Geomorphology 224 (2014) 39–54

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Impact of wind erosion on detecting active tectonics from geomorphic indexes in extremely arid areas: a case study from the Hero Range, Qaidam Basin, NW China

Lei Wu [a,b], Ancheng Xiao [a,*], Shufeng Yang [a]

[a] Department of Earth Sciences, Zhejiang University, Hangzhou, 310027, China
[b] Department of Geology, University of California, Davis 95616, CA, USA

ARTICLE INFO

Article history:
Received 15 September 2013
Received in revised form 16 June 2014
Accepted 4 July 2014
Available online 11 July 2014

Keywords:
Qaidam Basin
Wind erosion
Hypsometric curves
Stream length–gradient index
Drainage analysis

ABSTRACT

Geomorphologic analysis has been used widely to detect active tectonics in regions where fluvial incision is the major erosional process. In this paper, however, we assess the feasibility of utilizing these frequently-used geomorphic indexes (e.g., hypsometric curves, longitudinal channel profiles, normalized stream length-gradient (SLK) index) to determine active tectonics in extremely arid areas where wind erosion also plays an important role. The case study is developed on the Hero Range in the western Qaidam Basin, one of the driest regions on Earth with severe wind erosion since late Pliocene. The result shows that in the west and south sectors, as well as the western part of the east sector, of the Hero Range where fluvial incision prevails, these geomorphic indexes are good indicators of active faulting and consistent with the geological result based on study of fault traces, scarps, faulted Holocene fans and historical seismicity within the past four decades. In contrast, along the northeastern margin (the NE and the SE parts of the east sector) of the range where wind erosion is also important, the results from the geomorphic indexes show quite active tectonics, contrary with the geological evidence favoring weakly active tectonics. Moreover, the positive SLK anomaly lies oblique to the fault trace and the anticline axis but parallel to the wind direction. To reconcile the contradiction, we propose that wind erosion caused by northwestern winds has a tendency to make geomorphic indexes exhibit anomalous values that indicate higher activities, by way of (1) lowering the base-level to generate knickpoints on the longitudinal channel profiles and therefore positive SLK anomalies, and (2) lateral erosion of the mountain front making the hypsometric curves and even the longitudinal channel profiles more convex, and producing obvious slope breaks.

1. Introduction

Present-day topography is a function of rock uplift, erosion and deposition (England and Molnar, 1990; Bishop, 2007; Burbank and Anderson, 2012), suggesting that geomorphic features are good indicators for active tectonics and surface processes. Owing to the increasingly easier acquisition of high-resolution DEM and remote sensing data, a growing number of achievements on geomorphological response to active faulting and folding have been made over the past three decades (Seeber and Gornitz, 1983; Avouac and Peltzer, 1993; Jackson et al., 1996; Keller et al., 2000; Garcia and Herail, 2005; Pérez-Peña et al., 2010; Gao et al., 2013), giving us a good understanding of active tectonics in not only remote areas (Avouac and Peltzer, 1993; Clark et al., 2004) but also regions covered by Quaternary deposits without any obvious clues in the field (Keller et al., 2000; Hilley and Arrowsmith, 2008; Melosh and Keller, 2013).

A number of geomorphic indexes (e.g., stream length–gradient index, hypsometric curves, channel concavity and steepness) have proved to be good proxies for active faulting and folding in many active regions such as Himalaya and eastern Tibet (Kirby et al., 2003; Malik and Mohanty, 2007; Gao et al., 2013), Taiwan (Chen et al., 2003), the Betic Cordillera (Pedrera et al., 2009; Pérez-Peña et al., 2010; Azanon et al., 2012), the northern Apennine orogenic belt (Troiani and Della Seta, 2008) and the Transverse ranges in California (DiBiase et al., 2010). Most of the above-studied areas are regions where river incision is the major erosional process. It remains unknown whether these indexes are feasible to detect active tectonics in extremely arid areas, where annual precipitation is less than 100 mm and the fluvial incision is not so effective. Besides, wind erosion plays an important role in shaping the topography in the extremely arid areas, and its influence on the above geomorphic indexes needs to be carefully evaluated.

This paper aims to testify the applicability of using geomorphic indexes (e.g., hypsometric curves and integrals, longitudinal channel profiles and stream length–gradient index) to detect active tectonics in extremely arid areas, from the case study of the Hero Range in the western corner of the Qaidam Basin (Fig. 1), one of the driest deserts on

* Corresponding author.
E-mail addresses: wulei@zju.edu.cn (L. Wu), xiaoanch@zju.edu.cn (A. Xiao), yjsy-ysf@zju.edu.cn (S. Yang).

http://dx.doi.org/10.1016/j.geomorph.2014.07.010
0169-555X/

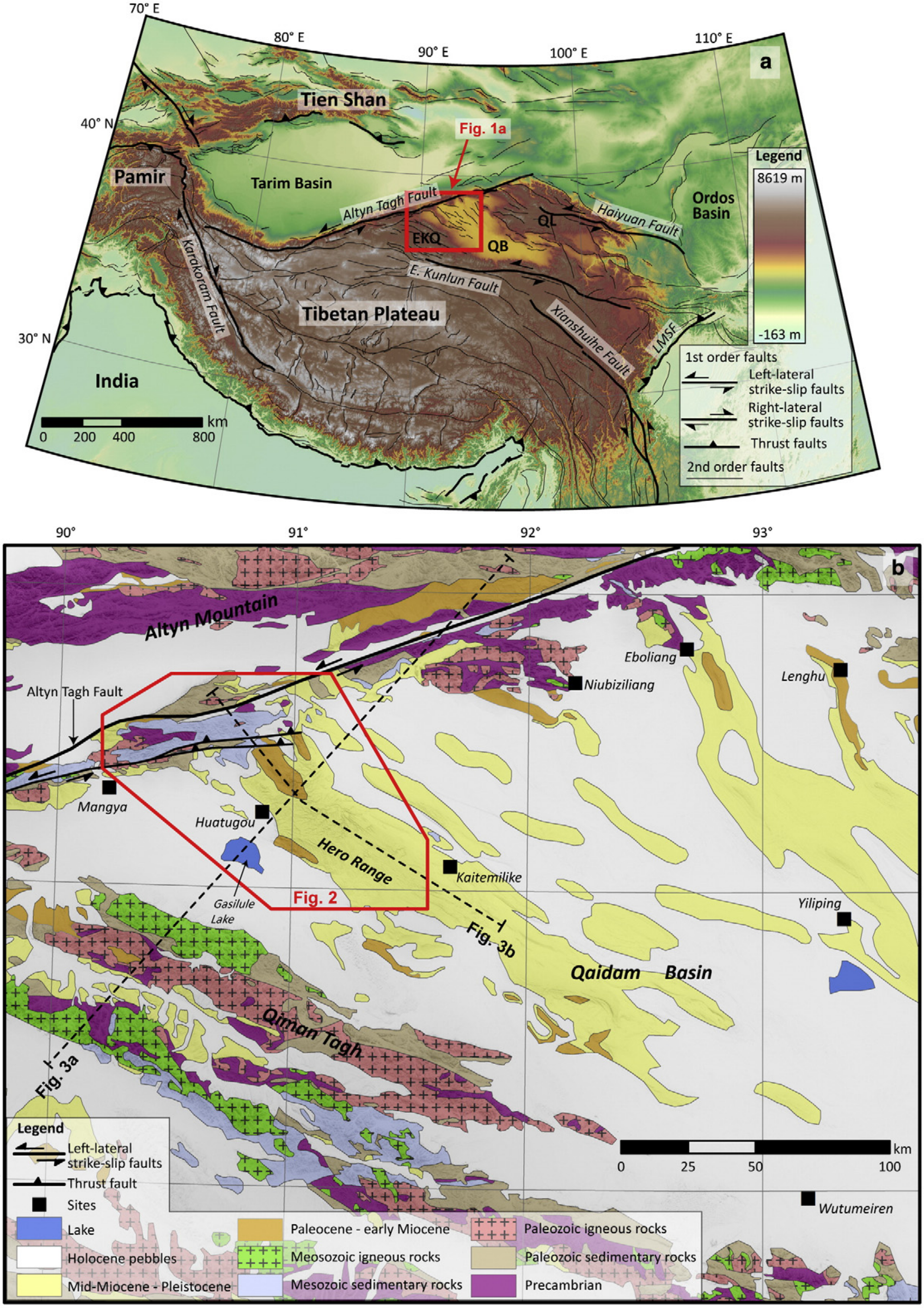

Fig. 1. (a) Active faults superimposed on the DEM map of the Tibetan Plateau and adjacent areas (Taylor and Yin, 2009), showing the location of western Qaidam Basin. DEM map is generated from the 90 m SRTM data, the same for Fig. 2. EKQ, East Kunlun–Qiman Tagh Mountain; QB, Qaidam Basin; QL, Qilian Mountain. (b) Simplified geological map of the western Qaidam Basin (the location is shown in Fig. 1a).