Available online at www.sciencedirect.com

SCIENCE DIRECT®

Earth-Science Reviews 68 (2005) 173–196

EARTH-SCIENCE REVIEWS

www.elsevier.com/locate/earscirev

Tibetan tectonic evolution inferred from spatial and temporal variations in post-collisional magmatism

Sun-Lin Chung[a,*], Mei-Fei Chu[a], Yuquan Zhang[b], Yingwen Xie[b], Ching-Hua Lo[a], Tung-Yi Lee[c], Ching-Ying Lan[d], Xianhua Li[b], Qi Zhang[e], Yizhao Wang[f]

[a] *Department of Geosciences, National Taiwan University, Taipei P.O. Box 13-318, Taipei 10699, Taiwan*
[b] *Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China*
[c] *Department of Earth Sciences, National Taiwan Normal University, Taipei, Taiwan*
[d] *Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan*
[e] *Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China*
[f] *Regional Geological Survey, Yuxi, Yunnan, China*

Received 24 June 2003; accepted 5 May 2004

Abstract

Cenozoic magmatism on the Tibetan plateau shows systematic variations in space and time that must be considered in models concerning Tibetan tectonic evolution. After the India–Asia collision, which started in the early Tertiary and terminated the Gangdese arc magmatism in the Lhasa terrane made of the southern Tibetan plateau, widespread potassium-rich lavas and subordinate sodium-rich basalts were generated from ~ 50 to 30 Ma in the Qiangtang terrane of northern Tibet. Subsequent post-collisional magmatism migrated southwards, producing ultrapotassic and adakitic lavas coevally between ~ 26 and 10 Ma in the Lhasa terrane. Then potassic volcanism was renewed to the north and has become extensive and semicontinuous since ~ 13 Ma in the western Qiangtang and Songpan–Ganze terranes. Such spatial–temporal variations enable us to elaborate a geodynamic evolution model which depicts when and how the Indian continental lithospheric mantle started thrusting under Asia by involving rollback and breakoff of the subducted Neo-Tethyan slab followed by removal of the thickened Lhasa lithospheric root. We propose that only after the lithospheric removal, which occurred at ~ 26 Ma, could the Indian mantle lithosphere have commenced its northward underthrusting and henceforth served as a pivotal control to the Himalayan–Tibetan orogenesis. Consequently, the Tibetan plateau is suggested to have risen diachronously from south to north. Whereas the southern part of the plateau may have been created and maintained since the late Oligocene, the northern plateau would have not attained its present-day elevation and size until the mid-Miocene when the lower part of the western Qiangtang and Songpan–Ganze lithospheres began to founder owing to the push of the underthrust Indian mantle lithosphere.

Keywords: Tibetan plateau; Continental tectonics; Post-collisional magmatism; Geochemistry; India–Asia collision

1. Introduction

It is widely accepted that the immense Tibetan plateau and surrounding mountain ranges form as a direct consequence of the collision of India with Asia

* Corresponding author. Tel.: +886-2-8369-1242; fax: +886-2-2363-6095.
E-mail address: sunlin@ntu.edu.tw (S.-L. Chung).

0012-8252/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.earscirev.2004.05.001

Magmatic Evidence for the Evolution from Accretionary to Collisional Orogeny in Southern Tibet

Sun-Lin Chung [a], Dunyi Liu [b], Jianqing Ji [c], Qi Zhang [d], Biao Song [b], Qing Qian [d], Da-Jen Wen [a], Mei-Fei Chu [a], Tung-Yi Lee [e], Ching-Hua Lo [a]

[a] *Department of Geosciences, National Taiwan University, Taipei, Taiwan*

[b] *Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China*

[c] *School of Earth and Space Sciences, Peking University, Beijing, China*

[d] *Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China*

[e] *Department of Earth Sciences, National Taiwan Normal University, Taipei, Taiwan*

The Tibetan plateau, which is generally regarded as the archetype of collisional orogens, is also an outstanding natural laboratory for investigating accretionary orogeny because it was located in an Andean-style convergent margin related to the northward subduction of the Neotethyan oceanic lithosphere before India started colliding with Asia along the Indus-Yarlung suture. Knowledge about the pre-collisional geologic processes, however, remains limited because most of investigations in this region have been focused on post-collisional geology. The Trans-Himalayan magmatism, which occurred extensively within the Lhasa terrane of southern Tibet related to the Neotethyan subduction, has long been documented but thus remains poorly studied. Here we report new SHRIMP zircon U-Pb age results for the Gangdese Batholith that represents the largest Trans-Himalayan plutonic complex. These data indicate two episodes of plutonism in the Late Cretaceous (ca. 103-80 Ma) and early Paleogene (ca. 65-46 Ma), respectively. Our results, together with literature information and petrochemical constraints, suggest that the older episode ended up with a combined magmatic and tectonic thickening of the crust while the younger episode resulted in little crustal thickening despite significant melt additions from the juvenile mantle. We attribute the former to a flattening of the Neotethyan northward subduction and the latter to rollback of the subducting slab, which caused tectonic switching from a contractional to extensional setting marked with southward migration and intensification of the magmatism that enhanced thermal softening of the Lhasa lithosphere. Therefore, subsequent India-Asia collision gave rise to distributed lithospheric thickening in southern Tibet where the orogeny eventually evolved from accretionary to collisional with a transitional stage of extension in between.

On The Nature and Timing of Crustal Thickening in Southern Tibet

論藏南地殼增厚發生的時間和可能機制

鍾孫霖 [1] 劉敦一 [2] 季建清 [3] Suzanne Y. O'Reilly[4] 張旗 [5]
朱美妃 [1] 宋彪 [2] N.J. Pearson[4] 李通藝 [6] 羅清華 [1]

1 台灣大學地質科學系，台北 10699
2 中國地質科學院地質所北京離子探針中心，北京 100037
3 北京大學地球與空間學院，北京 100037
4 GEMOC, Macquarie University, NSW 2109, Australia
5 中國科學院地質與地球物理研究所，北京 100037
6 台灣師範大學地球科學系，台北 106

Rising as "the roof of the world" Tibetan plateau is underlain by the thickest continental crust on Earth. How and when was this crust formed, which would have exerted pivotal controls to the formation of the plateau, has long been a subject of debates. Here, based on our study of collision-type adakites and associated igneous rocks from southern Tibet, we demonstrate that the Tibetan crust experienced a major phase of tectonic thickening between about 40 and 30 Myr ago in this region. The lower part of the thickened crust consisted prevailingly of mafic lithologies, which our new data suggest to have resulted from intense basaltic underplating and remelting that occurred during Late Cretaceous and mid-Eocene time owing to the Neotethyan subduction, a process responsible for not only the juvenile crust production but also creation of a thermally softened lithosphere. Subsequent collision between India and Asia, therefore, caused distributed lithospheric thickening with formation of an orogenic root beneath southern Tibet. Root foundering that took place during the Oligocene gave rise to the adakitic magmatism, regional uplift, and onset of northward underthrusting of the Indian plate that has since played a role in forming the entire Tibetan plateau. This study with emphasis on preexisting lithospheric controls to the Tibetan-Himalayan evolution has implications for not only the continental tectonics in Asia but also global orogenesis related to continental or terrane collisions. During terrane assemblages such as those formed the Asian continent, foregoing magma processes including underplating and remelting in the lower crust may have served as a common, rather than occasional, mechanism to effectively soften/weaken the continents involved and cause viscous instead of rigid intraplate deformation.