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Titanium concentration in lake sediments as a measure for Younger Dryas cirque glacier activity, Western Norway

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The sediment transfer in glaciofluvial systems can mainly be attributed to two effects; a) the low-frequent variability of suspended load-flux changes as the glacier size varies and thereby changes the proportion of the catchment that has active glacier abrasion and b) changes in runoff and sediment transfer-rates related to melting of the glacier, predominantly driven by ablation-season temperatures that increase the runoff that in turn enhance sediment deposition in downstream lake basins.

It has been demonstrated that dry bulk density (DBD) can be used as a measure for inorganic sediment production in glaciated catchments. Here we also introduce geochemical variations in lake sediments in order to quantify glacier activity at a high temporal resolution (sub decadal). Previously, titanium (Ti) and iron (Fe) concentrations have been used to infer minerogenic sediment transfer over the northern part of South America during the past 14,000 years. Here we have used sediments from a small lake (Lake Kråkenes 62^{o}02'N, 5^{o}00'E) at the extreme western coast of Norway, with a small catchment monitoring the growth and decay of a small cirque glacier during the Younger Dryas (YD). Because both Ti and Fe are present in the bedrock at Kråkenes, they both respond significantly to the presence of the glacier in the catchment, but the development of the two records contradict each other within the event. We therefore suggest that the iron concentration in the lake sediments at Kråkenes is masked by redox processes, either reflecting processes beneath the glacier, within the lake or by secondary sediment processes, e.g. paraglacial activity. Titanium is, however, insensitive to such environmental redox processes and can therefore be used as a measure of the sediment production and release from the cirque glacier into the glaciofluvial and lacustrine system. We thereby prescribe the variations in Ti to reflect melt-water fluxes, linking the variations in deposited Ti concentrations directly to temperature-driven melting, allowing a high-resolution reconstruction of summer season melt-rates throughout the YD. During the late Allerød Ti shows low intensity before the rapid transition into YD. Between 12,700 and 11,900 cal. yr BP there were four centennial-scaled events with increased titanium concentrations. This pattern indicates low-frequent oscillations in summer temperatures over the first part of the YD. After the Vedde Ash (12,000 cal. yr BP), there was a significant period (ca 30 years) where the lowest sedimentation occurred, likely related to reduced melt-rates after the deposition of the ash layer. At 11,900 cal. yr BP there was a marked upward step in the signal strength, starting at 11,875 cal. yr BP before the rapid transition into the Holocene at $\sim$11,600 cal. yr BP. This was most likely attributed to increased and more variable meltwater runoff from the cirque glacier over the last 400 years of the YD and throughout the YD-Holocene transition.