EGU2020-12130
https://doi.org/10.5194/egusphere-egu2020-12130
EGU General Assembly 2020

The interaction between uplift and landscape evolution in central and northern Qilian Shan: Insights from numerical modeling

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The Qilian Shan, located in the northeastern margin of the Tibetan Plateau, is characterized by intensive Cenozoic structural deformation with rapid lateral growth due to the continuous Indo-Asian continental collision. Both low-temperature thermochronological dating and geological mapping suggest that the major emergence of Cenozoic Qilian Shan occurred in the Miocene. The central and northern Qilian Shan uplift successively, and deformation has passed away from the adjacent Hexi Corridor Basin into the Gobi-Alashan. The regional landform shows a low-relief surface in the Qilian Shan hinterland and high steep relief in the northern range front.

The rivers rising in the hinterland of the Qilian Shan, i.e., the Shule River (SL), Beda River (BD), and Hei River (HE), are flowing across the northern range front. It is noteworthy that the development of these rivers is within the context of the in-sequence fault propagation pattern with the lifespan of ~3 Ma. When combined with the differential topographies between hinterland and range front, this kind of river drainage pattern inevitably has abundant geodynamical significances, mainly in terms of the long-term coupling between tectonic and surficial processes. To date, the dynamic conditions in shaping the aforementioned tectonic landscape features remain unknown and are critical in revealing the lateral growth of the NE Tibetan Plateau. A series of landscape evolution models are conducted based on thick-skinned Qilian Shan structural wedge. The wavelength of mountains is constrained by the critical wedge theory.

Our results show that the in-sequence fault propagation together with the arid climate since the Miocene contributes to the low-relief topography in the hinterland of Qilian Shan. The front regions with rapid uplifting rates cut off rivers. Thus, sediments from the hinterlands cannot be directly carried out by rivers. The intermountain areas receive sediments from the adjacent uplift regions, resulting in an increased elevation. Because of the long-term average arid climate, the river incision is limited. For most areas, it is difficult to form transversal rivers immediately that cut through mountains and carry sediment out of the plateau. With the northeastward in-sequence fault propagation, the transversal rivers finally formed with headwaters within the hinterland of Qilian Shan, such as the SL, BD and HE. The broad consistency of landforms, in turn, strongly favors the geological conclusion that faults in the central and northern Qilian Shan were activated sequentially. The rapid uplift rate in the active range front is tested in the range of 0.6-1.0 mm/a. It is found that this rate is insensitivity to the drainage and landscape evolution pattern. However, the background uplift rate has a great influence on the elevation of the plateau and is positively

correlated. The current topography of >4000 m in the hinterland of Qilian Shan is controlled by a background uplift rate of ~0.2mm /a.