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Morphodynamique des régions semi-arides de haute latitude : l'exemple de l'île Ellef Ringnes, Nunavut

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Résumé de l'article

Dans cet article, nous utilisons l'île Ellef Ringnes, au Nunavut, comme exemple en vue d'identifier les processus actifs pour cette région semi-aride de haute latitude. L'érosion fluviale contrôlée par la structure géologique est à l'origine du relief spectaculaire de l'île Ellef Ringnes. Le régime nival, qui concentre les débits sur une courte période à la fin du printemps, est caractérisé par une forte capacité érosive des cours d'eau en dépit des faibles précipitations annuelles. D'autres processus reliés aux milieux froids produisent une variété de formes mineures telles que les sols à figures géométriques, les coulées de boue associées à la présence de glace dans le sol et les lobes de solifluxion.

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MORPHODYNAMICS OF COLD HIGH LATITUDE SEMIARID REGIONS: THE EXAMPLE OF ELLEF RINGNES ISLAND, NUNAVUT*

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ABSTRACT In this paper we use the example of Ellef Ringnes Island, Nunavut, to examine active geomorphic processes in a high latitude semiarid region. The spectacular landscape of Ellef Ringnes Island is principally the result of fluvial erosion controlled by geological structure. The nival regime concentrates flow in a brief late-spring period which provides strong erosive capabilities for rivers in spite of low annual precipitation. Other processes related to the cold environment produce a variety of minor landforms such as patterned ground, mud flows associated with ground ice, and solifluction lobes.

RÉSUMÉ *Morphodynamique des régions semi-arides de haute latitude : l'exemple de l'île Ellef Ringnes, Nunavut.* Dans cet article, nous utilisons l'île Ellef Ringnes, au Nunavut, comme exemple en vue d'identifier les processus actifs pour cette région semi-aride de haute latitude. L'érosion fluviale contrôlée par la structure géologique est à l'origine du relief spectaculaire de l'île Ellef Ringnes. Le régime nival, qui concentre les débits sur une courte période à la fin du printemps, est caractérisé par une forte capacité érosive des cours d'eau en dépit des faibles précipitations annuelles. D'autres processus reliés aux milieux froids produisent une variété de formes mineures telles que les sols à figures géométriques, les coulées de boue associées à la présence de glace dans le sol et les lobes de solifluxion.

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INTRODUCTION

Ellef Ringnes Island is the most westerly of the Sverdrup Islands in the northwest sector of the Queen Elizabeth Islands archipelago. The island is 205 km long, between 20 and 106 km wide, with an area of approximately 11 295 km^2 (Fig. 1).

During the summers of 1959, 1960 and 1961, the first author mapped the geomorphology of the island as the basis for a D.Sc. thesis at the University of Leuven. The results were later published by the Geographical Branch (St-Onge, 1965) along with two geomorphological maps. The latter are pioneering examples of morphodynamic process mapping in an arctic environment (St-Onge, 1968).

Because of the excellent coverage of air photographs and maps at 1:50 000, Ellef Ringnes Island is an exceptional example for the study of landscape evolution under semiarid periglacial conditions, and for understanding the importance of lithology on the efficacy of geomorphological processes.

GEOLOGY, LANDFORMS, CLIMATE AND VEGETATION

The island is located in the central part of the Sverdrup Basin which is formed of a sequence of marine and non-marine sedimentary rocks of Carboniferous to Upper Cretaceous age (Tozer, 1970; Dawes and Christie, 1991). This 12 000 m thick sequence was deformed in Late Cretaceous to Early Tertiary times into gentle folds and pierced by diapirs of mostly gypsum evaporites, and gabbroic dykes and sills. The northern part of Ellef Ringnes is unconformably overlain by the Neogene Beaufort Formation, a deltaic sequence of gravel to fine sand rich in plant debris including tree trunks often over ten centimetres in diameter. A variety of geomorphic processes, with fluvial being the most dominant, have eroded a spectacular sequence of structural landforms including cuestas (Fig. 2), hogbacks, mesas and plateaux. Maps at 1:50 000 and good air photo coverage make this island an excellent example of the

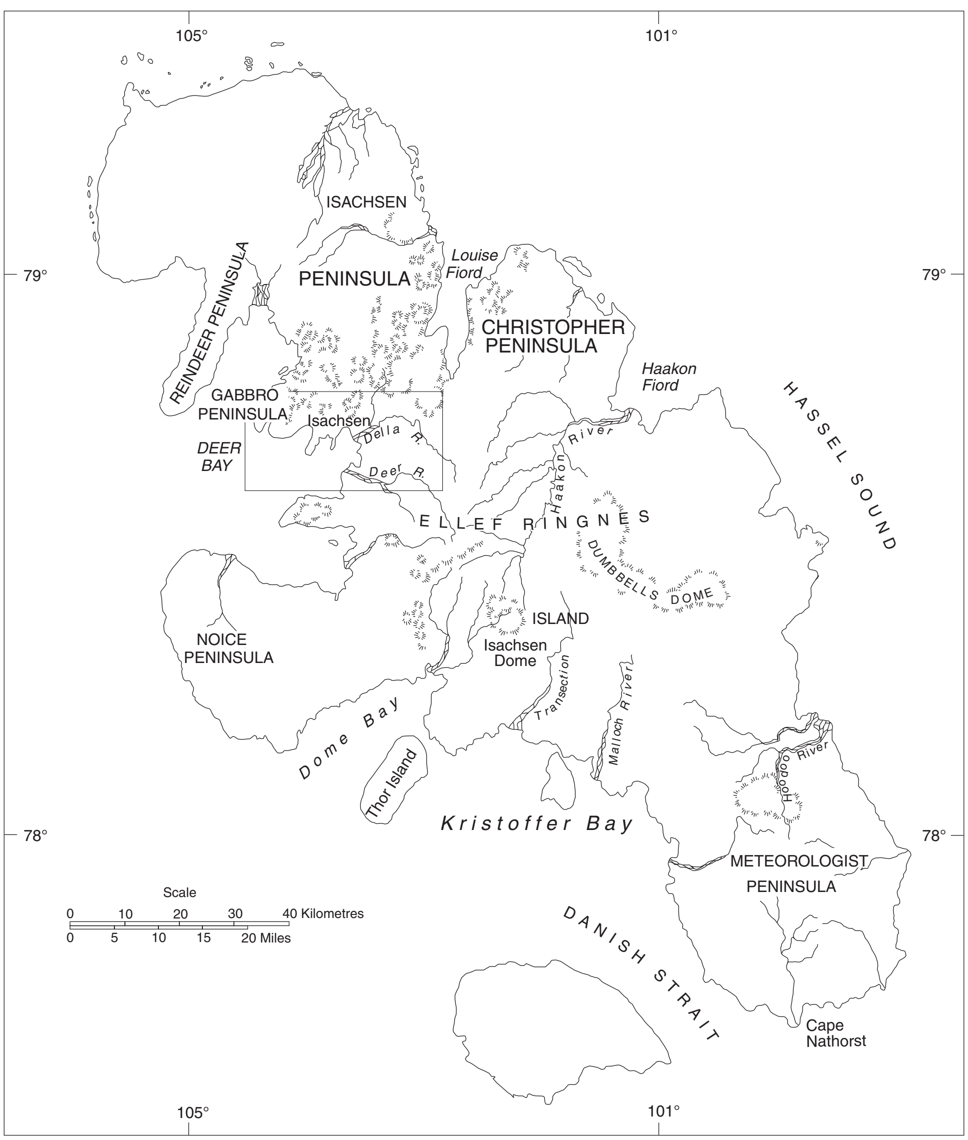

FIGURE 1. Ellef Ringnes Island, Nunavut. Area covered by geomorphologial map is outline by rectangle.

L'île Ellef Ringnes, Nunavut. La région couverte par la carte géomorphologique est définie par le rectangle.

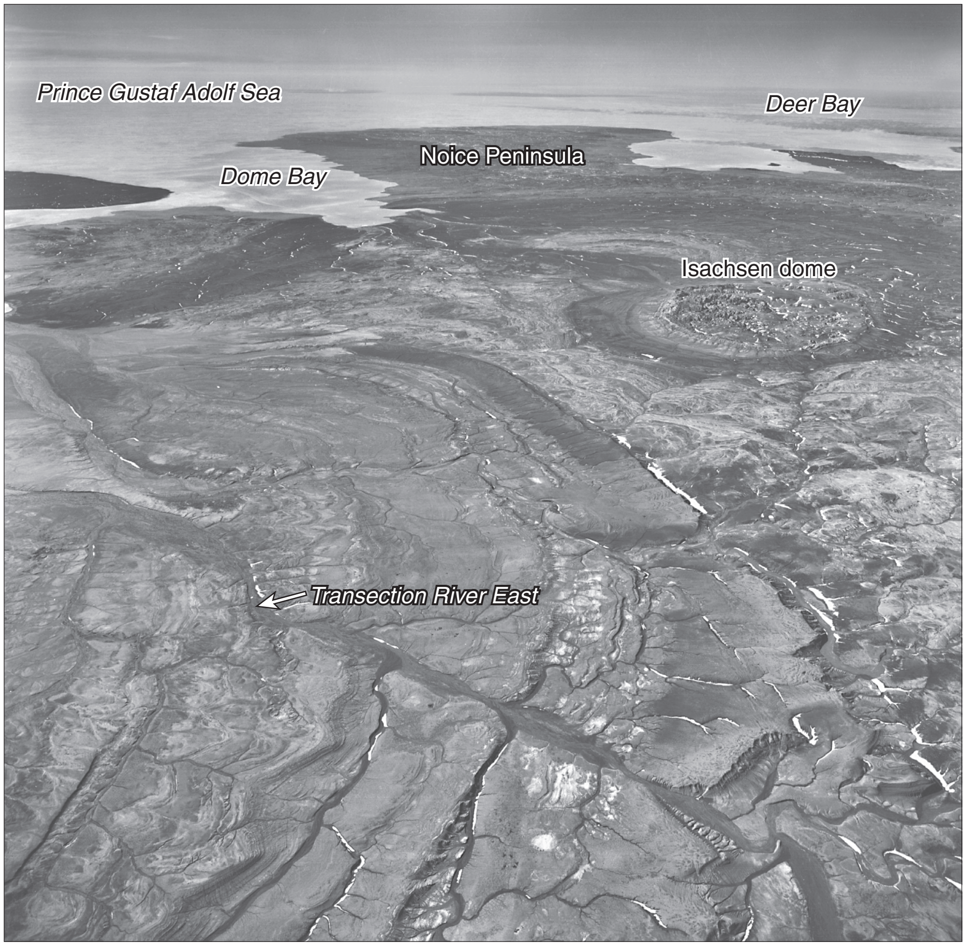

FIGURE 2. Oblique air photo of central Ellef Ringnes Island looking west. The predominant influence of geological structure on the landscape is clearly illustrated. In the middle right is the Isachsen Dome, with its intensely dissected core of mostly gypsum surrounded by a ridge of sandstone. The south dipping, thinly bedded shale and siltstone of the Kanguk Formation have been eroded into a series of cuestas by the East Transection River (Source: National air photo library T428L-118).

Photographie aérienne du centre de l'île Ellef Ringnes avec une vue oblique vers l'ouest. L'influence de la structure géologique domine le paysage. Au centre droit se trouve le dôme Isachsen, fortement disséqué, cerné d'une crête de grès. Les lits de schiste et de siltstone, avec un pendage vers le sud, de la formation Kanguk ont été façonnés en une série de cuestas par la rivière Transection Est (Source : Photothèque nationale T428L-118).

evolution of landforms in a high arctic region where glaciation has left little imprint.

The climate of Ellef Ringnes Island is typical of high arctic periglacial climates (French, 1996: p. 22-25). Daily mean below 0 °C lasts for about 300 days, with half the year below -25 °C bringing the yearly average to -19 °C. The mean daily temperature is positive during about 60 days with a mean maximum in July of 5.7 °C, the only month when temperatures above 10 °C have been recorded, with an extreme of 12.6 °C. July is also the only month when mean daily minimum are above 0 °C but even then extremes of -2.7 °C are noted. In the two other summer months night frost is the rule, notwithstanding a midnight sun slightly above the horizon. Over a thirty-year period the average total precipitation is 111.2 mm and, of this, only 32.6 mm fell as rain between June and early September. As a result of climatic conditions permafrost is thick on Ellef Ringnes Island (Hodgson, 1982). The single most important impact of permafrost on the geomorphology of the island is that, regardless of lithology, it provides an impermeable layer at very shallow depth.

Plant growth on Ellef Ringnes Island is inhibited by the semiarid conditions and the very short summer season (Saville, 1961; Hodgson and Edlund, 1978). Also, some lithologic units such as quartzose sandstone and some shales are not amenable to plant growth. As a result, relatively abundant plant cover is limited to the base of scree slopes where lichens mosses and some grasses are found. Saville (1961) notes that there are no endemics and the plants are extremely depauperate. The vegetation cover is such that it has little inhibiting effect on erosion.

A priori weather conditions on Ellef Ringnes are not favourable for aeolian activity. Due to lack of strong regional temperature contrasts wind velocity is generally moderate with occasional short lived gusts over 60 km/h during winter months. Low summer insolation does not favour complete drying of the soil surface. No eolian faceting was observed, although no extensive traversing was done in the sand plain of Isachsen Peninsula where wind faceting is most likely to occur. John Fyles collected a spectacular quartzite ventifact from Isachsen Peninsula indicating that eolian process were once active on the Beaufort Formation area.

Sandstone pillars are a common occurrence in some parts of the island (Fig. 3). These spectacular landforms lack the asymmetry and polish produced by dominant sand-laden winds. Instead, the surfaces are very irregular, indicating weathering by granular disintegration. Stratification lines suggest that a variable clay content of the matrix of the sandstones directs disintegration. These pillars are isolated by rill and gully erosion along an orthogonal fracture system in the bedrock and then etched by wind (St-Onge, 1965).

FIGURE 3. Sandstone pillars developed by erosion along an orthogonal joint pattern in the Isachsen Formation. Note the absence of wind polish on the surface of the pillars.

Piliers de grès découpés par l'érosion le long d'un réseau de fractures orthogonal dans la formation Isachsen. Notez l'absence de poli éolien sur la surface des piliers.

FIGURE 4. View south east along the southwest side of Dumbbells Dome. Because of the absence of significant surficial debris, the delicate bedding and minor faults of the southwest dipping shale, siltstone and limestone of the Christopher Formation appear clearly.

Vue vers le sud-est de la partie sud-ouest du dôme Dumbbells. La paucité de débris en surface permet de voir clairement les détails délicats du litage et les failles mineures dans les schistes et les siltstones, avec un pendage vers l'ouest, de la formation Christopher.

Therefore, in contrast to what is frequently assumed (Pissart, 1966; Pissart *et al.*, 1977; Seppala, 2004), wind is not now a significant geomorphic agent on Ellef Ringnes. However, as discussed below, wind is responsible for accumulation of snow banks which provide an essential component to other processes.

BEDROCK WEATHERING BY FROST ACTION

The importance of frost shattering of bedrock in high arctic regions has been debated for decades. For an historical summary see French (1996: p. 31-50). A striking aspect of the Ellef Ringnes Island landscape is the lack of extensive debris mantle on most rock types (Fig. 4). The exception is around gabbro plateaux and ridges where extensive debris has accumulated as talus (Fig. 5).

It has long been known that frost shattering is far more effective on saturated rocks than on dry ones (Tricart, 1956; Tourenq, 1970; Konishchev and Rogov, 1993; Thorn, 2004). Therefore, given that the small amount of snow is swept off ridges and interfluves, there is a limited moisture supply to saturate rocks and make frost an effective process.

Thus, in spite of negative annual temperatures there is little evidence for extensive frost shattering except in very localized conditions related to the presence of perennial or semiperennial snow banks. Based on evidence from Ellef Ringnes Island the obvious conclusions is that negative temperatures are not effective in breaking down unsaturated rock types ranging from shale, siltstone, sandstone, carbonates and gypsum. Recent support for this conclusion is provided by Hall (2004) who carried out a one-year study in northern British Columbia, in which he measured temperatures at 1 cm and 3 cm within concrete paving bricks with a porosity of 11.1%. He argues that "A ... rock weathering in cold regions is a synergistic combination of various chemical and mechanical weathering mechanisms". Hall's results are based on temperature variations within bricks "... comprised of Portland cement, a small amount of water, and fine and coarse aggregates and are moulded using extreme pressure and high-frequency vibration to achieve intersample conformity". It cannot be assumed that these results can be applied to softly indurated, high porosity rocks in the far more severe climatic conditions of the High Arctic. More detailed, long term temperature measurements within rocks need to be carried out in field conditions. Currently we are left with the overwhelming geomorphological evidence that, in high latitudes at least, frost weathering in sedimentary rocks is only effective if moisture is available to saturate the rock. In the absence of ample moisture supply, frost alone is not an effective agent in splitting rock. The implications are that, on most rock types, either frost shattering is ineffective or debris is efficiently removed. Available evidence suggests that, on Ellef Ringnes Island, frost is a potent geomorphic agent only in the vicinity of perennial or semiperennial snow banks in particular where slopes allow debris removal.

Extensive block fields or felsenmeer on gabbro plateaux represent a special problem. These uplands tend to be flat and poorly drained so that it is conceivable that saturation could occur making frost shattering possible. The coarse fragments produced as a consequence of low porosity and which are now separated by voids can no longer be saturated and are immune to frost shattering. Studies in the area west of Coronation Gulf indicate that frost shattering on dolomite can produce extensive block fields immediately following glacial retreat (St-Onge and McMartin, 1995). There is no indication of further disintegration once detached from bedrock. Thus, in the cold and semiarid conditions of Ellef Ringnes Island it is hypothesised that block field surfaces are very stable elements of the landscape having changed little since they were produced. Although the island was certainly covered by glacier ice (St-Onge, 1965; Hodgson, 1982), available evidence suggests

FIGURE 5. View north along the east side of Gabbro Peninsula. A talus of open work coarse debris has accumulated below a vertical outcrop of gabbro.

Vue vers le nord le long du côté est de la péninsule Gabbro. Une accumulation de débris grossiers sous une falaise de gabbro forme un talus.

that this was cold-based ice bordered by trunk glaciers in the outer fjords (Atkinson, 2003). It is thus possible that these block fields are quite old, very likely pre-last glaciation, and that they were formed during a period when the climate would have been comparable to that of the Coronation Gulf area during Late Wisconsinan ice retreat.

PATTERNED GROUND

Patterned ground occurs on Ellef Ringnes Island on most rock types but is more abundant and diversified in fine-grained lithologic units such as shale or finer grained marine and deltaic sediments. Hodgson (1982) estimates that “Frost fissures and ice wedges ... are widespread — possibly covering 50 to 75 percent of the map area — and have been identified on all map units except active fluvial surfaces, modern beach berms, and consolidated rock outcrops”. The ubiquity of these features reflects the widespread occurrence of permafrost. The presence of extensive ground ice is suggested by exposures in slump features in the silty clay sediments in the Isachsen area (Lamothe and St-Onge, 1961), in the radio mast anchor holes drilled near the Isachsen station and in slumps in low lying areas north of Black Lake. No detailed analysis has been done on this ground ice so that its origin is problematic. However, exposures of ground ice one metre or more in thickness suggests extensive ice bodies are probably the result of segregation in fine-grained deltaic sediments associated with postglacial uplift and emergence from a higher sea level (for an extensive review see French, 1996: p. 87-101). Significant amounts of ground ice are known to occur on Fosheim Peninsula, Ellesmere Island, further east (Lewkowicz, 1992).

PERMANENT AND SEMI-PERMANENT SNOW PATCHES

Numerous permanent to semi-permanent snow banks exist on Ellef Ringnes Island (St-Onge, 1969). As argued by Thorn (1988) the term “nivation” is too vague to be useful. However, there is no doubt that snowbanks provide a continuous source of moisture during the brief melting season (Thorn, 2004). This moisture has the potential to saturate underlying bedrock and therefore increase frost shattering. It also makes solifluction and sheet wash far more effective. For example, in 1959, when walking below the remnants of a large snowbank on the south slope of a glauconitic sandstone plateau northeast of Deer Bay (Fig. 6), footmarks 10 to 15 cm deep were quickly filled with water from surface wash and, within a few minutes, obliterated by a sand slurry flowing from up slope (St-Onge, 1969). If these snowbank-related processes operate in an environment where the transported material is deposited on a steep slope, rather than in a river bed as was the case on Ellef Ringnes Island, a sequence of solifluction beds of unsorted mass wasted material would alternate with partly to wellsorted sheet wash and rill deposits. This is the complex of processes that Guillien (1951, 1964) initially proposed for “Grèzes litées”. It is now apparent that that the processes involved may be far more complex (DeWolf, 1988; Van Steijn *et al.*, 1995). In glauconitic sandstone of Ellef Ringnes Island there is a close link between frost shattering, solifluction, sheetwash and the presence of snow banks; the coarse sand and sandstone debris are transported downslope by mass wasting below the snowbank while the surface material is “washed” by meltwater.

In the case of poorly consolidated fine-grained rock types such as shale, the presence of snow patches on steep cuesta fronts results in deeply gullied amphitheatres. In this lithologic context, frost shattering produce silt and clay that are easily evacuated by meltwater. Solifluction plays a very minor role. In more resistant rock types the role of perennial snow banks is less clear. Although it is likely that processes associated with snow patches contribute to ongoing modifications of terraces on gabbro as previously suggested (St-Onge, 1969), the extent to which these terraces are being currently modified is not clear. In a recent study (Atkinson, 2003) these benches are now interpreted as lateral meltwater channels but “... were not observed to terminate at ice-contact landforms, and lower lateral meltwater channels were not observed ...”. Given this, it is not possible at this time to quantify the role of snow-bank-associated processes to the evolution of terraces on hard rocks such as gabbro.

RIVER VALLEYS AND BEDFORMS

Rivers typically display a dendritic pattern that is spectacularly well developed on the sand and gravel of the Beaufort Formation which mantles the Isachsen Peninsula and in the sands of the Eureka Sound Group in the west central part of Meteorologist Peninsula.

In other parts of the island an orthogonal drainage pattern reflects the strong structural control of the gently folded rock

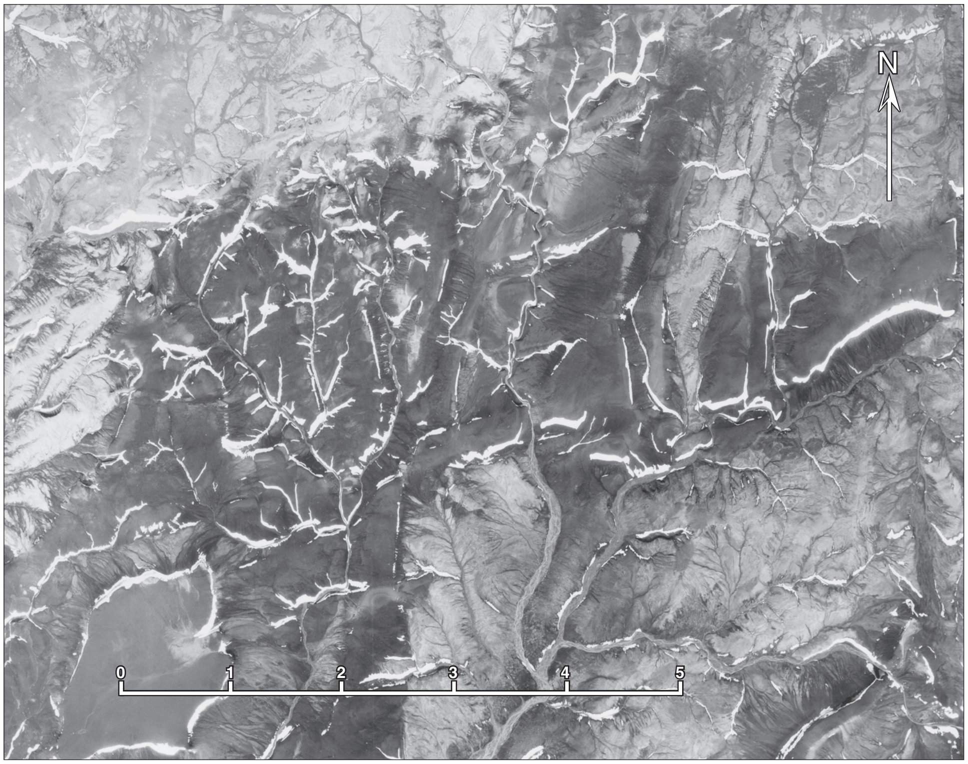

FIGURE 6. Vertical air photograph north east of Deer Bay showing snowbanks on the south facing slopes in uplands of glauconitic and ferruginous sandstone. Below the long, narrow snowbank in center right note the extensive solifluction-rillwash 6° slope down to the river bed (Source: National air photo library T411C-90).

Photo aérienne du nord-est de la baie Deer montrant des congères sur les versants sud de plateaux de grès glauconitique et ferrugineux. Notez au centre droit la pente de 6° de solifluxion et de ruissellement en nappe au bas de la congère (Source : Photothèque nationale T411C-90).

units. This is particularly evident in the sandstones of the Isachsen Formation and in the siltstones of the Kanguk Formation (Fig. 2). These patterns show no evidence of disruption by glaciation, even the two eskers do not appear to modify the pattern. This is further evidence that the ice cover was either cold based or too thin, or both, to generate erosive ice flow (Atkinson, 2003).

Multiple channels flowing between unvegetated sand bars are the most striking aspects of rivers on Ellef Ringnes Island. They satisfy the criteria for braiding (Bravar and Petit, 2000: p. 125-126). Their flow regime is nival in that most of the water comes from the spring melt of snow accumulated in valleys by wind drift during the long winter. The result is a series of high discharges in spring and early summer followed by lesser flow. The general sequence of events is as follows: in late May or early June, snow begins to melt even if air temperature is still below 0 °C on south-facing and wind-protected slopes. On flat surfaces melting occurs around protruding rocks particularly if they are dark coloured. Rivulets appear channelling water towards valleys where it accumulates as ponds dammed by large snow drifts. Eventually one of these snow dams collapses triggering a domino effect resulting in flow jumping from near zero to flood stage.

The ubiquitous braiding of rivers on Ellef Ringnes Island is related, mostly, to low flow stage. Late spring-early summer flood events with generally bank full discharge have a dramatic effect on river beds and banks. The ephemeral nature of channel bars indicates that flood events flush out a significant amount of alluvium or extensively redistribute them. Also scars up to one metre high along the channel margins point to effective lateral erosion. Braiding is most extensive in river beds in late July and August, when streams have become “dwarfs in a house of giants” (Tricart, 1960: p. 211). However, braiding cannot be taken as a reflection of a lack of capacity for vertical erosion. In spite of glacio-isostatic rise of at least 60 m in the past 10 000 years (Atkinson, 2003; Atkinson and England, 2004) rivers are graded to present sea level and, extensive deltas bear witness to extensive erosion and sediment transport during the Holocene.

The width of the river bed, and hence braiding, is controlled by lithology, which varies from steep sided V-shaped valleys in gabbro to progressively wider beds in sandstone and shale, the end member being the unconsolidated sands of the Beaufort Formation. The latter covers Isachsen Peninsula where a myriad of braided channels cross an otherwise featureless sand plain. In this case lateral erosion has resulted in numerous streams to become interlaced. Downstream, a stratum of coarser sand or gravel concentrates streams into individually defined entities (Fig. 7). This is an illustration of the effectiveness of lateral erosion by snow melt generated floods flowing over a still frozen bed.

Gypsum presents an interesting case (St-Onge, 1959). Five gypsum domes pierce the Mesozoic sedimentary rocks of Ellef Ringnes Island. The two larger domes rise to 125 metres above the surrounding plain. Isachsen Dome (Fig. 2) is a spectacular example of how a soft material like gypsum, under permafrost conditions, behaves as a relatively resistant material. The gypsum core is dissected by a dense network of steep-sided gullies with very narrow channels. Because of permafrost and a covering of debris, gypsum is no longer submitted to chemical erosion as may have been the case in the past or as would be the case in milder climatic conditions. The

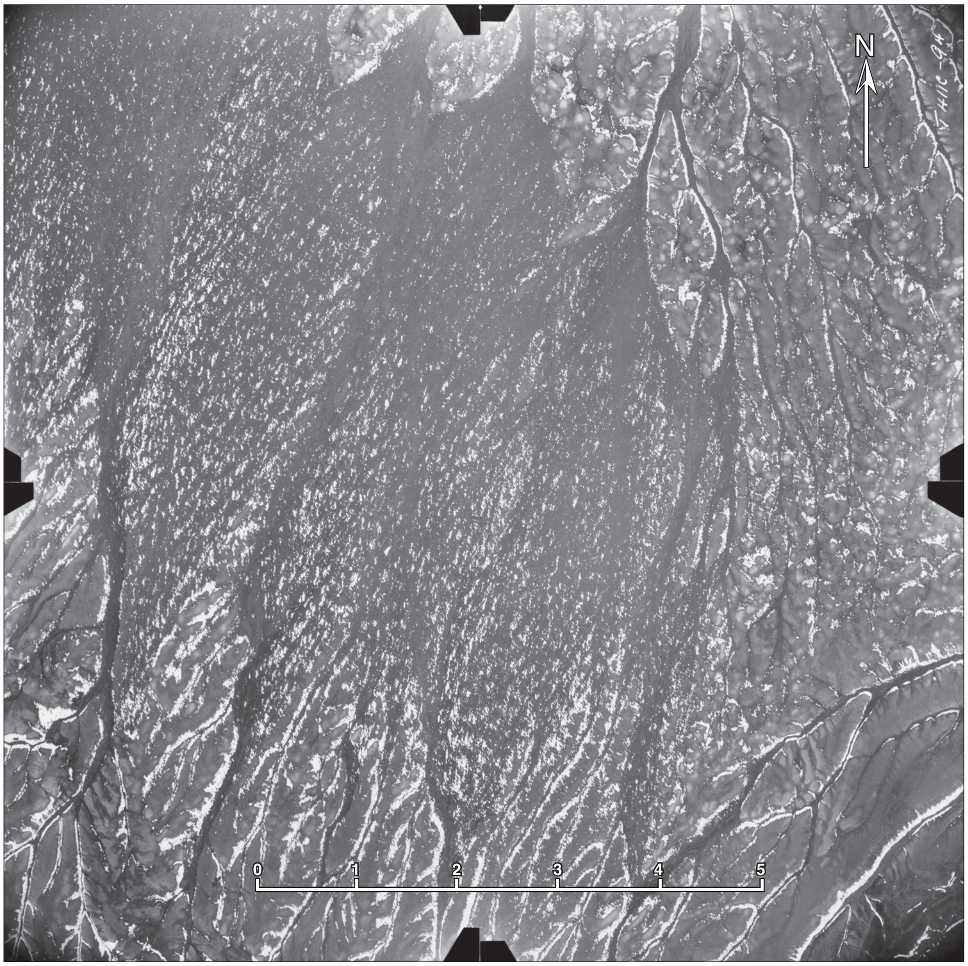

FIGURE 7. Vertical air photograph of the central part of Isachsen Peninsula. Lateral erosion by braided streams have eroded all interfluves in a fine sand units of the Beaufort Formation. Downstream, towards the northwest, rivers regroup through a series of water gaps carved in coarse sand and gravel. (Source: National air photo library T411C-94).

Photo aérienne du centre de la péninsule Isachsen, où l'érosion latérale des cours d'eau en tresses a éliminé toutes les interfluves dans le sable fin de la formation de Beaufort. En aval, au nord-ouest, les rivières se regroupent en une série de cluses taillées dans le sable grossier et le gravier (Source : Photothèque nationale T411C-94).

gabbro surface is at ~260 m asl while the gypsum surface is at ~198 m asl. This 60 metres difference can best be explained by chemical weathering under different climatic conditions in the past. Chemical weathering of the gypsum would have concentrated debris such as gabbro, sandstone, chert and limestone, entrained by the rising gypsum diapir. Under present climatic conditions and because the thickness exceeds the annual thaw layer, the debris provides a protective blanket against chemical erosion. Further, because of its low porosity, gypsum is immune to frost shattering. Debris laden streams remain the most effective erosive agent. Once the main river has passed through the gap cut in the sandstone ridge that delimits the dome, the change in pattern is spectacular: from a narrow channel in a steep-sided valley it immediately broadens into a wide braided stream on a terraced alluvial cone.

The braided streams of Ellef Ringnes Island are a particular periglacial bedform generated by powerful snow melt flows which aggressively erode river banks. These braided streams are the wilted heirs of short-lived but highly effective floods.

DISCUSSION

In the early 1960s the literature on periglacial geomorphology emphasized the importance of active processes on slopes and, in general, gave little importance to erosion and transport capabilities by ephemeral streams in arctic regions (Tricart and Cailleux, 1967: p. 361-367). Based on a regional study and mapping St-Onge (1965) concluded that the extreme climatic conditions of Ellef Ringnes Island determine which geomorphic processes are effective. Long and very cold winters along with short cool summers maintain a thick permafrost and a shallow active layer. Because of low precipitation, which falls mostly as snow, the environment is semiarid. Stream flow is concentrated in powerful floods generated by snow melt. In spite of their short durations these are remarkably erosive. Thus the relief of Ellef Ringnes Island is a spectacular landscape of structural landforms eroded by streams in gently folded sedimentary rocks and unconsolidated sediments. Gabbro and gypsum, because of their greater resistance to disintegration by frost action add some variations to this general scenario. Since the early 1960s the erosive and transport capacity of ephemeral streams in Arctic regions have been recognized and are now an integral part of the geomorphological paradigm (French, 1996: p. 185-203).

The role of snowbanks as a locii of intensified geomorphic activity has not progressed significantly during the past decades. According to Thorn (1988) the term "nivation" should be discarded although the landforms associated with permanent or semi-permanent snowbanks have been shown to vary with lithology (St-Onge, 1969; Thorn, 1988). Wind-concentrated snowbanks in valleys and on steep slopes provide a source of moisture which is not available on wind-swept flat surfaces. As a result, frost shattering and rill erosion are far more effective in areas of snowbank accumulation. The result is a variety of hollows and benches in which form is dictated by lithology. We certainly concur with Thorn (2004: p. 8) "... that the variability in moisture supply is probably of significantly greater importance than the local variability in ground temperatures". This applies to chemical as well as mechanical weathering.

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APPENDIX

GEOMORPHOLOGY OF THE ISACHSEN AREA

A geomorphological map of the Isachsen area is available in PDF format at the GpQ web-site with on-line version of this paper at:

http://www.erudit.org/revue/gpq/2005/v59/n2-3/index.html

The geomorphological map, with a process-based legend, depicts the landforms of the west-central part of Ellef Ringnes Island. The map illustrates the influence of both geological structure on macro landforms and of lithology on the variety of meso and macro landforms. As geomorphological mapping has been largely abandoned, the geomorphological map of Isachsen area remains a unique example of portraying the complex interrelations of processes active in a high arctic region.

Active geomorphic processes are discussed in detail for the Isachsen area located in west-central part of Ellef Ringnes Island (Fig. 1).

LITHOLOGICAL CONTROL

The high gabbro ridges in the northwest of the Isachsen area rise to over ~240 m asl (Fig. 8). From vertical rock outcrops at their edges steep slopes are mantled by coarse open work scree slopes which descend to the valleys or ocean below. Stony solifluction lobes commonly deform the lower part of these slopes. Steep-sided terraces are frequent on the upper surfaces of gabbro ridges, on the map these are interpreted as nivation terraces but recent studies suggest they are glaciofluvial channels although no associated sediments have been identified (Atkinson, 2003).

In the southeast, sandstone of the Isachsen Formation underlies a hilly region dissected by numerous gullies and moderately to steep-sided valleys. Here, erosion along orthogonal joints has produced numerous stone pillars.

The central part of the map area is a low plain eroded on shales of the Deer Bay Formation which is drained by the Delta River and other streams flowing in broad alluvial beds to deltas in Deer Bay. A variety of patterned ground cover this rolling lowland. Here, as elsewhere on the island, periglacial landforms are closely linked to lithology.

Periglacial features such as patterned ground, albeit spectacular, are but minor features on the fluvial-dissected, structurally-controlled landscape of Ellef Ringnes Island.

Detailed instrumented field measurement to identify and quantify processes associated with snowbanks in high latitudes still needs to be done. The role of geologic structure, in spite of its high visibility in imagery from space, does not appear to be an important preoccupation in current scientific periglacial geomorphology literature.

FIGURE 8. Oblique air photograph of the Station Bay area looking west. This view covers most of the area of the detailed geomorphological map. Gabbro mesas and generally circular dike ridges dominate the landscape in the north with valleys carved in intervening shale. The Delta River has eroded a broad lowland in the shale of the Deer Bay Formation. Note the snowbanks along the south facing slopes of gabbro mesas and along the banks of Delta River (Source: National air photo library T411R-41).

Photographie aérienne de la baie de la Station avec une vue oblique vers l'ouest. Cette vue couvre la majeure partie de la région de la carte géomorphologique. Des mésas et des crêtes circulaires de gabbro entrecoupées de vallées dans les roches schisteuses dominent le paysage de la partie nord. La rivière Delta occupe une large plaine dans les schistes de la formation Deer Bay. Notez la présence de congères sur les pentes sud des mésas et les versants de la rivière Delta (Source : Photothèque nationale T411R-41).

CANADA
GEOGRAPHICAL BRANCH
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GEOMORPHOLOGY

OF THE
ISACHSEN AREA
ELLEF RINGNES ISLAND, NORTHWEST TERRITORIES

Geomorphology by D.A. St-Onge, 1959-60-61

CANADA
DIRECTION DE LA GÉOGRAPHIE
MINISTÈRE DES MINES ET DES RELÈVES TECHNIQUES

GÉOMORPHOLOGIE

DES ENVIRONS
D'ISACHSEN
ÎLE ELLEF RINGNES, TERRITOIRES DU NORD-QUEST

ILE ELLEF RINGNESGéomorphologie par D.A. St-Onge, 1959-60-61

kilometres 0 1 2 3 4 5 kilomètres
miles 0 1 2 3 milles
contour interval 50 feet
équidistance des courbes, 50 pieds

LOCATION MAP — LIEU DE LA CARTE

LITHOLOGY — SCHÉMA LITHOLOGIQUE

FORMS / FORMES — STRUCTURAL / STRUCTURALES — GELIVATION / GÉLIVALES — NIVATION / NIVALES — FLUVIAL / FLUVIATILES — MARINE / MARINES — SEA ICE / GLACIELLES

- Straight slope over 35° / Pente droite de plus de 35°: 1 to 3 m / de 1 à 3 m de haut; 3 to 5 m / de 3 à 5 m; 5 to 8 m / de 5 à 8 m; over 8 m / de plus de 8 m
- Straight slope / Pente droite: 4° to 12° / de 4° à 12°; 12° to 18° / de 12° à 18°; 18° to 30° / de 18° à 30°; 30° to 35° / de 30° à 35°
- Concave slope / Pente concave
- Landslide scar / Couloir d'éboulement
- Sharp convexity / Convexité accentuée
- Gentle convexity / Convexité faible
- Very sharp ridge / Crête très aiguë
- Sharp ridge / Crête aiguë
- Asymmetric ridge / Crête asymétrique
- Flat ridge / Crête plane
- Rounded ridge / Crête arrondie
- Structural lineament / Traits structuraux
- Sandstone pillar / Pilier de grès
- Surficial deposits / Dépôts: block / blocs; gravel / gravier; sand / sable; silt / limon

- Gully over 5 m deep / Ravin de plus de 5 m
- Gully less than 5 m deep / Ravin de moins de 5 m
- Furrow / Rigolet
- Sheet-wash / Ruissellement diffus
- Single channel / Chenal unique
- Braided channel / Chenaux anastomosés
- Semi-permanent snow-bank / Banc de neige (pluri-annuel)
- Nivation scar / Gradin de nivation
- Nivation hollow / Niche de nivation
- Minor nivation scar / Encoche de versant
- Lake / Lac
- Thermokarst pond / Mare de thermokarst: rounded / arrondie; rhomboidal / en losange
- Polygonal network / Réseau de fentes en coin: tetragonal / Tracé tétragonal — low-relief centre plat: well defined / tracé net; incomplete / tracé incomplet; high centred / centre bombé; polygonal / Tracé polygonal — high centred / centre bombé; incomplete / tracé incomplet
- Minor patterned ground / Cercle, vermicule et forme mineures
- Soil stripe / Sol strié
- Stony solifluction lobe / Guirlande de pierres
- Solifluction lobe / Lobe de congéliflution
- Solifluction sheet / Nappe de congéliflution
- Mudflow on ground-ice / Coulée de boue sur glace de sol
- Inactive mudflow / Coulée de boue ancienne

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