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Post-Early-Cretaceous Basement-Controlled Uplift and Exhumation in the Sichuan Basin at Eastern Margin of the Tibetan Plateau

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With respect to Basin-mountain system, a key result of the last two decades of research is the idea of interactions and couplings between tectonics and surface processes (Willet, 1999; Whipple, 2009; Cloetingh et al., 2009), in particular around the Tibetan Plateau. The Sichuan basin and its periphery, located at eastern margin of the Tibetan Plateau and western margin of the Yangtze block, consists a composite basin-mountain system, being trisection in topography, basement and surface structure (Burchfiel et al., 1995; Liu et al., 2012). Thus, the tectonics or surface processes (e.g., Clark et al., 2004; Richardson et al., 2008) as a first-order controlling factor of uplift and exhumation across the Sichuan basin holds significant implications for the understanding of continental dynamics in the eastern Tibetan Plateau and the western Yangtze block. New apatite fission-track (AFT) ages from Mesozoic sediments in the Sichuan basin, show two types of AFT data occuring between the Huayin Mts. and the center of the Sichuan basin. One type is the fully reset sample with an age of 40~50 Ma and $\chi 2$ value >5% along the Huayun Mts., contrasting the partially reset sample with the age of 80~90 Ma and the $\chi 2$ value of <5% in the basin center. However, the modeled thermal histories from our new data, and the previous fission-track data across the Sichuan basin indicate that most of the samples have had slower continuous cooling and exhumation during post-Early-Cretaceous time (since 120~80Ma, the time it reached the maximum burial depth), with a significant acceleration in cooling rate during the last 20~10 Ma (Figure 1). They demonstrate differential uplift and exhumation across the basin. Particularly significant change in exhumation (at least ~2000m) was found across the Huayin Mts (Figure 1). The Boomerang plot based on our new AFT dataset in conjunction with previous fission-track studies (Arne et al., 1997; Shen et al., 2007, 2009; An et al., 2008; Richarson et al., 2008; Deng et al., 2009, 2013; Liu et al., 2008; Tian et al., 2011; Li et al., 2012), shows that there is two-stage cooling and exhumation across the Sichuan basin. First one is during the Late Cretaceous (120~80Ma) and the second one during Late Cenozoic (20~10Ma), indicating the start of the basin-scale differential uplift and exhumation which effected the eastern growth of Tibetan Plateau. In particular, an obvious nested center with the age older than ~120Ma (partially reset AFT age) and the length shorter than ~13 mm (Figure 2a-b), was found in the center-to-northwest part of the Sichuan basin separated by the Huayin Mts. to the southeast. A simplified one-dimensional, steady-state solution model was developed to calculate the mean exhumation rate, which is 0.05~0.2 mm/yr in most parts of the basin (Figure 2c). It suggests a slow uplift and exhumation across much of the basin. The regional pattern of AFT age, length and erosion rate supports a progressive change from the nested old-age center towards the southwest. To the southwest, the AFT length is longer than ~13.5 mm, with an age of ~15 Ma, and fast rate, which is ~0.9mm/yr. Furthermore, there is a good correlationship among the *in-situ* elevation, topographic slope and mean relief across the basin (Figure 2d-f). All of them have a consistent feature with the nested AFT age center indicating by the relatively lower topographic slope and mean relief area superposed on the nested AFT age center. However, the higher elevation, topographic slope and mean relief area located at the southwestern part of the basin, is consistent with the area characterized with longer AFT length, younger age and fast rate. Thus, all the features can be interpreted as consistent with a long-term, mean exhumation rate across the Sichuan basin, followed by a recent significant increase in the exhumation rate relatively to most of other parts of the basin. Not only do they imply that a relatively prolonged, steady-state uplift and exhumation took place across the basin controlled by the cratonic basin structure, but they also suggest that the

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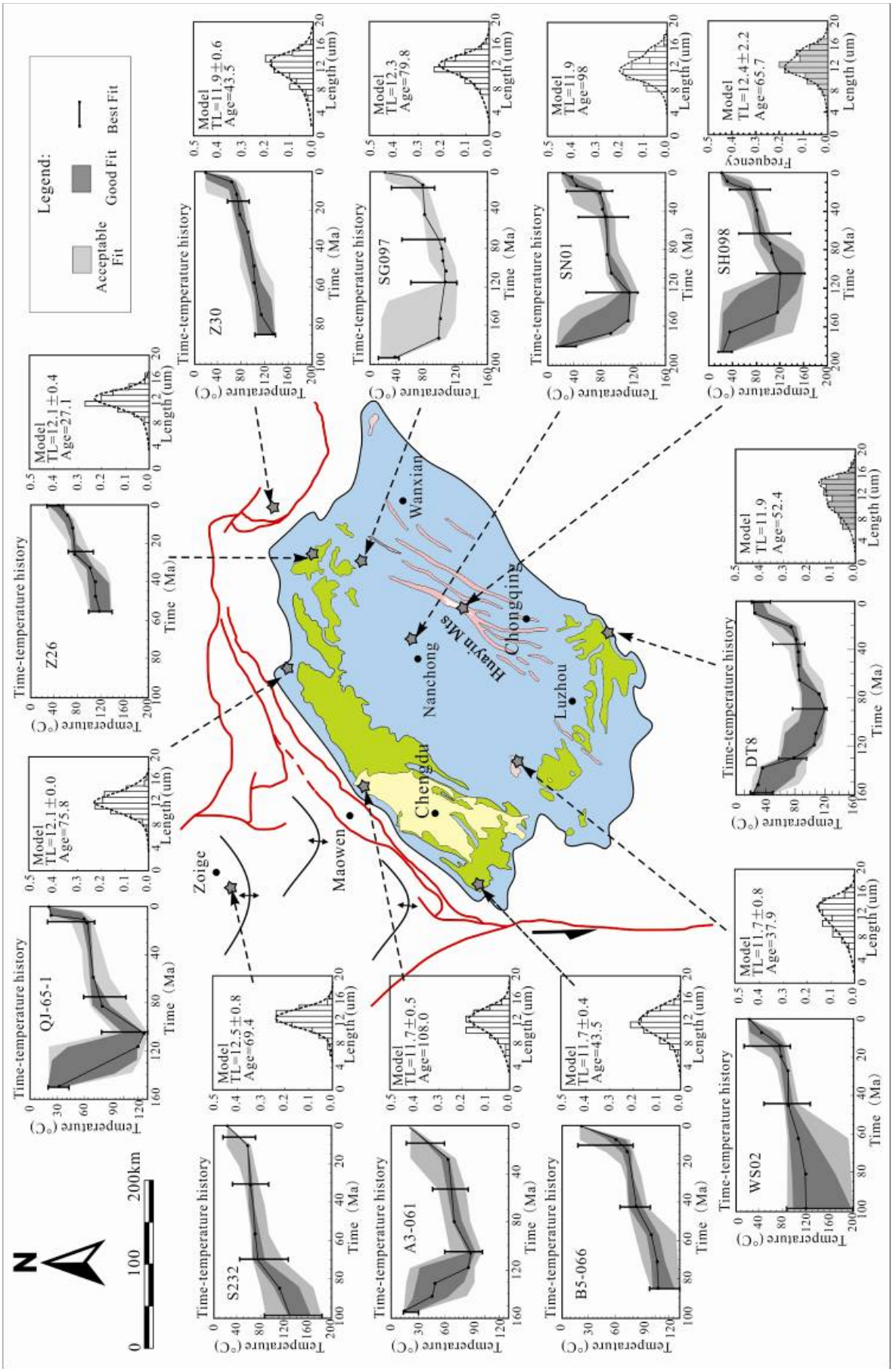

Fig. 1 Post-Early-Cretaceous episodic uplift and cooling processes across the Sichuan basin indicated by the modeled cooling histories for selected representative samples from the inversion of AFT age and length distribution. It should be note that there is significant change in exhumation (at least ~2000m) across the Huayin Mts.

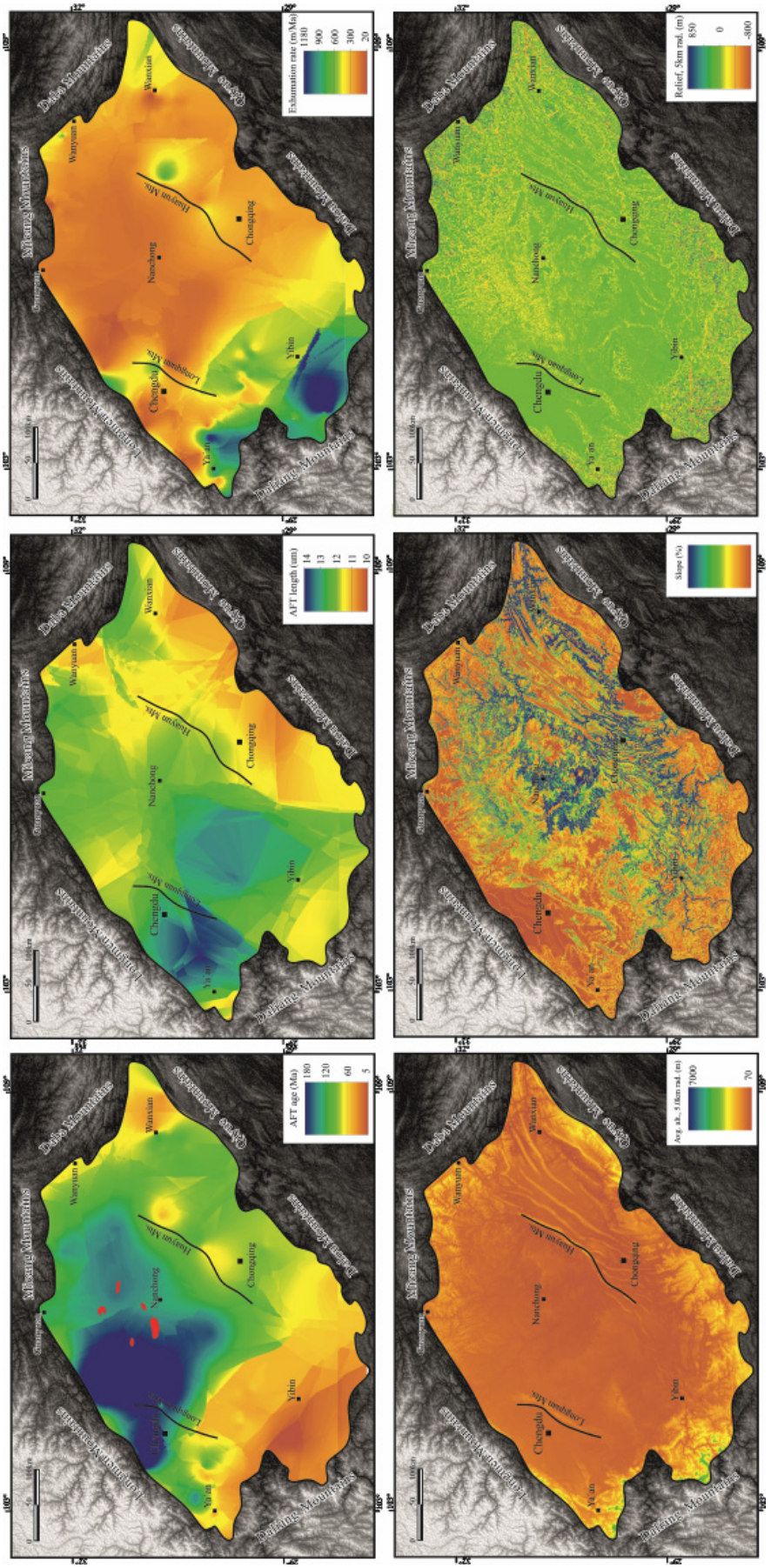

Fig.2 Differential exhumation and in-situ topographic features across the Sichuan basin

(a), Interpolated map of the apatite fission-track age across the Sichuan basin, results are calculated from the central age in all samples showing a nested AFT age center and a progressive change with young age towards the southwest; (b), Interpolated map of the mean fission-track length across basin, showing a progressive change with long length towards the southwest; (c), The interpolated map of exhumation rate from the AFT age across basin, indicating a roughly similar exhumation rate in most parts of the basin and an increase in the rate towards to southwest; (d)-(f), *in-situ* elevation, topographic slope and mean relief across the Sichuan basin. It should be noted that there is a good correlationship among the lower elevation, lower topographic slope, mean relief and the nested AFT age center across the basin, indicating a state-steady uplift and exhumation during in a long-term and a short-term time.

latest rapid uplift and exhumation, in particular in the southwestern part of the basin, may be attributed to the eastward growth of the Tibetan Plateau during the Late Cenozoic with the effect of eastward growth decreasing into the basin center. We argued that the eastern growth of the Tibetan Plateau has exerted a significant control on the rapid exhumation of the southwestern part of the Sichuan basin, but not on all of the Sichuan basin during the Late Cenozoic.

Key words: Post-Early-Cretaceous, Apatite fission-track, Differential exhumation, Sichuan basin

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