Forum Comment

https://doi.org/10.1130/G39841C.1

Evidence from Paleosols for low to moderate elevation of the India-Asia suture zone during mid-Cenozoic time

Qiang Xu[1]*, Robert A. Spicer[2,3], and Lin Ding[1]
[1]Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, and Center for Excellence in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, Beijing 100101, China
[2]Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Yunnan 666303, China
[3]School of Environment, Earth and Ecosystem Sciences, The Open University, Milton Keynes MK7 6AA, UK
*E-mail: xuq@itpcas.ac.cn

A recent study by Leary et al. (2017) applied stable isotope and major element analyses of paleosols from the Liuqu Conglomerate (China) to reconstruct paleoclimate and paleoelevation of the India-Asia suture zone (Fig. 1). Their results indicate the Liuqu area was wet, well-vegetated, and at a low to moderate elevation when the Liuqu Conglomerate was deposited. Although the authors acknowledged that the age estimates of the Liuqu vary, they assigned an early Miocene depositional age. In order to reconcile the contradiction of an early Eocene uplift due to crustal shortening with a low-to-moderate elevation in the early Miocene, Leary et al. argued that rollback/shearing of the subducted Indian slab extended to the upper crust and prevented significant surface uplift until at least ca. 20 Ma.

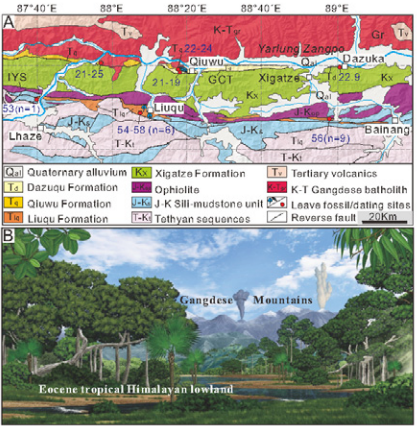

Figure 1. A: Tectonic map of the Yarlung-Zangpo regions (China) between Lhaze and Xigatze, showing the Liuqu and Kailas Conglomerates. Ages of the Qiuwu, Dazuqu, and Liuqu Formations are determined by zircon U-Pb dating (Leary et al., 2016; Ding et al., 2017 and references therein). B: Low-elevation, tropical rainforest paleoenvironment of the Himalayan regions during the early Eocene reconstructed from Liuqu plant fossils and soil carbonates. The Liuqu basin, at an altitude of ~1 km, was located to the south of the volcanically active Gangdese Mountains, which rose to an altitude of ~4.5 km (Ding et al., 2017).

The Liuqu depositional age is critical for understanding the paleoelevation history and geodynamic mechanism of the Himalayan orogen. Leary et al. cited their previous biotite ^{40}Ar/^{40}Ar data from crosscutting dikes, detrital zircon U-Pb and zircon fission-track (ZFT) analyses, and δ^{13}C values of soil carbonates (Leary et al., 2016) to obtain their age estimate of ca. 20 Ma. However, none of these approaches directly define the age of the Liuqu Conglomerate deposition for the following reasons:

(1) Only one or two zircon grains from different samples analyzed for detrital U-Pb and ZFT gave ages younger than 20 Ma. Such low grain counts cannot provide a definitive maximum age determination.

(2) The age of the lamprophyre dikes crosscutting the Liuqu Conglomerate only indicate that the latter was older than 20 Ma because this is the ^{39}Ar/^{40}Ar age of biotite in the dikes.

(3) The depleted δ^{13}C values of paleosols match global average values both at ca. 56–50 Ma and younger than 20 Ma (Ekart et al., 1999). Because of these two matches, δ^{13}C values cannot independently constrain the Liuqu age to be only 20 Ma.

Plant megafossil leaves and tuffites in the Liuqu Conglomerate let us more accurately constrain the Liuqu ages (Ding et al., 2017) (Fig. 1A). Plant megafossils in the upper Liuqu successions (36 species) include palms and indicate a diverse tropical-subtropical vegetation, which is distinctly different from the nearby early Miocene (ca. 22–20 Ma) Qiabulin flora, which has a temperate, not tropical, aspect, and paleoenthalpy values derived from fossil leaves indicate a paleoelevation of ~2.3 km (Ding et al., 2017) (Fig. 1A). The Liuqu flora is undoubtedly indicative of low elevations, and on taxonomic grounds has been assigned to the middle Eocene (Fang et al., 2006). In addition, EMPA analysis confirms a tuffite bed in the lower part of the Liuqu Conglomerate mainly contains volcanic glass with an SiO_2 content generally over 85%. A U-Pb concordia age of 59.3 ± 1.6 Ma was determined from nine zircons giving ages of 56.4 Ma to 61.4 Ma (Ding et al., 2017). This age range reproduces previous detrital zircon ages of 53–58 Ma ($n = 7$) (Leary et al., 2016; Ding et al., 2017 and references therein) (Fig. 1A). Together with the megafossil age estimations, we therefore determine the depositional age of the Liuqu Conglomerate to have been between ca. 56 Ma and 50 Ma, which is also compatible with the first negative excursion of the global carbon isotopic composition in the Cenozoic (Ekart et al., 1999).

The age information presented here strongly challenges the geodynamic interpretations of Leary et al. (2017). Well-vegetated, wet, and low-elevation (~1 km) land surfaces in the Himalayan orogen abutted pre-existing Gangdese Mountains to the north in the early Eocene, as evidenced by both the megafossils and soil geochemistry data (Ding et al., 2017; Leary et al., 2017) (Fig. 1B). Furthermore, the interpretation of the Eocene low-to-moderate elevation in the Liuqu basin does not require a decrease in elevation in the Miocene, but directly results from Eohimalayan crustal shortening (Yin, 2006); while the early Miocene rapid uplift from 2.3 km to >5.0 km likely arose from both the crustal thickening and deep lithospheric processes associated with the subducted Indian slab (DeCelles et al., 2016).

ACKNOWLEGMENTS

Funding was supported by the National Natural Science Foundation of China (No. 41472207, 41496015, and 41661134049).

REFERENCES CITED

DeCelles, P.G., Castañeda, I.S., Carrapa, B., Liu, J., Quade, J., Leary, R., and Zhang, L., 2016, Oligocene-Miocene Great Lakes in the India-Asia Collision Zone: Basin Research, https://doi.org/10.1111/bre.12217.

Ding, L., et al., 2017, Quantifying the rise of the Himalaya orogen and implications for the South Asian monsoon: Geology, v. 45, p. 215–218, https://doi.org/10.1130/G38583.1.

Ekart, D., Cerling, T., Montanez, I., and Tabor, N., 1999, A 400 million year carbon isotope record of pedogenic carbonate: Implications for paleoatmospheric carbon dioxide: American Journal of Science, v. 299, p. 805–827, https://doi.org/10.2475/ajs .299.10.805.

Fang, A., Yan, Z., Liu, X., Pan, Y., Li, J., Yu, L., Huang, F., and Tao, J., 2006, The age of plant fossil assemblage in the Liuqu Conglomerate of southern Tibet and its tectonic significance: Progress in Natural Science, v. 16, p. 55–64, https://doi.org/10. 1080 /10020070612331343192.

Leary, R.J., DeCelles, P.G., Quade, J., Gehrels, G.E., and Waanders, G., 2016, The Liuqu Conglomerate, southern Tibet: Early Miocene basin development related to deformation within the Great Counter Thrust system: Lithosphere, v. 8, p. 427–450, https://doi.org/10.1130/L542.1.

Leary, R.J., Quade, J., DeCelles, P.G., and Reynolds, A., 2017, Evidence from paleosols for low to moderate elevation of the India-Asia suture zone during mid-Cenozoic time: Geology, v. 45, p. 399–402, https://doi.org/10.1130 /G38830.1.

Yin, A., 2006, Cenozoic tectonic evolution of the Himalayan orogen as constrained by along-strike variation of structural geometry, exhumation history, and foreland sedimentation: Earth-Science Reviews, v. 76, p. 1–131, https://doi.org/10.1016/j.earscirev.2005.05.004.