Available online at www.sciencedirect.com

SCIENCE DIRECT®

Earth and Planetary Science Letters 234 (2005) 83–97

EPSL

www.elsevier.com/locate/epsl

The onset of India–Asia continental collision: Early, steep subduction required by the timing of UHP metamorphism in the western Himalaya

Mary L. Leech[a,*], S. Singh[b], A.K. Jain[b], Simon L. Klemperer[c], R.M. Manickavasagam[d]

[a]*Geological and Environmental Sciences, Stanford University, Stanford, CA 94305-2115, United States*
[b]*Department of Earth Sciences, Indian Institute of Technology, Roorkee 247667, India*
[c]*Department of Geophysics, Stanford University, Stanford, CA 94305-2215, United States*
[d]*Institute Instrumentation Center, Indian Institute of Technology, Roorkee 247667, India*

Received 15 October 2004; received in revised form 31 January 2005; accepted 17 February 2005
Available online 25 April 2005
Editor: Scott King

Abstract

Ultrahigh-pressure (UHP) rocks in the NW Himalaya are some of the youngest on Earth, and allow testing of critical questions of UHP formation and exhumation and the timing of the India–Asia collision. Initial collision of India with Asia is widely cited as being at 55 ± 1 Ma based on a paleomagnetically determined slowdown of India's plate velocity, and as being at ca. 51 Ma based on the termination of marine carbonate deposition. Even relatively small changes in this collision age force large changes in tectonic reconstructions because of the rapid India–Asia convergence rate of 134 mm/a at the time of collision. New U–Pb SHRIMP dating of zircon shows that Indian rocks of the Tso Morari Complex reached UHP depths at 53.3 ± 0.7 Ma. Given the high rate of Indian subduction, this dating implies that Indian continental crust arrived at the Asian trench no later than 57 ± 1 Ma, providing a metamorphic age for comparison with previous paleomagnetic and stratigraphic estimates. India's collision with Asia may be compared to modern processes in the Timor region in which initiation of collision precedes both the slowing of the convergence rate and the termination of marine carbonate deposition. The Indian UHP rocks must have traveled rapidly along a short, hence steep, path into the mantle. Early continental subduction was at a steep angle, probably vertical, comparable to modern continental subduction in the Hindu Kush, despite evidence for modern-day low-angle subduction of India beneath Tibet. Oceanic slab break-off likely coincided with exhumation of UHP terranes in the western Himalaya and led to the initiation of low-angle subduction and leucogranite generation.

Keywords: western Himalaya; Tibet; ultrahigh-pressure metamorphism; India–Asia collision; Tso Morari Complex; subduction model

* Corresponding author. Tel.: +1 650 736 1821; fax: +1 650 725 0979.
E-mail address: mary@geo.stanford.edu (M.L. Leech).

0012-821X/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.epsl.2005.02.038

1. Introduction

Ultrahigh-pressure (UHP) metamorphism, demonstrated by the index mineral coesite (a high-pressure polymorph of quartz) that requires a minimum depth of 90 km for its formation, is now widely known from continental collision zones [1–3]. The Tso Morari Complex (TMC) (Fig. 1) underwent UHP metamorphism during subduction of the Indian continent beneath Asia in the Early Eocene. The coesite-bearing UHP eclogites from Tso Morari, India, and Kaghan, Pakistan (e.g., [8,9]), are evidence that the leading edge of the entire northwestern part of the Indian continental margin was subducted beneath the Kohistan–Ladakh arc to a minimum depth of 90 km. Tentative evidence for coexisting coesite and carbonate phases in the TMC

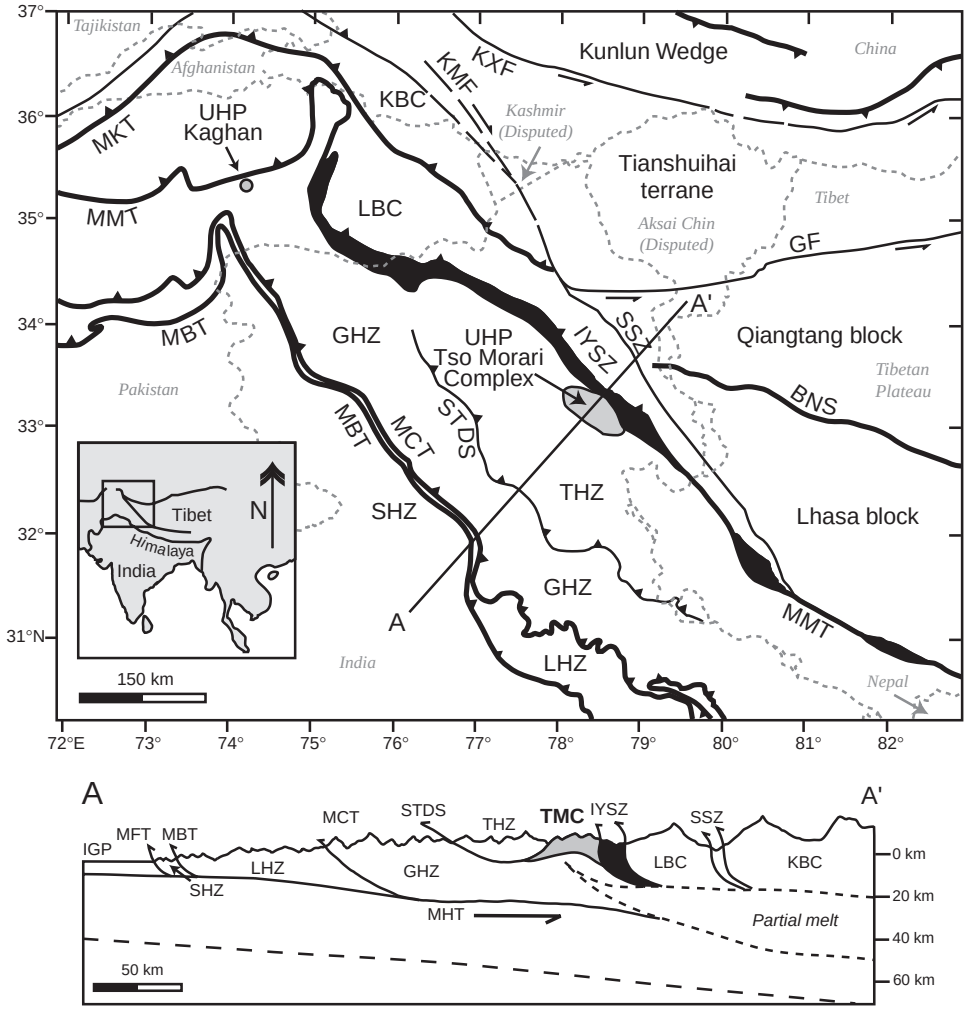

Fig. 1. Regional tectonic map of the western Himalaya showing the Tso Morari Complex (pale gray) and the Indus–Yarlung suture zone (dark gray) (adapted from [4–7]). Simplified modern cross-section A–A′ (modified after [6]; approximate location on map) shows the Tso Morari Complex in the footwall of the Indus–Yarlung suture zone and the ca. 10° modern subduction angle (true scale below sea level; topography is exaggerated). Abbreviations: BNS, Bangong–Nujiang suture; GF, Gozha fault; GHZ, Greater Himalayan zone; IGP, Indo-Gangetic plain; IYSZ, Indus–Yarlung suture zone; KBC, Karakoram batholith complex; KMF, Karakoram fault; KXF, Karakax fault; LBC, Ladakh batholith complex; LHZ, Lesser Himalayan zone; MBT, Main Boundary thrust; MCT, Main Central thrust; MHT, Main Himalayan thrust; MKT, Main Karakoram thrust; MMT, main mantle thrust; SHZ, Sub-Himalayan zone; SSZ, Shyok suture zone; STDS, South Tibetan detachment system; THZ, Tethyan Himalayan zone.