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A catastrophic Late Pleistocene debris flow sourced in the glaciated High Atlas of Morocco

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Catastrophic events such as debris flows and big floods are important agents of landscape change in steep-land mountain environments. These events can be prominent in paraglacial settings as well as those that are tectonically active. Since such catastrophic events pose a significant natural hazard in deglaciating modern settings (e.g. Haeberli et al. 2017), it is useful to better understand analogous events in the recent geological past.

The Tamatert Valley, near the village of Imlil, on the northern slopes of Jebel Toubkal (4167 m a.s.l.) in the High Atlas, holds a valuable record of Quaternary landscape change. The steep-land Tamatert Valley was glaciated during the Pleistocene (Hughes et al. 2018) and lies on the major Tizi n'Test Fault Zone.

More than 200 well rounded basalt mega-boulders (>2m b axis) have been mapped in the Tamatert Valley catchment (9 km²). Many of the boulders are larger than 5 m (b axis). The mega-boulders are found in the active channel of the Tamatert River, stranded above the modern channel, and embedded in valley-fill deposits. A preliminary chronological framework, combining cosmogenic exposure and luminescence dating, points to deposition of these boulders in the Late Pleistocene. The boulders are porphyritic basalt and lithologically distinct from the local diorite/granite bedrock. They were transported by a catastrophic flood or debris flow over a distance of more than 3 km from the glaciated basalt source area.

Serendipitously, a debris flow producing a similarly extensive deposit of boulders (up to 3 m b axis) occurred in the neighbouring Mizane Valley in September 2019. Mapping of this modern deposit allows direct comparison with the Late Pleistocene event. Together, these provide valuable insights into the geomorphological significance of high magnitude, large boulder transit events in glaciated, steep-land river catchments in the High Atlas.

Haeberli, W., Schaub, Y. & Huggel, C. 2017. Increasing risks related to landslides from degrading permafrost into new lakes in de-glaciating mountain ranges. *Geomorphology*, 293, 405–417

Hughes, P.D., Fink, D., Rodés, Á., Fenton, C.R. & Fujioka, T. 2018. Timing of Pleistocene glaciations in the High Atlas, Morocco: New¹⁰Be and³⁶Cl exposure ages. *Quaternary Science Reviews*, 180,

