

DEVELOPMENT OF LANDFORM AND SEDIMENT ASSEMBLAGES AT MARITIME HIGH-ARCTIC GLACIERS

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Abstract

Detailed studies of sedimentary processes and landform development at modern glaciers are an essential pre-requisite for the interpretation of Quaternary glacial sediments and landforms. Recent work on polythermal glaciers in Svalbard has provided new insight concerning the processes responsible for glacial sediment/landform assemblages. Although the landforms associated with Svalbard glaciers are not in themselves unique, the particular assemblages and proportions of sedimentary facies differ markedly from those in temperate and cold glacier systems. The main conclusion is that deformation within glacier ice, as debris is entrained and subsequently transported, is the primary control on the nature of landform/sediment assemblages in the proglacial areas of Svalbard valley glaciers. The most important landform-creating modes of debris entrainment are:

- (1) Incorporation of angular rockfall material within the stratified sequence of snow, firn and superimposed ice, followed by folding with flow-parallel axes; the resulting medial moraines are preserved in the proglacial area as linear debris trains;
- (2) Entrainment of debris at the bed to form a several metre-thick basal ice layer, which is released as a sheet of basal till;
- (3) Incorporation of basal debris within longitudinal foliation, resulting in landforms referred to as foliation-parallel ridges;
- (4) Thrusting, whereby basal and subglacial sediments are uplifted towards the glacier surface, and ultimately released as individual mounds within a large end-moraine complex (often referred to as 'hummocky moraine');
- (5) Subglacial upright folding with transverse axes and faulting also producing large end-moraine complexes;
- (6) Reworking of thrust- or fold-derived glaciofluvial material to produce longitudinal debris ridges in the ice, although their translation into landforms is poor.

The principal sedimentary facies associated with these polythermal glaciers is diamicton of basal glacial origin, followed by sandy gravel of glaciofluvial origin. These facies, reworked by thrusting in glacier ice, dominate the end-moraine complexes.

These observations and inferences have been applied to areas such as Britain, where glaciers no longer exist, in the interpretation of Pleistocene landforms and sediments.

1. Introduction

The development of landforms associated with late Quaternary glaciers and ice sheets has often been based on temperate alpine or Icelandic glaciers. However, this has sometimes resulted in an erroneous perception of the processes responsible for these landforms. Only in the last decade has the Arctic received the attention that it warrants, and a range of new models has now emerged for the development of ice-marginal constructional landforms that have considerable bearing on how landforms developed in areas no longer occupied by ice. In these investigations, it has been recognised that the only way to understand landform genesis is to establish the glaciological basis for debris-incorporation and transport. Many landforms, then, are controlled by the way debris is associated with ice deformational structures within the glacier.

This contribution examines the various processes of debris incorporation, transfer and deposition in High-Arctic glaciers, focusing especially on the archipelago of Svalbard (including Spitsbergen) at the NW edge of the European continental shelf (Figure 1). In this climatically sensitive polar-maritime environment, the glaciers are believed to be mainly of the polythermal type, that is they consist of warm ice in their deeper, upper reaches, and cold ice (frozen to their beds) in their marginal and snout areas. The polythermal glacier thermal regime gives rise to a distinctive suite of landforms which, if identifiable in formerly glaciated areas, can help constrain palaeoclimatic reconstructions in those areas.

2. Climatic and Glaciological Regime in Svalbard

The Svalbard archipelago (77° N to 80° N) lies at the northern extent of the mild Norwegian Current, a branch of the Gulf Stream, and enjoys a relatively mild climate for its northern latitude. On the western coast, the average annual temperature is -6°C. The average temperature on the west coast in the warmest month (July) is 5°C whilst in the coldest month (January) it is -15°C. Although there are contrasts between the maritime west coast and the more continental interior, precipitation in Svalbard is generally low. Typical values at sea level are 400 to 600 mm annually, falling to half these values inland. Precipitation in the more mountainous regions is increased by orographic effects, but even on the glaciers snowfall of more than 2-4 m is rare (Hagen *et al.* 1993). Ice-free land areas are underlain by permafrost to depths of between 100 and 400m.

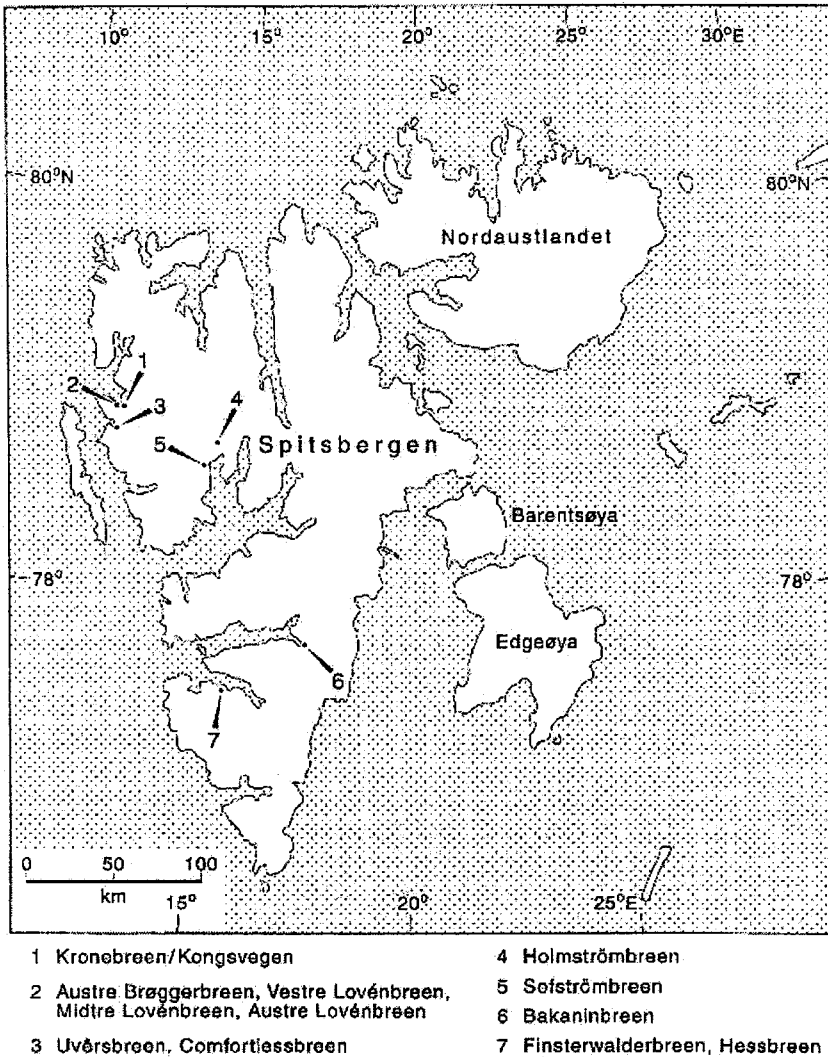


Figure 1. Location map of glaciers in Svalbard referred to in the text

The archipelago is currently 60% glacierised. The largest volumes of ice are accounted for by the highland icefields and ice caps of eastern Spitsbergen, Edgeøya, Barentsøya and Nordaustlandet (Figure 1). These ice masses cover the low mountainous areas, and their outlets are divided into individual glaciers by mountain ridges and nunataks. Many of these reach the sea to form large calving glaciers. Smaller cirque glaciers are also common, particularly on the more alpine terrain in western Svalbard.

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