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Tectonic evolution of Kashmir basin in northwest Himalayas

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ABSTRACT

Geomorphology has long been recognised as a key to evaluate the interplay between tectonics and landscape geometry in the regions of active deformation. We use geomorphic signatures at varied spatial scales interpreted from SRTM-DEM/Landsat-ETM data, supplemented with field observations to review the tectonic evolution of Kashmir basin in northwest Himalayas. Geomorphic evidence is persuasive of a credible NNW–SSE trending dextral strike–slip structure (central Kashmir Fault — CKF), with the strike length of ~165 km, stretched centrally over the NNW–SSE length of the Kashmir basin. As a result of the strike–slip motion and subsequent erosion, significant deformation has taken place along the CKF. In addition, broad geomorphic architecture of the basin reveals typical pull-apart characteristics. Hence, we deduce that the Kashmir basin has evolved as a pull-apart Quaternary sediment depression owing to the deformation along the central Kashmir Fault. The spatial distribution pattern of seismic events (NEIC-catalogue, 1973–2013) and GPS measurements (published), collectively substantiate our geomorphic interpretations.

1. Introduction

Pull-apart basins are elongated sedimentary troughs that generally evolve from tectonic activity along dextral (right lateral) or sinistral (left lateral) strike–slip faults. The San Andreas Fault is first place where strike–slip fault movement was convincingly demonstrated (Bloom, 2003). Large strike–slip faults are an important feature of actively deforming parts of continents, accumulating displacements of many kilometres, and are capable of generating large earthquakes (Walker et al., 2006). Most strike–slip faults accommodate oblique displacements along some segments or during part of the time they are active; strike–slip movements are associated with an assemblage of second-order related structures, including normal and/or reverse faults (Christie-Blick and Biddle, 1985). The evolution of pull-apart basins (rhombochasms) has been widely attributed to strike–slip faulting on the basis of field and experimental data (e.g., Crowell, 1974; Aydin and Nur, 1982; Sylvester, 1988; Petrunin and Sobolev, 2008; Joshi and Hayashi, 2010). These basins are characterised by sedimentary cover above the strike–slip fault in the basement (e.g., Atmauoi et al., 2006; Nemer et al., 2008), bounded on the sides by two or more faults and on their tips by diagonal transfer faults (Gürbüz, 2010). All the pull-apart basins, regardless of offset geometry, evolve progressively from narrow depressions bounded by oblique–slip faults to wider rhombic basins flanked by terraced basin sidewall fault systems (Dooley and McClay, 1997). These basins differ dramatically from simple strike–slip systems: they share properties with strike–slip and extensional settings, resulting in complex basin structures (Rahe et al., 1998).

Geomorphology in tectonically active regimes is a powerful tool to assist in differentiating more active segments of geologic structures and can help in establishing the structural evolution of a region (Ul-Hadi et al., 2012). Moreover, widespread availability of the high quality, high-resolution topographic data encourages the development of simple morphological models that can be used to deduce recent tectonic evolution (Brocklehurst, 2010). The DEMs and optical remote sensing satellite images are widely used to study the tectonically emerged geomorphic anomalies (e.g., Jordan, 2003; Arrowsmith and Zielke, 2009; Wechsler et al., 2009; Yang et al., 2011), and provide new cost/time effective opportunities for a better understanding of earth surface processes (e.g., Tarolli, 2014), in the vast and inaccessible areas, where detailed field checks are difficult.

Located in the Indo–Eurasian collision zone (northwest Himalayas, Fig. 1), with an area of ~15,000 km^2, spread over an elevation range of ~1570–6000 m above mean sea level (amsl), the Kashmir basin is the locus of active deformation (e.g., Madden et al., 2011). The overall geomorphic configuration suggests that all the major landforms of the basin are tectonic in origin. In the present study, we use geomorphic

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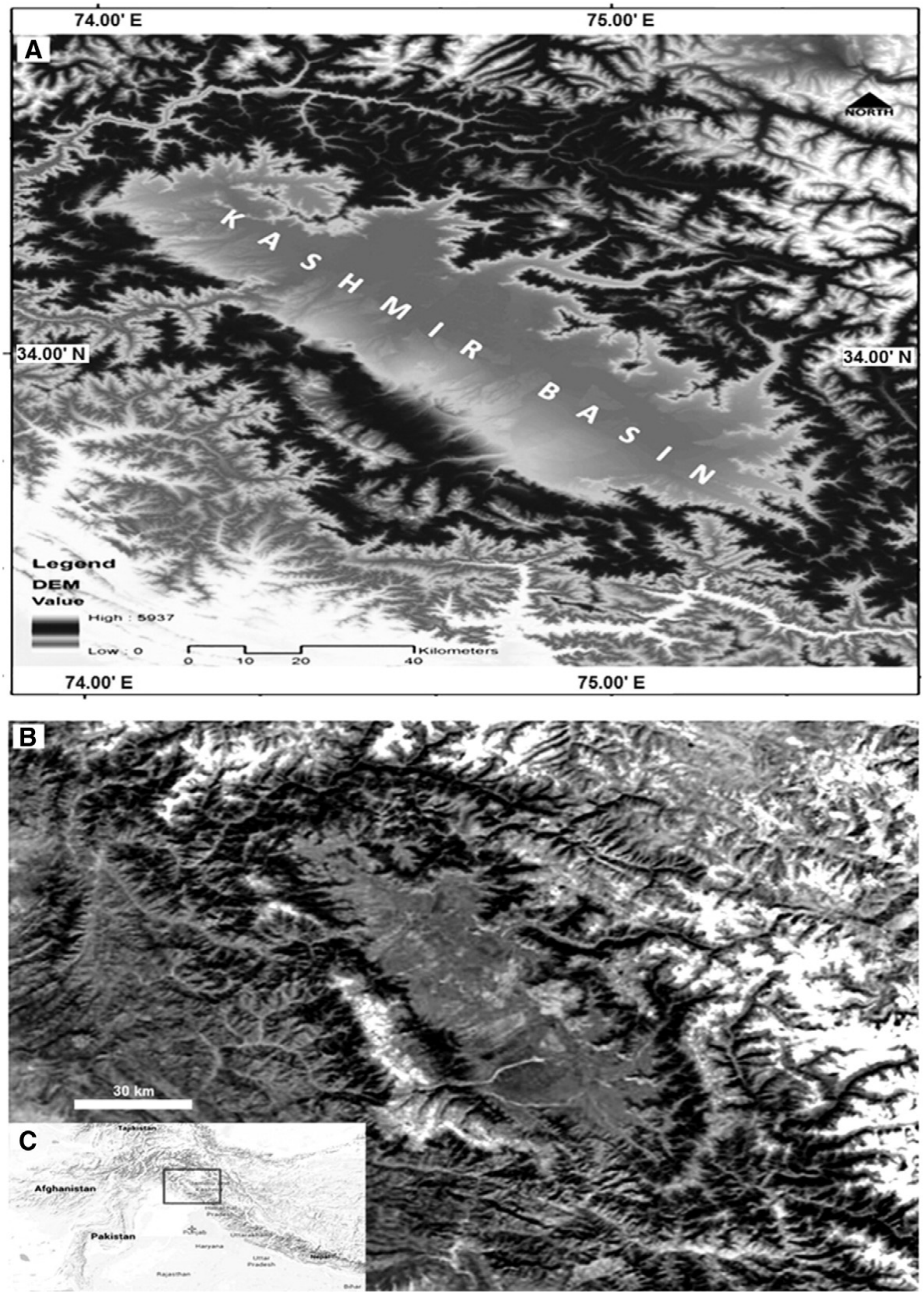

Fig. 1. Location of the Kashmir basin. (A) SRTM-DEM, (B) Google Earth image, (C) Google Earth terrain image of the northwest Himalayas.

parameters, obtained from Shuttle Radar Topographic Mission (SRTM) digital elevation model (DEM-90 m) and Landsat-Enhanced Thematic Mapper (ETM-30 m, 2001) to unravel the tectonic evolution of the Kashmir basin, followed by validation of the geomorphic interpretations using seismic data (NEIC-Catalogue, 1973–2013), and published GPS data.

2. Regional setting

2.1. Regional geology

The geology of Kashmir basin is diverse with the Salkhala series (Precambrian) and Dogra slates (lower Cambrian) as its