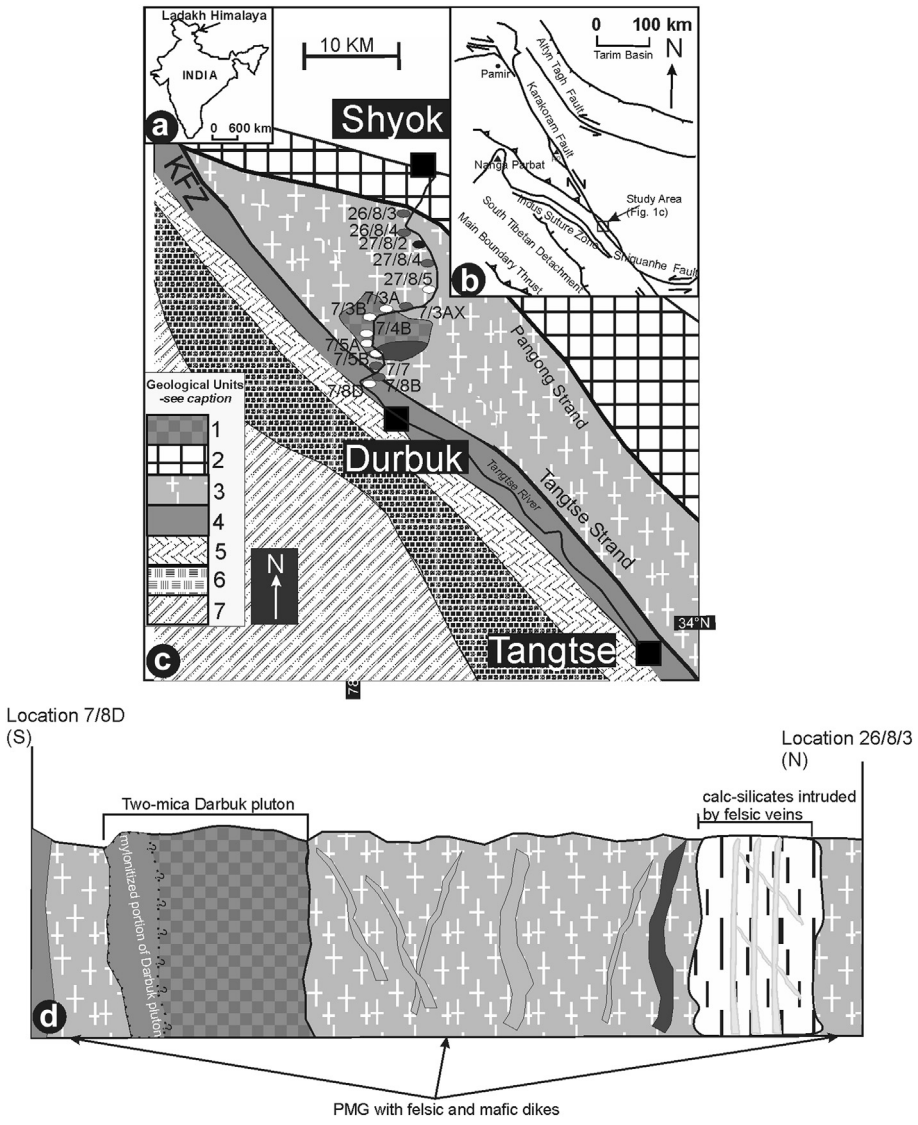

Fig. 1. (a) Location of Ladakh Himalaya in India. (b) Tectonic framework of western Himalaya including Tibet (after Phillips et al., 2004). (c) Geological map of the eastern Karakoram terrane (modified after Searle et al., 1998; Jain and Singh, 2008). AMS sample locations are also shown; Black ellipse is migmatite. Grey ellipses are dioritic gneisses and white ellipses are two-mica leucogranites. Keys: 1 = Durbuk Leucogranite pluton; 2 = Karakoram Metamorphic Complex; 3 = Pangong Migmatites and Gneisses; 4 = Karakoram Mylonite Zone; 5 = Units of the Shyok Suture Zone and Chillam Granodiorite; 6 = Khardung Volcanics; 7 = Ladakh Batholith. Darker shade at the bottom part of the Durbuk Pluton indicates its mylonitized part. d) cross-section of Shyok–Durbuk section along the Tangtse gorge.

outcrop-scale and microscopic structures present within the KFZ, 2) examine the emplacement and deformation related fabric within the Miocene leucogranite pluton and Cretaceous calc-alkaline granitic gneisses present in the KFZ using Anisotropy of Magnetic Susceptibility (AMS), and, 3) determine the timing of arc magmatism and subsequent partial melting within the KFZ using U/Pb zircon geochronology. These analyses are then integrated to further constrain the timing of initiation of the Karakoram Fault Zone, and hence, the eastward-directed tectonic escape.

2. Geology of the area

The study area lies in the eastern part of the Karakoram terrane between Shyok (34°10′42.21″N/78°08′31.73″E) and Durbuk (34°06′00.07″N/78°07′09.73″E) villages in Ladakh (Fig. 1c). The most striking feature of this region is the bifurcation of the dextral strike-slip Karakoram Fault into two strands, the Pangong (or Muglib) and Tangtse strands (Searle et al., 1998). The area bounded by these two strands is called the Pangong Transpressional Zone (PTZ) (Searle et al., 1998; Weinberg and Searle, 1998). Searle et al. (1998) were the first to infer transpressional tectonics in the region on the basis of (1) high rate of exhumation and erosion between 18 and 13 Ma ago due to crustal thickening, followed by a dominantly strike-slip motion, and; (2) the moderate plunges (~20°) of stretching lineations. The late-stage exhumation path (between 10.34 Ma to 9.48 Ma) of the KFZ mylonites, deduced by Mukherjee et al. (2012), also indicates a thrusting component facilitating exhumation along the KFZ.

According to Weinberg et al. (2000), the PTZ is a pop-up block of migmatites and gneisses that was exhumed by transpression between the Pangong and Tangtse strands. The Pangong strand separates the PTZ from the Karakoram Metamorphic Complex (Fig. 1c and d). This complex consists of migmatites, calc-silicates, pelitic schists and marbles and represents the exhumed southern margin of the Asian plate, which experienced repeated deformation, magmatism and metamorphism from Cretaceous to Miocene times