Widespread crustal melting since 28 Ma creates the modern flat Tibet

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As the largest and highest plateau on Earth, the Tibetan Plateau is distinguished from most other ranges and linear continental orogenic belts (e.g., the Alps) by its broad and flat topography. According to influential numerical and theoretical models, the (former) existence of ductile and molten mid-to-lower crust was an essential contributor to the topographic smoothing process. However, the question of whether the Tibetan Plateau has undergone widespread crustal melting remains highly controversial and hard to prove due to the scarcity of direct evidence from the deep crust. Here we first report on a series of hydrous crustal xenoliths entrained in 28 Ma host lavas from central and northern Tibet. Our new results document the former existence of hydrous crust at 28 Ma as a potentially highly fertile magma source. Quantitative modeling reveals a thermal gradient reaching about 680 °C to 790 °C at a depth of 14 to 40 kilometers, which is significantly lower than that of recent (since 2.3 Ma) evidence for hot Tibetan crust. Petrological data suggest that the initial crustal melting beneath Tibet began at 28 Ma at depths of 23–40 km (and even deeper) with 0.5–9.6 vol. % melts, which would lead to a significant reduction of seismic speeds similar to the low-velocity zones observed in the present Tibetan mid-to-lower crust. As the geothermal gradient continued to rise from 28 to 2.3 Ma, wholesale crustal melting (> 20–30 vol. %) of the mid-to-lower crust beneath Tibet was inevitable and created the modern flat Tibetan Plateau.