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Formation and evolution of glacial landforms during a melt season

This study presents a detailed investigation into the evolution of sedimentary landforms over an ablation (melt) season at Blåisen, an outlet glacier of the Hardangerjøkulen Icecap in Norway. The two visits to Blåisen in 2019, one each side of the ablation season, allowed the formation, preservation, and evolution of the landforms to be studied.

Much research is conducted studying glacial landforms, which are key in our understanding of past and future ice behaviour. This is important in researching the past, present and future response of the cryosphere to climate forcing, and the impact of such changes. Increasingly, fewer glacial landform studies are conducted focusing on fieldwork, with even fewer making repeated visits to sites to study the changes. Many studies now favour remote sensing which, while being a powerful tool to understand ice behaviour, means that smaller, more subtle features may be missed. An awareness of what may be missing when studying forelands is important in gaining a better overall understanding of the ice behaviour and the processes occurring.

This study focuses on the younger landforms close to the ice margin. The ice margin retreated up to 30-40 m over the summer of 2019, exposing a number of landforms that had been covered by ice and snow in June. GPS mapping, field observations and Structure from Motion Photogrammetry (a 3D modelling technique) was used over the two visits to Blåisen in June and September. Four main landform types were recorded: snowbank squeeze moraines, flutes, minor moraines, and an ice-cored wedged shaped ridge system (called a sediment wedge in this study after its characteristic shape).

The foreland of Blåisen had several interesting areas where the bedrock sloped back towards the glacier. This had the effect of preventing meltwater from draining, leading to saturated sediments around the ice margin. These sediments were easily deformable, so played an important role in the formation of the snowbank squeeze moraines, flutes, minor moraines.

The mechanisms of formation are explored using the field evidence to create theoretical models for how the landforms formed and evolved over the melt season. The model for the formation of the sediment wedge presents freezing-on of sediment to the ice as an important mechanism. This allowed the transport of debris in a band from the base of the glacier to the margin, where it covered the underlying ice, cutting it off from the main glacier and forming an ice-cored wedge.

Snowbank Squeeze Moraines were observed as ridges of sediment protruding out of the snow in June. They formed by the deformation (squeezing) of sediments between the ice margin and the winter snowbank lying over the margin. The 'squeeze' type of snowbank moraines have not been widely studied in part due to their poor longer-term preservation beyond a few months. This was illustrated by the lack of remaining evidence for them in September. Few flutes were recorded aside from those mapped in September. This indicates that either in past seasons, conditions had not been favourable for formation, or that preservation was poor. The latter theory is supported by the lack of remaining evidence of the snowbank squeeze ridges in September. The poor preservation of these landforms highlights how they may be missed in other studies and the need for further research in this area.

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