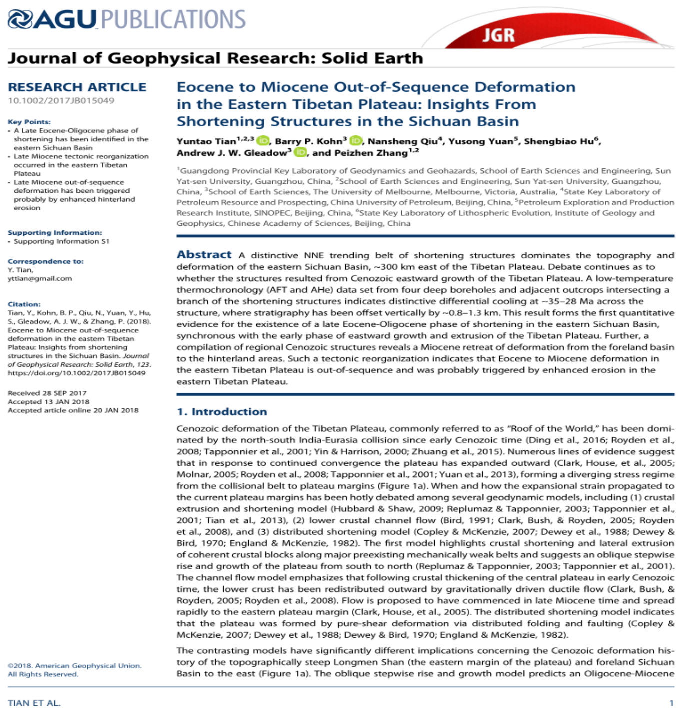
Proceedings Of The Fourth International Conference On Basement Tectonics, Oslo, Norway, August 10-14



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JGR

Journal of Geophysical Research: Solid Earth

RESEARCH ARTICLE

10.1002/2017JB015049

Key Points:

- A Late Eocene-Oligocene phase of shortening has been identified in the eastern Sichuan Basin
- Late Miocene tectonic reorganization occurred in the eastern Tibetan Plateau
- Late Miocene out-of-sequence deformation has been triggered probably by enhanced hinterland erosion

Supporting Information:

- Supporting Information S1

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Citation:
Tian, Y., Kohn, B. P., Qiu, N., Yuan, Y., Hu, S., Gleadow, A. J. W., & Zhang, P. (2018). Eocene to Miocene out-of-sequence deformation in the eastern Tibetan Plateau: Insights from shortening structures in the Sichuan Basin. *Journal of Geophysical Research: Solid Earth*, *123*. https://doi.org/10.1002/2017JB015049

Received 28 SEP 2017
Accepted 13 JAN 2018
Accepted article online 20 JAN 2018

Eocene to Miocene Out-of-Sequence Deformation in the Eastern Tibetan Plateau: Insights From Shortening Structures in the Sichuan Basin

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Abstract A distinctive NNE trending belt of shortening structures dominates the topography and deformation of the eastern Sichuan Basin, ~300 km east of the Tibetan Plateau. Debate continues as to whether the structures resulted from Cenozoic eastward growth of the Tibetan Plateau. A low-temperature thermochronology (AFT and AHe) data set from four deep boreholes and adjacent outcrops intersecting a branch of the shortening structures indicates distinctive differential cooling at ~35–28 Ma across the structure, where stratigraphy has been offset vertically by ~0.8–1.3 km. This result forms the first quantitative evidence for the existence of a late Eocene-Oligocene phase of shortening in the eastern Sichuan Basin, synchronous with the early phase of eastward growth and extrusion of the Tibetan Plateau. Further, a compilation of regional Cenozoic structures reveals a Miocene retreat of deformation from the foreland basin to the hinterland areas. Such a tectonic reorganization indicates that Eocene to Miocene deformation in the eastern Tibetan Plateau is out-of-sequence and was probably triggered by enhanced erosion in the eastern Tibetan Plateau.

1. Introduction

Cenozoic deformation of the Tibetan Plateau, commonly referred to as "Roof of the World," has been dominated by the north-south India-Eurasia collision since early Cenozoic time (Ding et al., 2016; Royden et al., 2008; Tapponnier et al., 2001; Yin & Harrison, 2000; Zhuang et al., 2015). Numerous lines of evidence suggest that in response to continued convergence the plateau has expanded outward (Clark, House, et al., 2005; Molnar, 2005; Royden et al., 2008; Tapponnier et al., 2001; Yuan et al., 2013), forming a diverging stress regime from the collisional belt to plateau margins (Figure 1a). When and how the expansional strain propagated to the current plateau margins has been hotly debated among several geodynamic models, including (1) crustal extrusion and shortening model (Hubbard & Shaw, 2009; Replumaz & Tapponnier, 2003; Tapponnier et al., 2001; Tian et al., 2013), (2) lower crustal channel flow (Bird, 1991; Clark, Bush, & Royden, 2005; Royden et al., 2008), and (3) distributed shortening model (Copley & McKenzie, 2007; Dewey et al., 1988; Dewey & Bird, 1970; England & McKenzie, 1982). The first model highlights crustal shortening and lateral extrusion of coherent crustal blocks along major preexisting mechanically weak belts and suggests an oblique stepwise rise and growth of the plateau from south to north (Replumaz & Tapponnier, 2003; Tapponnier et al., 2001). The channel flow model emphasizes that following crustal thickening of the central plateau in early Cenozoic time, the lower crust has been redistributed outward by gravitationally driven ductile flow (Clark, Bush, & Royden, 2005; Royden et al., 2008). Flow is proposed to have commenced in late Miocene time and spread rapidly to the eastern plateau margin (Clark, House, et al., 2005). The distributed shortening model indicates that the plateau was formed by pure-shear deformation via distributed folding and faulting (Copley & McKenzie, 2007; Dewey et al., 1988; Dewey & Bird, 1970; England & McKenzie, 1982).

The contrasting models have significantly different implications concerning the Cenozoic deformation history of the topographically steep Longmen Shan (the eastern margin of the plateau) and foreland Sichuan Basin to the east (Figure 1a). The oblique stepwise rise and growth model predicts an Oligocene-Miocene

Proceedings of the Fourth International Conference on Basement Tectonics: Oslo, Norway, August , / editors, Roy H. Gabrielsen [et al.].Proceedings of the fourth International Conference on Basement Tectonics: Oslo , Norway, August , / editors, Roy H. Gabrielsen [et al.].Results - of by International Conference on Basement Tectonics ; Roy Tectonics, Oslo, Norway, August , by International Conference.Proceedings of the Fourth International Conference on Basement Tectonics, Oslo , Norway, August , by. International Conference on Basement., Proceedings of the Fourth International Conference on Basement Tectonics (International Conference held: August , , Oslo, Norway.Proceedings of the Fourth International Conference on Basement Tectonics, Oslo , Norway, August , by International Conference on Basement.Bussod, G.Y., and Irving, A.J., , Thermal and rheologic history of the upper Rio Grande rift: Proceedings, 4th International Basement Tectonics Conference (Oslo, Norway, August 1014,): Salt Lake City, (abstract): Proceedings, 33rd International Geological Congress, Oslo, Norway, August , Abstracts, p.(English)In: Proceedings of the fourth international conference on basement tectonics, Oslo, Norway, August , / [ed] Roy H. Gabrielsen, Salt.Fundamentals of rock joints: proceedings of the International Symposium on . conference on basement tectonics, Oslo, Norway, August , / [ed] Roy .Duplicate Measurements After Nine Years Support a Non-tectonic Origin for Displacement Sep ; Northwest Trans-Pecos Texas, and Chihuahua, Mexico, Texas Bureau of (Editors), Proceedings of the Fourth International Conference on Basement Tectonics Association, Oslo, Norway, August 1014, Publication No.Proceedings of the Fourth International conference on. Basement Tectonics, Oslo , Norway, August , , Salt Lake. City (UT): International Basement.Proceedings of the fourth International Conference on Basement Tectonics: Oslo , Norway, August , QEI5 Earth Sciences Library.