Summary

The Himalayan is rapidly emerging as a natural laboratory for studying intracontinental deformation related to continent-continent collision coupled with climatic-driven erosion.

The extreme topography of the Himalaya forms a barrier, differentiating climatic conditions and erosional patterns between the two sides of the belt. The interaction between crustal-tectonic and climate-erosional processes is borne out by the present day topography resulting in the bent patterns, and deep incised gorges of the major Himalayan rivers: the Indus and the Brahmaputra.

In the Eastern Himalaya, the Namche Barwa syntaxis is exhuming and eroding faster when compared with the central sectors of the belt since Lete-Miocene Pliocene. In the Namche Barwa syntaxis, cooling ages record a major exhumation pulse at ~5 Ma as young as ~10^6 a depending on the applied thermochronometer. The sediment flux derived from the Namche Barwa area is estimated at ~70% of the total sediment flux in the Brahmaputra when reaching the foreland. However, the young thermochronometric signature (< ~5 Ma) downstream the Namche Barwa syntaxis seems to be suppressed by older age peaks derived from sediment components from tributaries draining the more central Himalayan rock units. This discrepancy in the modern river sediment age distributions is reflected in the syn-sedimentary basins where ages are as young as ~6-7 Ma and older. The difference between the modern rate of sediment eroded from the Namche Barwa syntaxis and its downstream evolution is not completely understood. The implied question, then, concerns on how the detrital records can be used to assess the transient change in exhumation/erosion in a dynamic mountain belt. The present work is aimed at these outstanding questions.

For shedding new light on these issues, we proposed the following approach: We first studied the consistency of the detrital mica \(^{40}\)Ar/\(^{39}\)Ar and zircon fission tracks dating approach as tools to characterize the tectonic history of source rocks within the river network of an evolving mountain range. We than developed a numerical linear inversion of the age distributions, the “mixing model” method (Chapter 3). The method was tested on available literature data from the eastern Himalaya. Our results show how we can get averaged present-day erosion estimates and the exhumation signature at the superficial rocks from detrital age distributions. This approach was tested for modern river sand sediments obtained from 19 river’s catchments in the Eastern Alps (Chapter 4). In the second part of this thesis, we present the outcomes of studies where we analyzed the modern river sediments of the eastern Himalayan (Chapter 5) using two different thermochronometers (mica \(^{40}\)Ar/\(^{39}\)Ar and zircon fission-tracks).
Understanding the tectonic evolution of the eastern Himalayan syntaxis is key to differentiating different models of coupling between tectonics and erosion. The multi-proxy approach allowed to produce a synoptic cooling-age map of the eastern Himalaya that highlighted the spatial variation in exhumation rates of the contributing sources to the fluvial system. The relative present-day erosion estimates were then compared with a quantitative estimate of steady-state exhumation rates required to produce major age components observed in the detrital samples.

We noticed that whilst the young age peak is distinctive for the studied minerals and endures many kilometers downstream, the young mica population is much more suppressed, both in proximal and distal samples. The potential effect of dilution of the analysed target minerals has been addressed by looking at different grain-size fractions in the last part of this work (Chapter 6). We show that grain-size variability can bias age distributions when studying large catchment areas, such as the Brahmaputra foreland. The most important finding is that multiple grain-size analysis allows having a better resolution of the sources drained in the catchment area.

This thesis has explored the exhumation/erosion patterns of two dynamically evolving mountain ranges characterized by two distinct spatio-temporal evolutions. The analysis of multi-proxy thermochronology shed lights on the dilution processes governing the Himalayan foreland for different target minerals. We have demonstrated that a combination of multi-proxy thermochronology, numerical modeling, and analytical technique improvement provides new opportunities to study the evolution of the transient response of mountain belts to changes in boundary conditions on geological (Ma) time scales.