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Geometry, kinematics, and landscape characteristics of an active transtension zone, Karakoram fault system, Southwest Tibet

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Abstract

We investigate the style of active transtensional deformation and characteristics of the landscape along the southern segment of the Karakoram fault system through field mapping, structural analysis, and examination of digital topography (SRTM, ASTER), multi-spectral (ASTER, Landsat 7+), and panchromatic (Corona photography) imagery. Our data suggests that wrench-dominated transtension is occurring within a 90-km-wide zone; simple shear within the zone is accommodated by right-lateral R and P shears as well as left-lateral R′ shears, vertical shortening is accommodated by ∼north-striking extensional shear zones and horizontal shortening is accommodated by ∼east–west-trending transtension-related corrugations. Drainage divides strike at high angles and subparallel to the transtension zone. Those that strike at high angles to the zone can be explained by movement along north-striking extensional fault systems, while the geometry of drainage divides subparallel to the zone are consistent with uplift of corrugations as well as rapid uplift of mountain ranges by normal-right-slip faulting.

Keywords: Strike-slip faulting; Transtension; Himalaya; Tibetan plateau

1. Introduction

Central to assessing the deformation behavior of continental lithosphere is a complete description of the bulk strain in theorized intracontinental plate boundaries. In various tectonic settings worldwide it has been shown that deformation within the continents is distributed across wide zones and that the motion is commonly oblique to the boundaries resulting in transpressional or transtensional deformation, for example, the Walker Lane belt (e.g. Oldow et al., 2001), Central Alps (e.g. Dewey et al., 1998), and Alpine fault zone (e.g. Norris et al., 1990). Sophisticated kinematic models due to oblique motion (transpression and transtension) have been developed (e.g. Tikoff and Teyssier, 1994; Fossen and Tikoff, 1998; Dewey, 2002) and have held up to extensive field-based structural studies. What has received considerably less attention is examination of landscape characteristics and how they compare with predictions made by transpression and transtension models.

Herein, we present geologic and geomorphologic observations from southwest Tibet and northwest Nepal, in the vicinity of Mt. Kailas. We assess the relationship between active deformation along the Karakoram fault, topography, and drainage patterns and show that they support the view that the landscape can be explained by wrench-dominated transtension, distributed across a 90-km-wide zone.

The central and southern segment of the Karakoram fault system is broadly situated between two structurally distinct domains within the Tibet–Himalayan collision zone. To its east is the Tibetan plateau, which is actively undergoing conjugate strike-slip faulting and east–west extension (Rothery and Drury, 1984; Armijo et al., 1989; Taylor et al., 2003; Kapp and Guynn, 2004), while to its west is the Himalayan fold-thrust belt, which is dominated by thrusting perpendicular to the trace of the Himalayan front. This dramatic change in deformation style across the fault as well as its regional extent and long life-span has attracted a great deal of attention on the role of this fault in accommodating the relative motion between the Tibetan plateau and Himalayas (e.g. Armijo et al., 1989;

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Avouac and Tapponnier, 1993; Searle, 1996; Yin and Harrison, 2000; Replumaz and Tapponnier, 2003; Taylor et al., 2003; Murphy and Copeland, 2005).

Transtensional deformation has been described along the Karakoram fault at several localities (Armijo et al., 1989; Ratschbacher et al., 1994; Searle, 1996; Searle et al., 1998; Murphy et al., 2000; Kapp et al., 2003; Murphy and Copeland, 2005) and is predicted by GPS-derived velocity models of the Tibet–Himalaya orogen (Larson et al., 1999; Wang et al., 2001; Zhang et al., 2004; Jade et al., 2004). The Karakoram fault system is widely considered to be a discrete narrow fault zone. However, south of 32°N the fault system appears to be more

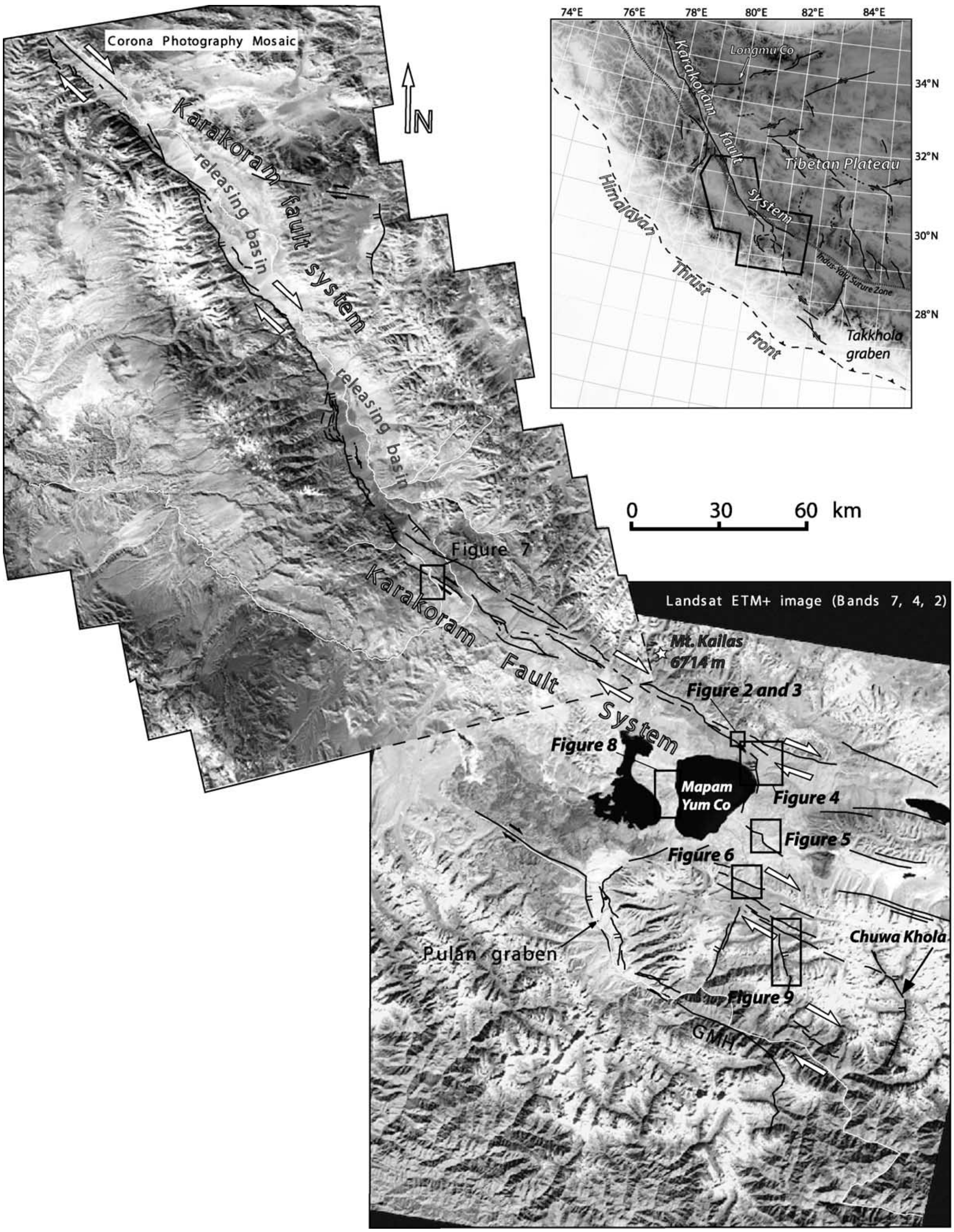

Fig. 1. Active fault map of the southern segment of the Karakoram fault system. Base map is a mosaic of Corona photography scenes in the north and Landsat ETM+ in the south. Black boxes indicate the location of sites investigated in the field and using satellite imagery. Inset shows the location of the Karakoram fault system in the Tibet–Himalayan orogen. GMH, Gurla Mandhata–Humla fault system.