Lithos 179 (2013) 275–292

Contents lists available at ScienceDirect

Lithos

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

A *P–T–t–D* discontinuity in east-central Nepal: Implications for the evolution of the Himalayan mid-crust

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A R T I C L E I N F O

Article history:
Received 25 March 2013
Accepted 13 August 2013
Available online 24 August 2013

Keywords:
Tectonics
P–T–t–D paths
Phase equilibria modeling
U–Th–Pb geochronology
Himalaya

A B S T R A C T

Rock specimens collected from lower, middle, and upper portions of the exhumed Himalayan mid-crust in the upper Tama Kosi region of east-central Nepal yield pressure–temperature–time–deformation (*P–T–t–D*) paths that demonstrate the presence of a structural, metamorphic, and geochronologic discontinuity. A *P–T–t–D* path from below the discontinuity defines a loading path with deformation at staurolite-grade metamorphic conditions occurring at ~10–8 Ma. *P–T–t–D* paths from above the discontinuity, in contrast, record an earlier and protracted metamorphic history that includes decompressional heating. Monazite ages from specimens collected above the discontinuity constrain prograde garnet growth to be >21 Ma with decompression-related garnet breakdown initiating at c.19 Ma and likely continuing until c.15 Ma. These contrasting *P–T–t–D* histories separated by a tectonometamorphic discontinuity are consistent with an evolutionary model for the Himalaya in which rocks above the discontinuity were metamorphosed in the deep hinterland of the orogen and deformed during lateral extrusion from beneath Tibet while rocks below the discontinuity were deformed and metamorphosed later within the shallower foreland of the orogen. These results demonstrate the spatial and temporal relationships and compatibility between lateral midcrustal extrusive flow and wedge taper processes within an evolving orogen.

1. Introduction

Ideas about convergence accommodation processes in orogenic systems have evolved with prevailing geologic thought. While classical orogenic models have generally been based on critical-taper wedge concepts, more recent hypotheses have evoked large-scale lateral midcrustal flow, commonly referred to as channel flow, as a means for accommodating significant convergence. Dispute over the viability of these deformation mechanisms for the mid-crust during a collisional orogen has been a focal point of much recent research about the Himalayan orogenic system (Beaumont et al., 2001; Bird, 1991; Corrie and Kohn, 2011; Corrie et al., 2012; Cottle et al., 2007, 2009; DeCelles et al., 1998, 2001; Grujic et al., 1996; Kellett and Grujic, 2012; Kellett et al., 2010; Kohn and Corrie, 2011; Larson, 2012; Larson and Godin, 2009; Larson et al., 2010, 2011; Law et al., 2006; Long et al., 2011; McQuarrie et al., 2008; Pearson and DeCelles, 2005; Robinson et al., 2001, 2003; Sachan et al., 2010; Searle and Szulc, 2005; Webb et al., 2007) and other orogens around the world, e.g. the Canadian Cordillera (Carr and Simony, 2006; Gervais and Brown, 2011; Glombick et al., 2006; Simony and Carr, 2011; Williams and Jiang, 2005), the Grenville (Jamieson et al., 2007; Rivers, 2008), and the Appalachians (Hatcher and Merschat, 2006). Many of the studies referenced above frame their interpretations against 'end members' of critical-taper wedge and channel flow.

In critical-taper models deformational processes are related to the development of an accretionary wedge, the evolving shape of which reflects equilibrium between the strength of the material in the wedge and friction across the basal detachment (e.g. Dahlen, 1990; Platt, 1986). In channel flow models, however, deformation occurs as a result of the flow of a low-viscosity, partially-molten midcrustal layer down a lateral pressure gradient created by the difference in elevation (lithostatic pressure) between the orogenic hinterland and foreland, commonly paired with erosional removal of material along the orographic front (e.g. Beaumont et al., 2001, 2004; Jamieson et al., 2004). These 'end members' (i.e. some type of critical-taper wedge vs. channel flow) are commonly viewed as mutually exclusive processes. Indeed, much research has been published in support of each specific 'end-member' model.

However, the mutual exclusivity between channel flow and critical-taper wedge processes commonly portrayed in the literature is in fact a false dichotomy (Beaumont and Jamieson, 2010; Larson et al., 2010, 2011). Thermo-mechanical channel flow models predict that the foreland in front of a laterally-extruding midcrustal channel will deform as

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0024-4937/$ – see front matter
http://dx.doi.org/10.1016/j.lithos.2013.08.012

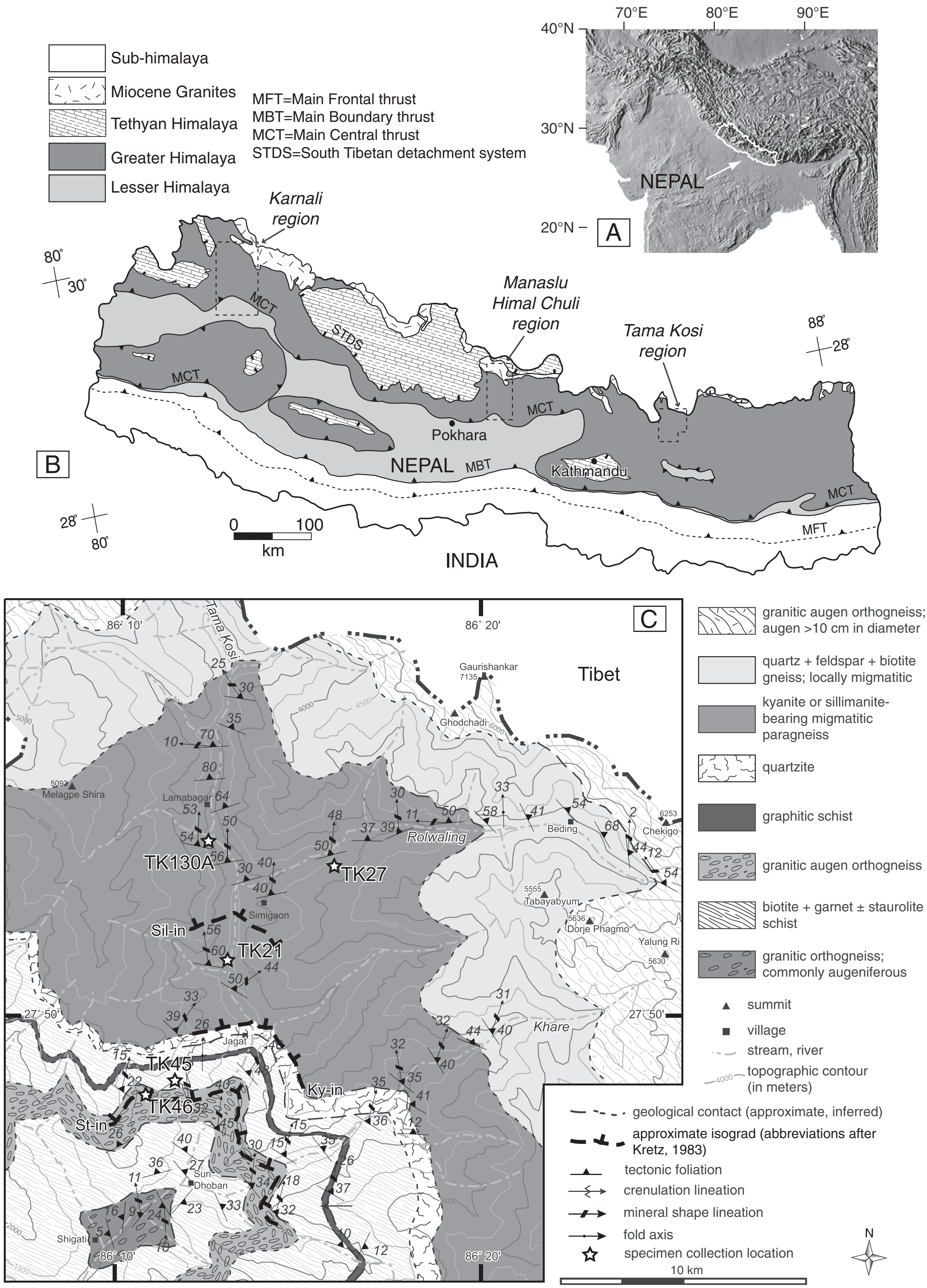

Fig. 1. A) Digital elevation model of the Himalayan system. The borders of Nepal are drawn in white (modified from Searle et al., 2008). B) Simplified geologic map of Nepal (modified from Pearson and DeCelles, 2005). C) Geologic map of the study area along the Tama Kosi river (modified from Larson, 2012). Locations of specimens collected for this study are indicated with stars.