TRACKING COARSE SEDIMENT IN AN ALPINE SUBGLACIAL CHANNEL WITH RADIO-TAGGED PARTICLES

Suivi de sédiments dans une rivière sous-glaciale grâce à des particules radio-marquées

Matt Jenkin[1]* ([1] IDYST, University of Lausanne, Switzerland), **Margaux Hofmann[1]**, **Bryn Hubbard[2]** ([2] Department of Geography and Earth Sciences, Aberystwyth, UK), **Davide Mancini[1]**, **Floreana M. Miesen[1]**, **Frédéric Herman[1]**, **Stuart N. Lane[1]**

* corresponding author

Alpine glaciers erode large amounts of sediments that are exported via active subglacial meltwater channels to their proglacial environments. Proglacial measurements of exported suspended sediment and bedload have been used to estimate rates of glacial erosion and downstream sediment yields, assuming that eroded sediment is rapidly evacuated by flowing meltwater, that subglacial sediment storage remains constant and that the measurements of sediment export are unaffected by transport through proglacial areas (e.g. Riihimaki et al. 2005). Studies have focused on suspended sediment due to the difficulty of monitoring bedload, and subglacial sediment transport dynamics remain poorly understood. A growing body of field and model-based research indicates that subglacial sediment transport may instead be attenuated in the rapidly thinning and retreating snout marginal zones of many Alpine glaciers due to variable transport competence in non-pressurised subglacial channels and the related cycles of alluviation and deposition (Beaud et al., 2018; Perolo et al. 2019), with potentially significant consequences for studies that estimate erosion rates using sediment export measurements.

To address the lack of field data on subglacial sediment transport, we develop a method to track radio-tagged bedload particles through meltwater channels under shallow temperate glacier ice (<50 m), extending existing fluvial particle tracking technology (Cassel et al., 2017) to a glacial environment. Active radio transmitters were inserted into natural pebbles and deployed into a 10 m wide snout-marginal subglacial channel at the Glacier d'Otemma, Switzerland using boreholes that reached the channel directly. A roving antenna at the surface was used daily to estimate each tagged particle's point location and downstream transport distance as it moved through the subglacial channel. Particle localisation was achieved by performing kernel density estimation (KDE) on the spatially distributed RFID point data. In addition, stationary antennas placed on the glacier surface and over the proglacial channel monitored the passage of the particles through successive reaches of the channel, constraining the timing of particle transport events. The roving and stationary antenna data were combined to create a transport distance model for each particle. The method may, when applied at scale and used in conjunction with river gauging and meteorological data, be used to examine the drivers and timescales of coarse subglacial sediment transport. We present results that confirm this method as a highly original means of quantifying subglacial sediment transport using particle tracking.

REFERENCES

Beaud, F., Flowers, G.E., Venditti, J.G., 2018. Modeling Sediment Transport in Ice-Walled Subglacial Channels and Its Implications for Esker Formation and Proglacial Sediment Yields. Journal of Geophysical Research: Earth Surface 123, 3206–3227. https://doi.org/10.1029/2018JF004779

Cassel, M., Dépret, T., Piégay, H., 2017. Assessment of a new solution for tracking pebbles in rivers based on active RFID. Earth Surface Processes and Landforms 42, 1938–1951. https://doi.org/10.1002/esp.4152

Perolo, P., Bakker, M., Gabbud, C., Moradi, G., Rennie, C., Lane, S.N., 2019. Subglacial sediment production and snout marginal ice uplift during the late ablation season of a temperate valley glacier. Earth Surface Processes and Landforms 44, 1117–1136. https://doi.org/10.1002/esp.4562

Riihimaki, C.A., MacGregor, K.R., Anderson, R.S., Anderson, S.P., Loso, M.G., 2005. Sediment evacuation and glacial erosion rates at a small alpine glacier. Journal of Geophysical Research: Earth Surface 110. https://doi.org/10.1029/2004JF000189