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What the fingerprinting method reveals about main contributing soil and glacial deposits to sediment supply in a glacier-fed tributary valley (Bødalen, Norway)

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The Norwegian fjord landscapes are coined by the inheritance of glacial processes since the Last Glacial Maximum. Glacial fluctuations have influenced geomorphic processes including fluvial runoff and associated erosion, sediment transport and deposition within the glaciated valleys to a great extent. In glacierized catchments the ongoing ice retreat exposes new surfaces providing sediments that may affect fluvial sediment transport. Sediment fingerprinting techniques are increasingly being used in different climatic environments for quantifying the contribution of different sediment sources as well as catchment erosion dynamics. This study shall contribute to identifying the most important sediment sources and their relative contribution to the sediment budget of a representative glacier-fed tributary valley (Bødalen) located in western Norway based on sediment fingerprinting. This work is adding to ongoing longer-term process geomorphological studies in this valley system where fluvial suspended sediment and bedload transport have been investigated for several years.

The Bødalen drainage basin is W-E oriented and covers an area of 60.1 km2. The local relief ranges from 52 m a.s.l. at the outlet draining into lake Lovatnet up to 2083 m a.s.l. at the peak Lodalskåpa. The mean annual air temperature at 360 m a.s.l. is 5.5 ºC and the annual precipitation is ca 1500 mm. The lithology in Bødalen consists of Precambrian granitic orthogneisses on which Leptosols and Regosols are the most common soils. Parts of the upper valley were affected by the Little Ice Age glacier advance with the maximum glacier extent around 1750 BP.

Based on a conducted field survey the different predominant sedimentary deposits and covers with connectivity to the main streams were identified. In July 2014 a number of 39 composite samples of recent fine sediment deposits were collected in Bødalen, covering all existing sediment sources within the entire drainage basin. Glacial till, soil, glacio-fluvial sediment, and slope deposits were sampled with a 2 cm high plastic cylinder of 5 cm diameter. Attention was paid to the different stages of ice retreat as well as to the limited variety of vegetation covers. In addition, three suspended sediment samples were collected through installed sediment traps which were placed within the existing proglacial lake and in front of the outlet of the main stream. For comparison between sources and suspended sediments all samples were sieved at 63 micrometre. For general characterization, grain size, pH, electrical conductivity, organic carbon and carbonates were determined. Specific analyses for applying the fingerprinting method included 6 radioisotopes (2 FRNs and 4 ERNs), magnetic susceptibility measurements and 28 stable elements. For selecting the optimum composite fingerprint we used range test followed by Kruskal Wallis test and discriminant function analysis. It was found that FRNs had great potential to discriminate soil from recent sediment deposits but the optimum composite fingerprint extracted from the combination of 36 parameters was fundamental for the correct discrimination of the sources. FingerPro (open Source R package), a state of the art unmixing model, allows the identification of landforms and deposits that produce suspended sediments transported in the Bødalen stream.