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Crustal thickening and uplift of the Tibetan Plateau inferred from receiver function analysis

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ABSTRACT

The India–Eurasia collision, crustal thickening and northward convergence leading to uplift of the Tibetan Plateau have been topics of multidisciplinary studies. Here we employ the *H*–*k* stacking technique and depth domain receiver function to constrain the crustal thickness and *P*- and *S*-wave velocity ratio as well as the upper mantle discontinuity. Our results identify the signature of slab break-off and lower crustal delamination in southern Tibet, which might have induced the mantle upwelling and crustal melting. The convergence of the Indian plate inducing northward crustal flow might be a major factor that contributes to the uplift and crustal thickening of Tibet. We also evaluate the E–W trending cumulative compression as another dominant factor that contributes to the increase in crustal thickness in the northern Tibet.

1. Introduction

The India–Asia collision at 50 Ma and continuous northward movement of the Indian continent built the Tibetan Plateau with one of the thickest crust on Earth (Ji et al., 2012; Mo et al., 2007; Chen et al., 2011; Owens and Zandt, 1997; Zhao and Nelson, 1993; Chatterjee et al., 2013; Replumaz et al., 2014). The Tibetan Plateau is composed of a series of east-west-trending blocks from the south to the north such as the Himalaya, Lhasa, Qiangtang, Songpan–Ganzi, and Kunlun (Yin and Harrison, 2000; Ji et al., 2012; Xu et al., 2008; Hu et al., 2012; Zhang et al., 2014a,b). These blocks are separated by at least five bordering sutures: the Indus–Yarlung suture, Bangong–Nujiang suture, Jinshajiang suture, Anyimaqen–Kunlun–Mutztagh suture, and South Qilian suture (Yin and Harrison, 2000; Sherrington and Zandt, 2004; Zhang et al., 2011, 2014a,b; Aitchison et al., 2011; Hebert et al., 2012), which represent Neo-, Meso-, Paleo- and Poto- Tethyan oceanic relicts, respectively (e.g., Yin and Harrison, 2000). Covering 10° of latitude and 20° longitude, the Tibetan Plateau covers more than a million square kilometers (Ruddiman, 1998).

The Tibetan Plateau is one of the natural museums to investigate Cenozoic tectonics of Asia (Dewey and Burke, 1973; Chang and Zheng, 1973; Le Fort, 1975, 1996; Allègre et al., 1984; Dewey et al., 1988; DeCelles et al., 2002; Yin, 2006, 2010). As one of the youngest continent–continent collision belts, the Himalayan–Tibetan orogen (Hemant and Mitchell, 2009; Dong et al., 2013) preserves several unique features of deep lithospheric processes and exhumation mechanism as keys to understanding the mechanisms of continental collision with implications on global climate change (Wang et al., 2010a,b; Xia et al., 2011; Zhang and Santosh, 2011; Lai and Qin, 2013).

Geological investigations and structural patterns suggest that deformation in the central part of the Tibetan Plateau is largely related to the north–south convergence (Molnar and Tapponnier, 1975; Rowley, 1996; Xu et al., 2007). The Tibetan crust is undergoing coeval east–west extension and north–south shortening with north-trending normal faulting and strike-slip faulting (Tapponnier et al., 2001; Taylor et al., 2003; Murphy et al., 2010).

The mechanism of deformation in three dimensions during collisional orogen is a topic of debate (Harrison, 2006; Klemperer, 2006; Webb et al., 2007; Yin, 2006). A number of hypotheses have been proposed to explain the tectonic evolution and rapid uplift of Tibet (e.g., Coleman and Hodges, 1995; Harrison et al., 1992; Molnar et al., 1993; Turner et al., 1993, 1996a,b; Chung et al., 1998; Hu et al., 2012). The salient highlights of these contrasting proposals are: (1) the thin-viscous-sheet model (Bird and Piper, 1980; England and Houseman, 1986; England and McKenzie, 1982; Flesch et al., 2005), (2) the continental subduction model with strike-slip assisted oblique subduction (Meyer et al., 1998;

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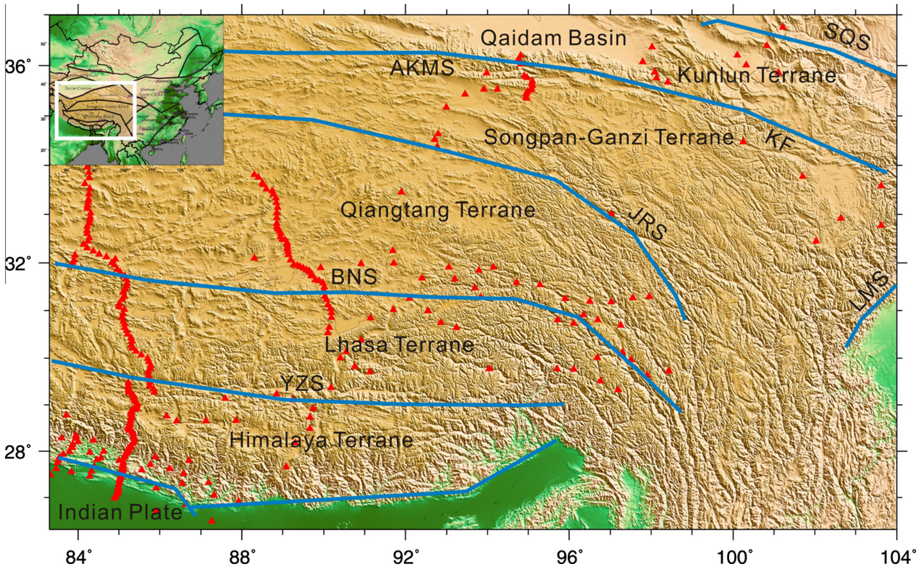

Fig. 1. Distribution of seismic stations (red triangles) in the Tibetan region. YZS: Indus–Yarlung suture, BNS: Bangong–Nujiang suture, JRS: Jinshajiang suture, KF: Kunlun fault, AKMS: Anyimaqen–Kunlun–Mutztagh suture, SQS: South Qilian suture, LMS: Longmenshan suture.

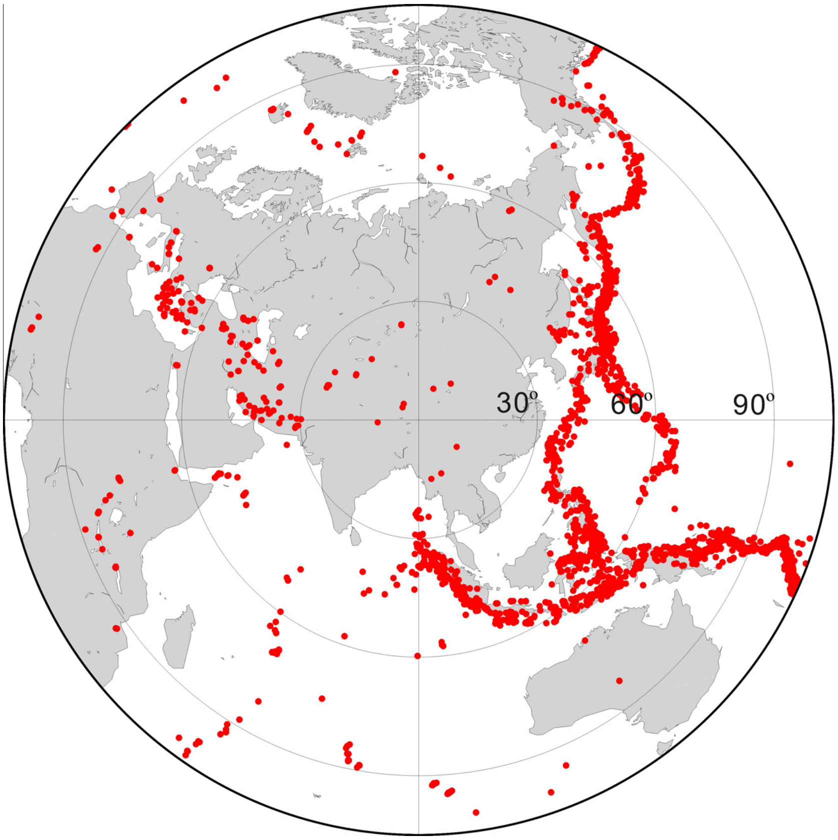

Fig. 2. Locations of the 18429 teleseismic events used in this study with an epicentral distance between 30° and 95° for a seismic station.

Tapponnier et al., 2001); and (3) the middle- or lower-crustal channel flow (Bird, 1991; Clark and Royden, 2000; Royden et al., 1997, 2008; Wang et al., 2011).

Meanwhile, geophysical studies have provided important insights into the lithospheric architecture of the Himalayan and Tibetan regions. The various studies undertaken in these regions include deep seismic (Hauck et al., 1998; Galve et al., 2002; Haines et al., 2003; Meissner et al., 2004; Jiang et al., 2006; Bai et al., 2013; Chen et al., 2013), seismic tomography (Zhang et al., 2014a,b), receiver function (He et al., 2014e; Wang et al., 2010a,b; Tian and Zhang, 2013; Xu et al., 2013), magnetotellurics (Wei et al., 2001; Unsworth et al., 2004), gravity (Jin et al., 1996;