



River responses to tectonics and monsoon-dominated climate: A long-term record from northern Vietnam and Laos.

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To understand how rivers respond to tectonics and monsoon-dominated climate we studied long-term denudation patterns and histories of the Song Ma and Song Ca catchments. These large rivers originate in the mountainous regions of Laos and drain the coastal mountains and plains of northern-central Vietnam before entering the South China Sea (East Sea of Vietnam). Trunk streams follow the paths of the NW-SE trending Song Ma, Song Ca and Son La strike-slip fault zones, the largest strike slip faults in northern Vietnam after the Red River. These were active at the same time as the Red River fault and would have played a role in distributing strain during extrusion of Indochina (c. 35-17 Ma).

Apatite thermochronometry record catchment-wide depths of denudation and responses to tectonics in relation to rifting in the South China Sea and patterns of strain release associated with extrusion and block rotation. River network morphometric analyses centred on normalized river steepness (ksn) and chi-analyses show how river network topology has adjusted to strain distribution. Thermochronometry results identified a regional rock uplift event between 40-30 Ma across a large elevation range. Depths of erosion are < 3 km since the Oligocene or earlier and < 1-2 km in the mountainous headwater region, which is surprising given the monsoon-dominated climate and corresponding high stream power. River analyses and thermochronometry show that, apart from the coastal plains, large parts of the river network are in disequilibrium and are still adjusting to Oligo-Miocene deformation. Rivers surrounding the extensional Bhu Khang dome are a prime example of disequilibrium: Tectonic denudation between 36-21 Ma drove exhumation by block rotation within a north-south dextral shear zone. Preservation of old (50-100 Ma) fission track ages in the headwater region is explained by low erosion rates caused by area gain in advancing aggressor subcatchments. All of the evidence points to a secondary role for climate compared to tectonics in driving erosion rates and shaping landscapes.