# LAB 7: DENUDATION AND UPLIFT OF THE LANDSCAPE

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## 1. Introduction

You are conducting an active tectonics investigation of a fold and thrust belt in the Salt Ranges of Pakistan. After a field season of mapping and research, you have mapped the structures and characterized the stratigraphy of this area. In addition, you have collected samples for geochronologic analyses that will help constrain the timing and rates of uplift and denudation in the area. In particular, you have collected and analyzed Apatite Fission Track (AFT) samples, Uranium-Thorium-Helium low temperature thermochronometric samples (U-Th-He), and cosmogenic radionuclide samples for $^{21}$Ne age dating.

Generally, a cross section of your study area (Figure 1) shows a number of important features. First, a flat-ramp-flat structural geometry brings a package of early Miocene terrestrial sediments towards the surface. The base of this package contains a resistant sandstone unit that forms a flat erosion surface as it rides onto the flat after the ramp (right side of figure). This erosional surface has numerous preserved remnants that record the stripping of the overlying, less competent Miocene strata.

## 2. Collected Data

The three types of data you collected may be used to infer the exhumation and uplift history of the area. First, AFT samples were collected within the erodible Miocene strata adjacent to the ramp (their ages are shown by the bold ages along the topographic profile). Second, these same samples were dated using U-Th-He thermochronology (their ages are shown below the AFT ages). You assume that the AFT and U-Th-He samples cooled at 110 and 75 degrees C, respectively. Finally, samples along the erosion surface remnant were collected for dating with $^{21}$Ne Cosmogenic Radionucludes (CRN) methods. This particular CRN is a stable isotope, and so their concentration in a sample directly gauges the exposure age of the sample. The number of $^{21}$Ne atoms measured in each sample is shown in bold italic numbers along the exposed surface. The production rate for $^{21}$Ne at this latitude and elevation is 45 atoms/(gram yr). In addition to your collected data, other studies performed on the drainages within the flat on the right side of the cross section reveal bedrock incision rates of 0.01 mm/yr and basin wide denudation rates of 0.001 mm/yr.

## 3. Laboratory Exercise

In this laboratory, you are to determine the denudation rates using the AFT, U-Th-He, and CRN data given to you. Also, infer the rock uplift and surface uplift rates in the area. Compare each of these rates to determine their consistency. In addition, compare these rates to those cited in the literature regarding the fluvial

bedrock incision and basin denudation rates given. How do these rates compare? If there are differences between the rates, think about what these differences might mean for the exhumation of this landscape.

## 4. Laboratory Write-up

Your laboratory write-up should be structured in the Introduction, Methods, Results, Discussion, and Conclusion format used in this class. Particular to this exercise, please make sure to do the following in your write-up:

- Include calculations of exhumation and exposure ages and rates determined from the AFT, U-Th-He, and CRN methods. Make sure to state what your inferred geothermal gradient is.
- In the discussion, make sure to talk about how your results compare with those presented in the literature. If they are different, discuss the potential sources of these discrepancies.
- Discuss your results of exhumation in terms of the development of the landscape over the various spatial and temporal scales sampled by each method. In particular, give your ideas (based firmly on the rates and observations you have made) on how the landscape developed over each of these timescales and how the tectonic and geomorphic processes change with each time-scale.

**Please turn in this laboratory to Dr. Hilley no later than July 9, 2002**.

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