Holocene sedimentary rocks in Mathiesondalen, central Spitsbergen, Svalbard

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Holocene lithified sediments of glacial and glaciofluvial origin have been found in environments where carbonate cementation is a present-day process. The rocks occur as well cemented tillites, conglomerates, coarse sandstones and breccias, indicating a complex depositional pattern within a limited area. Both clasts and carbonate cement are mainly derived from underlying Carboniferous and Permian sequences which form the bedrock of this area.

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Introduction

During the summer 1981, members of the Norsk Polarinstitutt's expedition to Svalbard visited Mathiesondalen in Bünsow Land in central Spitsbergen (Fig. 1). The bedrock in Mathiesondalen consists of gently dipping Carboniferous and Permian limestones and dolomites. Sequences in the valley floor belong to the Ebbadalen and Nordenskiöldbreen Formations (Cutbill & Challinor 1965), and consist of dolomites with anhydrite passing up into calcitic limestones. Outcrops of these sediments are uncommon near the coast where there is Quaternary cover. However, exposures are found along the streams in the inner parts of the valley.

During a general survey of the area, several outcrops of well cemented, lithified young sediments were found in scattered exposures along the whole length of the valley (Fig. 2). These rocks have not been reported earlier, even though parts of the Quaternary succession have been studied by Feyling-Hanssen (1955, 1965), Boulton (1979), and Troitsky et al. (1979). Well cemented young sedimentary rocks have been observed elsewhere in Svalbard, but never described. Although such rocks usually occur as carbonate cemented breccias in talus deposits, the deposits described here are sediments of glacial and glaciofluvial origin, located on the valley floor.

Description

Both cemented and unconsolidated rocks with the same depositional origin occur in association on the valley floor. The present regime of the valley is evidently glaciofluvial with braided streams depositing sediments showing great similarities to some of the carbonate cemented rocks. The degree of cementation is variable, and non-consolidated beds abut well cemented rocks.

The well cemented rocks can be divided into three main types: bedded sedimentary breccias, conglomerates/sandstones, and tillites. These three rock types occupy discrete parts of the valley floor as indicated in Fig. 2.

Breccias

The breccias occur in the outermost part of these valley deposits, approximately 6 m above sea level. The best exposure is seen in a 12 m thick bedded succession which is evidently part of a delta foreset, with individual co-sets 1.5 to 1.6 m thick, each co-set fining upwards (Fig. 3).

The material is polymict, angular, and poorly sorted. Clasts are normally less than 25 cm, but some few boulders of 35 to 45 cm are found. More clasts are bioclastic limestones, with a fossil content typical of the Carboniferous and Permian beds in the area, and one rugose coral has been

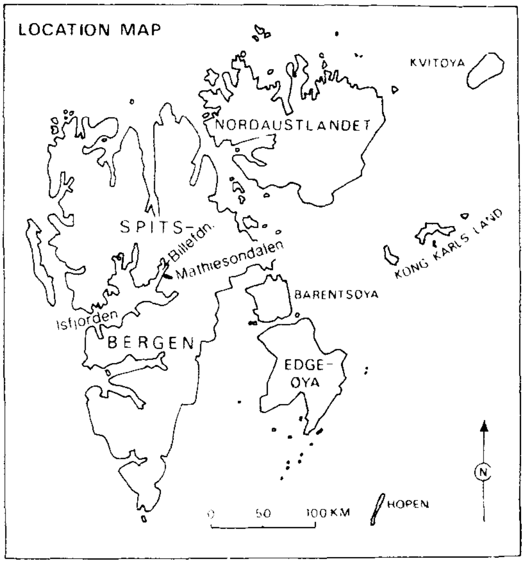

Fig. 1. Location map in Svalbard.

found as a separate clast. Rare clasts of gypsum/anhydrite are also seen, while dolomites, cherts and silicified limestones are relatively common. Only a few fragments of Hecla Hoek rocks and no Devonian rocks have been found. There may be a weak preferred orientation among some of the more elongated clasts, parallel to the foreset bedding.

Conglomerates/sandstones

The conglomerate and sandstone beds are located in the central part of the valley floor, best exposed north of the present river (Fig. 4). This facies represents the glaciofluvial regime of Mathiesondalen, but the deposits are capped by tills (see Fig. 2). The glaciofluvial deposits are well bedded.

The conglomerates are polymict, with well rounded pebbles dominated by fossiliferous limestones of local origin. The pebbles vary in size from 1 to 10 cm, but individual beds are well sorted.

Sandstone dominated horizons occur interbedded with the conglomeratic beds. The coarse sand fraction consists both of limestone and quartz or chert. The conglomerates and sandstones are found in approximately 0.5 m thick beds, and internal structures are evident within the sandstone horizons. Some beds represent trough infills, with sand at the bottom coarsening up to pebbles in the top layers. Some imbrication was observed.

Tillites

A 10–12 m high exposure of tillite rises above the valley floor (see Figs. 2 and 5), resting on a sandstone. The tillite exhibits no bedding and is laterally overlain by unconsolidated till, although good contacts are not seen at this major exposure.

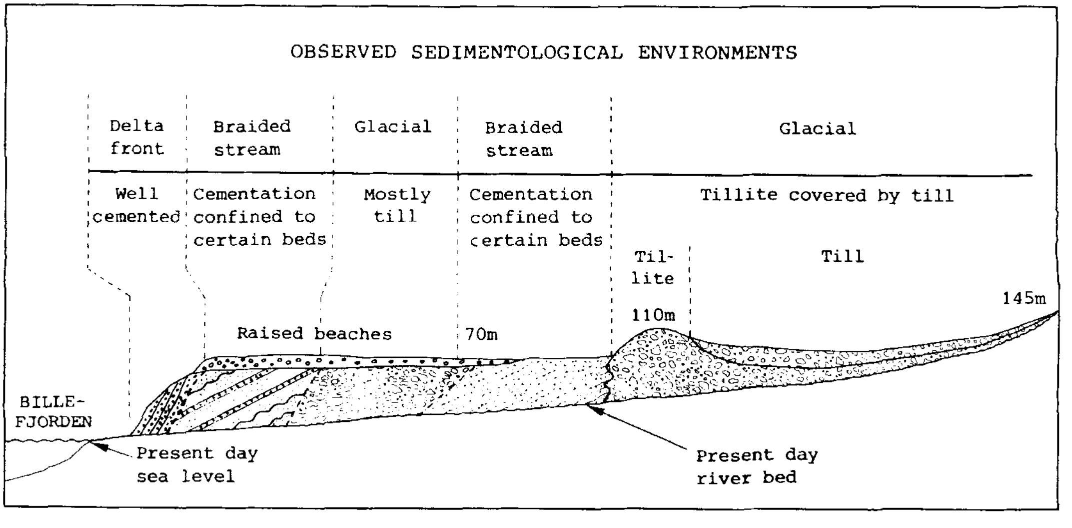

Fig. 2. Sketch of the sections exposed along the river of Mathiesondalen, where both well cemented and non-cemented deposits occur. The sections exhibits glacial and glaciofluvial deposits covered by raised beach sediments. Figure not in scale.

Fig. 3. Delta front foresets, as they appear in the outer part of Mathiesondalen. Their lithology is similar to that of breccias, but exhibits well developed bedding.

Fig. 4. Conglomerates and sandstones in a bedded braided river sequence. Well cemented rocks occur along with noncemented ones along the present day river bed.

Fig. 5. Tillite as found in the inner part of Mathiesondalen. The rock is well cemented and stands up from the valley floor.

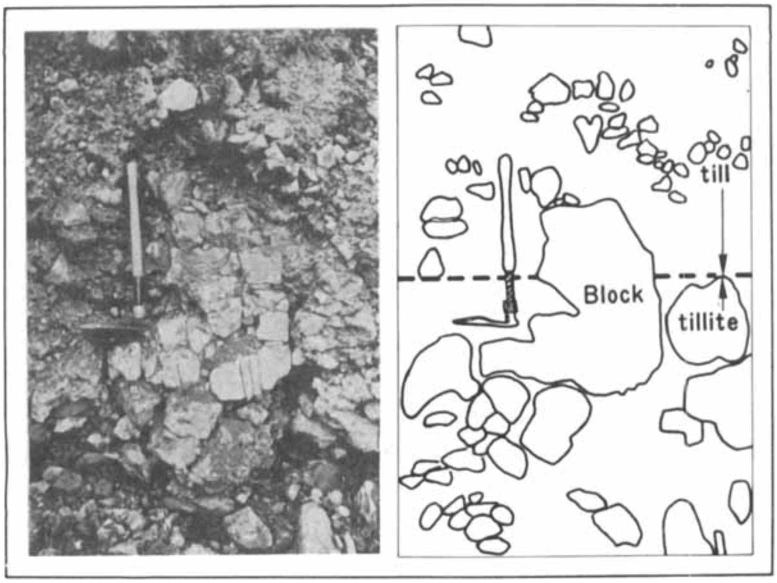

Fig. 6. This figure exhibits the tillite covered by till. The block's lower part is cemented in the tillite, while the upper part is within the unconsolidated till above. Both till and tillite belong to the same sedimentological event.

The tillite is, however, exposed further northwards along the stream overlain by unconsolidated till.

This contact between the tillite and the till is crucial for the understanding of the age relationship of these rocks. One boulder is found in both till and tillite; the lower part of it is stuck in the tillite, while the upper part is surrounded by unconsolidated till (Fig. 6), exhibiting that these two units belong to the same sedimentary sequence and episode. The unconsolidated till can further be followed up to the present glacier, which is only a couple of hundred metres away.

Thin sections

Thin sections from all three lithofacies show obvious similarities as regards cement and lithification. All sections were coloured with alizarin red, and the rim of calcite cement around all clasts thus showed great contrast to the other minerals. These sediments are highly porous and some beds disintegrate on disturbance.

Discussion and conclusion

These lithified units reflect the cementation processes active in a limited limestone area of Svalbard. We also know that solution of sulphatic bedrock with formation of karstic features is a presently active process in the valley (Salvigsen et al. 1983), but we cannot relate these dissolved elements to the cementation discussed here.

We know that carbonate cementation is active in some areas, but such observations from Svalbard are mostly scattered and local. In Mathiesondalen, however, we have for the first time found a larger area, where systematic observations were possible. Although observations were located to one valley floor, we feel that the different regimes compensate for the lack of regional distribution.

The carbonate-rich bedrock of the area plays a major part in this process, supplying the sediments along the valley floor with the cement needed. The cool climate of this high arctic area accelerates precipitation of the calcite, a fact stressed by Swett (1974) in a work on calcrete crusts in a permafrost environment in central east Greenland. At the present stage, we cannot explain properly why this process acts so selectively in apparently similar beds. One bed may show no cementation at all, while the next one is completely cemented and lithified.

Little is known about the thickness of these lithified sediments, but it is evident that a large number of them have permafrost. Permafrost is apparently an effective barrier for the groundwater percolation, and it is difficult to understand how solutions and cement can be distributed within the permafrost layer.

The age determination of these rocks is a matter of great importance, but unfortunately no fossil material was found in any of the carbonate cemented units. However, there is shell material in the marine, unconsolidated beds above, revealing a Holocene age of these raised beach deposits (Salvigsen et al. 1983). We attach great importance to the fact that one of the tillite exposures shows both cemented and non-cemented material, showing a gradual transition from one stage to the next. In this locality a boulder more than 0.5 m in diameter is cemented in the underlying tillite, while the top stays within the unconsolidated till (Fig. 6). This find indicates that the till above and the tillite below were deposited during the same sedimentological event, probably during the last deglaciation of the area. Indications of erosional contact between cemented and non-cemented deposits were not seen.

We mean to point out from our observations that the carbonate cementation of these rocks commenced during the Holocene, and to indicate that this process is still active in the area today.

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