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Evidence against Quaternary slip on the northern Karakorum Fault suggests kinematic reorganization at the western end of the Himalayan–Tibetan orogen

Alexander C. Robinson *

Department of Geosciences, University of Houston, Houston, TX, 77204, USA

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ABSTRACT

While the right-slip Karakorum fault is one of the most prominent structures in the Himalayan–Tibetan orogen, its evolution and role in accommodating deformation related to the collision between India and Asia is controversial. Different models interpret the Karakorum fault as either: 1) a long-lived, stable feature analogous to a plate boundary structure, or 2) an evolving fault system with limited displacement (<200 km) and transient kinematics. While active deformation along the southern segment of the Karakorum fault is well established, neotectonic activity along the fault north of its intersection with the active left-slip Longmu–Co Gozha–Co fault system has not been documented. Analysis of Corona and ASTER satellite images along the northern end of the Karakorum fault zone provide several lines of evidence that show this portion is no longer active: 1) multiple generations of Quaternary glacial and fluvial deposits which can be correlated with previously dated deposits in the region, the oldest of which are >150 ka, overly the trace of the two strands of the Karakorum fault and show no evidence of tectonic disturbance; 2) older (late Pliocene to early Quaternary) loess deposits which overlie the trace of the fault are either undisturbed, or are cut by small normal fault scarps with no evidence of strike-slip displacement; 3) east–west trending bedrock incised stream valleys up to 500 m deep cross both strands of the fault with no sign of lateral deflection. I suggest that termination of slip along the northern segment of the Karakorum fault occurred in the Pliocene due to southward propagation of the Altyn Tagh fault system along the Longmu–Co Gozha Co fault and impingement of the Karakorum fault. This study suggests that large intracontinental strike-slip faults embedded within orogenic plateaus are transient features which should be expected to have complicated kinematic histories and short life-spans relative to the life of an orogenic belt.

1. Introduction

The >1000 km long right-slip Karakorum fault bounds the western margin of the Tibetan Plateau and is one of the most prominent morphologic features in the western Himalayan–Tibetan orogen (e.g., Molnar and Tapponnier, 1978) (Fig. 1). Despite its prominence, nearly every aspect of the Karakorum fault is still highly debated, including total displacement, initiation age, depth extent, and long term and Quaternary slip rate (Tapponnier et al., 1982; Peltzer and Tapponnier, 1988; Searle, 1996; Searle et al., 1998; Banerjee and Burgmann, 2002; Brown et al., 2002; Jade et al., 2004; Lacassin et al., 2004; Phillips et al., 2004; Schwab et al., 2004; Wright et al., 2004; Chevalier et al., 2005; Valli et al., 2007; Valli et al., 2008; Robinson, 2009). Thus the role the Karakorum fault plays in accommodating the continued convergence between India and Asia remains unclear.

Models for the role and evolution of the Karakorum fault can be grouped into two families. In the first family of models, the Karakorum fault plays a major role in the evolution of the Himalayan–Tibetan orogen by facilitating eastward lateral extrusion of the Tibetan Plateau and/or accommodating significant northward displacement of the Pamir–Karakorum region relative to the Tibetan Plateau (Tapponnier et al., 1982; Peltzer and Tapponnier, 1988; Lacassin et al., 2004; Schwab et al., 2004; Valli et al., 2008). In these models, the Karakorum fault is interpreted as a stable long-lived feature initiating in the late Oligocene along its entire current trace with only minor changes in kinematics (i.e., from transpressional to transtensional) (Lacassin et al., 2004; Schwab et al., 2004; Valli et al., 2007; Valli et al., 2008). In the second family of models, the role of the Karakorum fault is more limited, either acting as a transfer structure linking trust belts in the Pamir and western Tibet and/or accommodating outward radial growth of the Himalayan arc (Burtman and Molnar, 1993; Ratschbacher et al., 1994; Searle, 1996; Searle et al., 1998; Seeber and Pecher, 1998; Murphy et al., 2000). In these models the Karakorum fault is interpreted to have initiated more recently in the Middle Miocene (Searle, 1996; Searle et al., 1998; Phillips and Searle, 2007) with several studies suggesting a complex kinematic evolution for the

* Tel.: +1 713 743 3571.
E-mail address: acrobinson@uh.edu.

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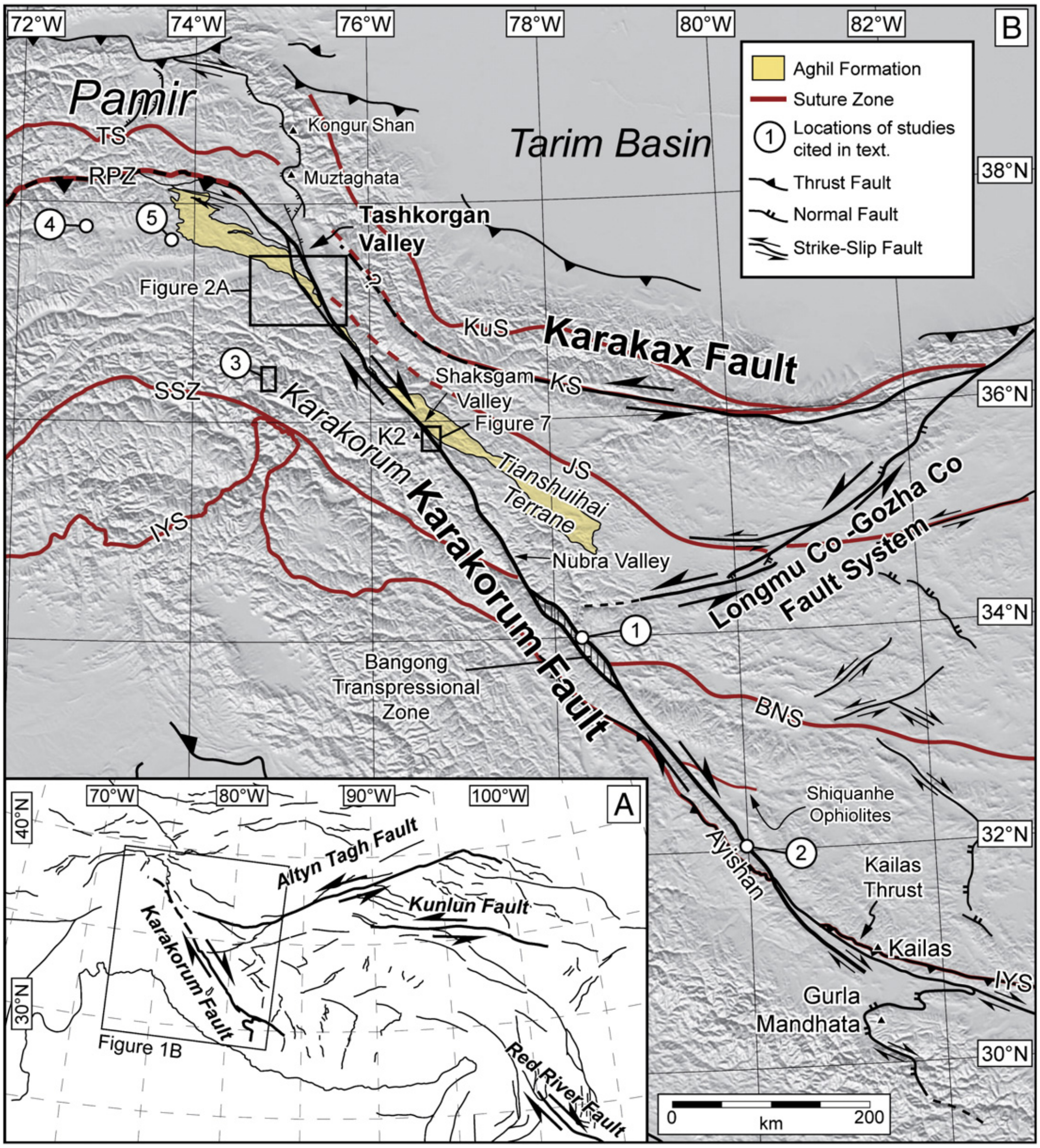

Fig. 1. (A) Simplified tectonic map of the Himalayan–Tibetan orogen showing active faults. Modified from Taylor and Yin (2009). (B) Simplified tectonic map of the western end of the Himalayan–Tibetan orogen showing faults which are active or inferred to be active (Taylor and Yin, 2009), suture zones, offset exposures of the Aghil formation from Robinson (2009), and site locations from papers mentioned. Site locations: 1) Brown et al., 2002; 2) Chevalier et al., 2005; 3) Zech et al., 2005; 4) Abramowski et al. (2006)); 5) Owen et al., (2002). IYS—Indus–Yalu suture; BNS—Bangong–Nujiang suture; JS— Jinsha suture; KS—Kunlun suture; KuS—Kudi Suture; SS—Shyok Suture; RPZ—Rushan Pshart Zone; TS—Tanymas Suture.

Karakorum fault involving southward propagation into southwestern Tibet and a change in the role of the fault from a transfer structure to accommodating radial expansion of the Himalayan arc (Ratschbacher et al., 1994; Seeber and Pecher, 1998; Murphy et al., 2000; Murphy and Copeland, 2005).

The general question these models raise is: how geometrically and kinematically stable are large, intracontinental strike-slip faults which are embedded within orogenic plateaus? Are these structures stable features like plateau-bounding faults such as the Altyn Tagh, with slip histories similar to the life-span of an orogenic belt, or are they inherently unstable with complicated kinematic evolutions and short slip histories relative to the life-span of an orogenic belt?

Importantly, most prior work along the KKF has implicitly assumed that the entire length of the Karakorum fault is currently active. This assumption forms the basis for arguments over discrepancies in Quaternary and long term slip rates, the importance and role of the Karakorum fault in the Indo-Asian collision zone, and arguments over the stability of large (~1000 km) strike-slip faults embedded within orogenic plateaus (e.g. Valli et al., 2008).

2. Geologic setting

2.1. Karakorum fault

The right-slip Karakorum fault runs for >1000 km across the western margin of the Himalayan–Tibetan orogenic belt from the southwestern Tibetan Plateau to the Pamir, separating the Pamir–Karakorum mountains from the Tibetan Plateau (Fig. 1A). At its southeastern end, the Karakorum fault links with the Gurla Mandhata detachment system and continues into the Himalayas (Murphy et al., 2002; Murphy and Copeland, 2005) with a portion of the slip interpreted to continue along the Indus–Yalu suture zone (Lacassin et al., 2004) (Fig. 1B). At its