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Late Quaternary glacial relief evolution and fracture-density control on erosion revealed by low-temperature thermochronometry and remote sensing (Granite Range, Alaska)

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Long-term erosion and topographic evolution of mountain belts arise from complex coupling between tectonics, climate and surface processes. The Granite Range (Wrangell-St Elias National Park, Alaska) presents an ideal setting to study such interactions. Its alpine landscape, preserving typical glacial features (U-shaped valleys, cirques), appears highly smoothed in the west, and progressively more rugged towards the east. In the field, this is evidenced by minor and only localized faulting of massive bedrock (granite and paragneiss) in the west, while the eastern part shows highly fractured bedrock (penetrative faults, fault gouges). Remote-sensing analysis confirms that fracture density is much higher towards east, and also reveals high post-glacial incision only in areas associated with high fracture density.

To quantify our morphometric observations, we sampled four elevation profiles ($\sim$15 samples in total) over an 80-km East-West transect for low-temperature thermochrometry. Apatite (U-Th-Sm)/He dating provides ages between $\sim$10 and 30 Ma, in agreement with published data, and shows apparent low long-term exhumation rates ($\sim$0.05-0.1 km/Ma). Preliminary 4He/3He thermochronometry data reveal a more complex exhumation history, with a significant increase since $\sim$6-5 Ma which can be related to either onset of glaciations in Alaska or a major change in tectonic activity occurring at that period. Further data collected within the Granite Range will help to decipher the origin of this late-Miocene acceleration in exhumation.

We also performed luminescence thermochronometry measured on feldspar separates from bedrock samples. Our results show a strong East-West gradient in samples saturation ratio. Apparent ages vary from $\sim$250 ka in the western part of the range, towards younger ages of $\sim$30 ka in the east. This pattern reveals spatially variable erosion rates during the late Quaternary associated with a major fracture-density control on erosion, and further supports the notion of amplified erosion due to intense glacial/periglacial activity. This presents evidence for a bimodal relief evolution and structural control on erosion in a glacially-active mountain range, and demonstrates the potential of luminescence thermochronometry in resolving topographic evolution and surface processes over 100-ka timescales enclosing high-frequency climate modulations (e.g., glacial-interglacial oscillations).