

THE SPATIAL DISTRIBUTION OF COAST TYPES ON SVALBARD

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Introduction

In connection with an oil spill protection program in the Barents Sea a major part of the coast of Svalbard was mapped with regard to geomorphological coast types and coastal fauna (Dep. of Physical Geography, Univ. of Oslo and Norwegian Polar Institute, unpublished). In collaboration with the Norwegian Polar Institute the coast maps were produced in a scale of 1:200,000 at the Department of Physical Geography, University in Oslo, led by Prof. J.L. Sollid. All geomorphological information was digitized, and a Geographical information system of Svalbard's coast was established. In this extended abstract paper, digital spatial analyze techniques were used to depict the spatial distribution pattern of different coast types on Svalbard. A coastal zonation of Svalbard is suggested based on geomorphological parameters.

Setting

The Svalbard archipelago is located between 74°N and 81°N and 10°E and 35°E (Fig. 1), and comprises a total area of approximately 63,000 km², where more than 60% of the land area is glaciated. The archipelago consists of the islands Spitsbergen, Nordaustlandet, Barentsøya, Edgeøya and a range smaller islands. The climate is relatively mild, seen in relation to the high latitude. At the Spitsbergen west coast annual mean temperature of -6°C to -8°C are measured (Hanssen-Bauer et al. 1990). Besides some taliks beneath the accumulation area of the glaciers the whole island has continuous permafrost conditions, with measured permafrost depth of 500 m, decreasing to ca. 100 m in the coastal areas (Liestøl 1977; Isaksen et al. 2001). The coastal water areas are usually covered with sea ice throughout the wintertime, with a maximum in April. Off the west coast sea ice belt open water is possible during the wintertime (cf. Vinje and Kvambekk 1991)

The geology of Svalbard displays all the main geological systems from Precambrian to Quaternary (Fig. 2). Pre-Devonian rocks consist mainly of hard metamorphic rock types, located on Nord-Austlandet and along most of the west-coast of Spitsbergen. Devonian conglomerates, sand- and siltstones dominate in northern Spitsbergen, while often fine-grained sedimentary rocks from the Mesozoic and Tertiary covers most of central Spitsbergen and the islands of Edgeøya and Barentsøya. During the Quaternary time period Svalbard was glaciated several times. During Weichsel maximum the ice reached the continental shelf (e.g. Mangerud et al. 1992).

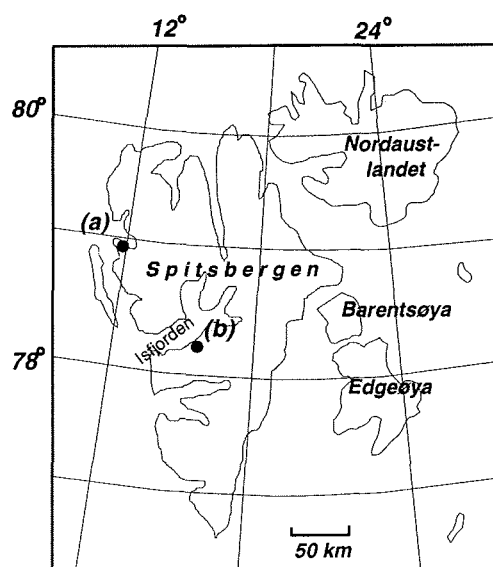


Figure 1. Key map over the Svalbard archipelago. (a) Ny-Ålesund, (b) Longyearbyen.

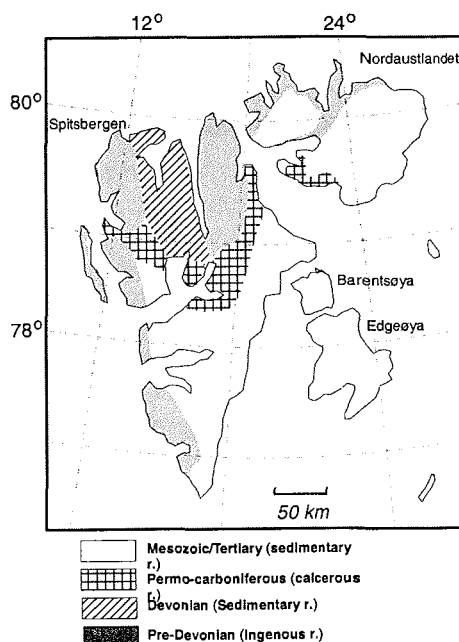


Figure 2. Simplified geological sketch over Svalbard.

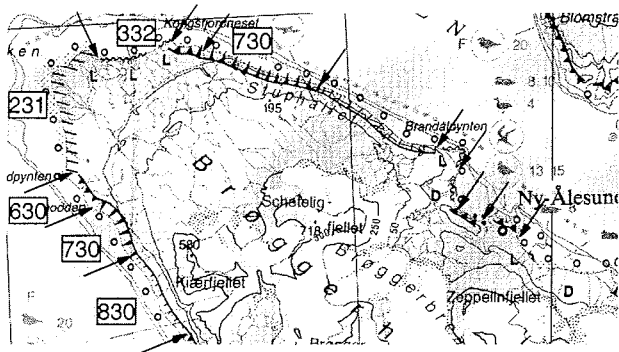
Methods

The classification system of the coast maps is based on grain-size distribution of beach sediments and geomorphological parameters as differences in bedrock- and unconsolidated sediment cliffs and abrasion platforms in connection to rock shores (Table 1). A comparable system was used on the Norwegian mainland (Klemsdal 1979). In order to make the system operate for Svalbard conditions, there were applied some corrections, especially in relation to grain-size parameters and rock cliffs (see also Owens et al. 1981; Harper and Sawyer 1983).

The coastal types and grain size of beach sediments were mapped using vertical air photos in scale 1:30,000 and 1:50,000. Additionally, helicopter-borne video pictures, which are available along most of Svalbards coast at the Dep. of Phys. Geography, Univ. of Oslo, were used. The coast maps are based on the topographic maps 1:100,000 (©Norwegian Polar Institute). Mapping accuracy and coast type generalization is approximately in the range 300 m to 500 m. The classification is based on five classes of grain-size distribution and 14 parameters for different geomorphological types. Beach sediments in front of rock cliffs are mapped as well (Table 1).

The coastal maps were digitized using the GIS ARC/INFO (ESRI). Digitizing was based on the topographic maps in scale 1:100,000. Totally ~6000 km coast line was registered in that scale. The coast line was split into segments, containing an unique code which attributes the coast types (Fig. 3). Additionally, the coast segments contain information on bedrock

geology. The coastal GIS developed within this project offers the possibility to analyze frequency or coast length relationships interactively, both by selecting certain geographical regions in relation to location, bedrock geology or wave energy exposure.



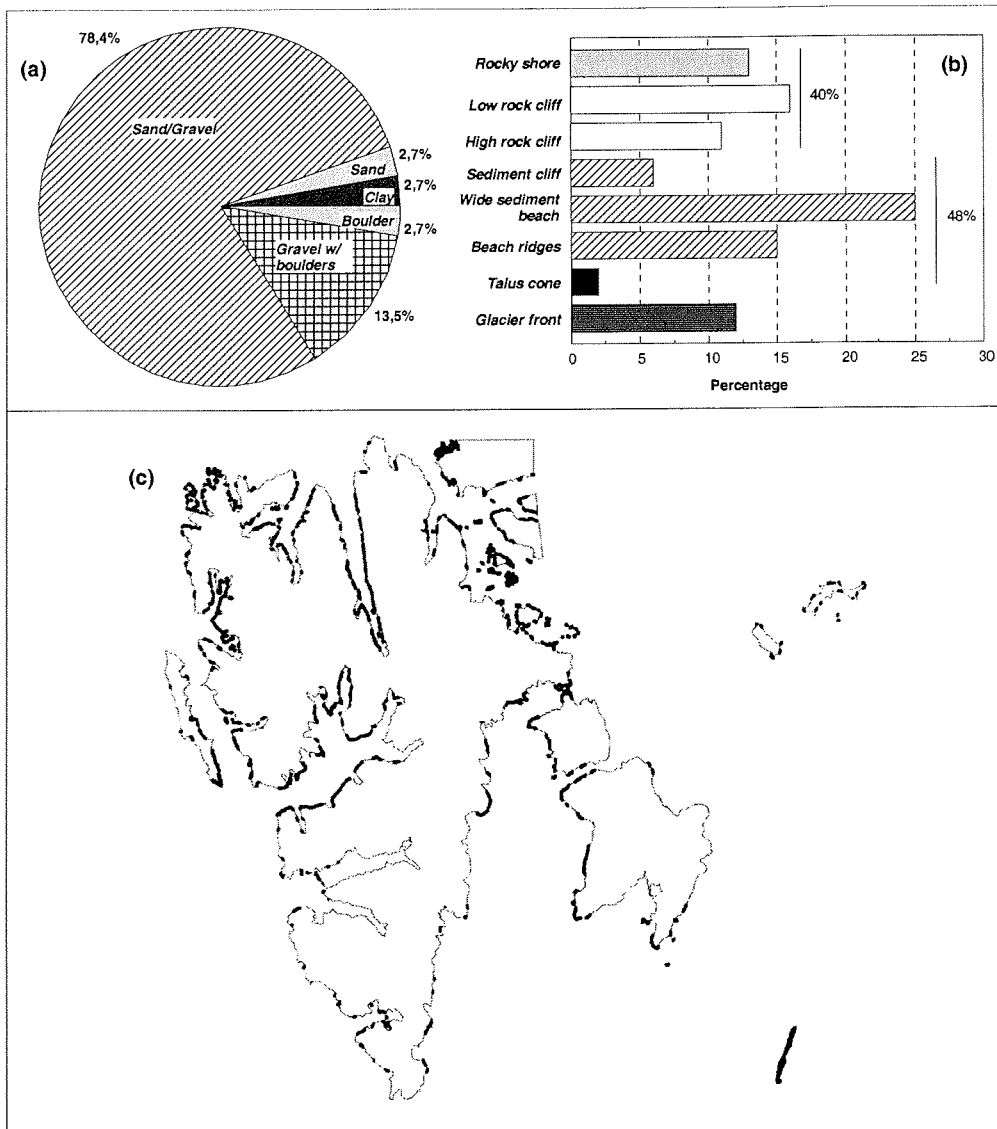


Figure 4. (a) Grain size distribution of unconsolidated sediments in the coast zone. (b) Frequency of geomorphological coast types on Svalbard. Calving ice cliffs are underrepresented as only parts of Nordaustlandet is within the analyses. (c) Spatial distribution of coastal cliffs in bedrock on Svalbard, indicating active zones of coast erosion. Active sediment cliffs are only identified at ca. 5% of the coast line.

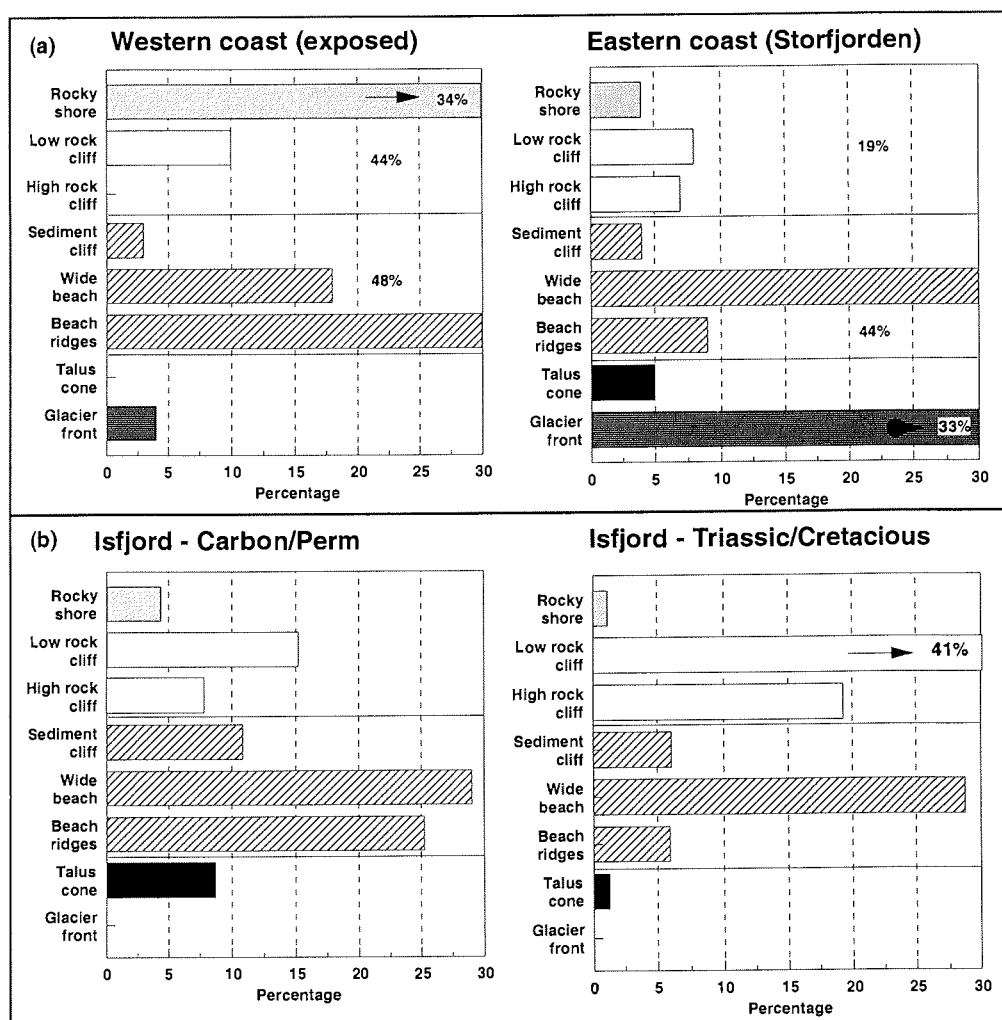


Figure 5. Frequency distribution of geomorphological coast types of certain areas on Svalbard. (a) Exposed western coast and eastern coast (Storfjorden) on Spitsbergen. (b) Coast types along Isfjorden within Permo-carboniferous (often calcareous) and tertiary rock types (mostly sedimentary, sand and silt).

The Coastal Zones on Svalbard

Svalbard is classified in different coastal regions. Eight coast classes on Svalbard were identified (Fig. 6):

- 1) *Wave exposed areas along the west- and north coast of Spitsbergen.* The area is dominated by rocky shore (> 30%), barriers and lagoons, indicating active marine transport processes along the coast. Calving glaciers and rock cliffs (< 15%) are seldom.

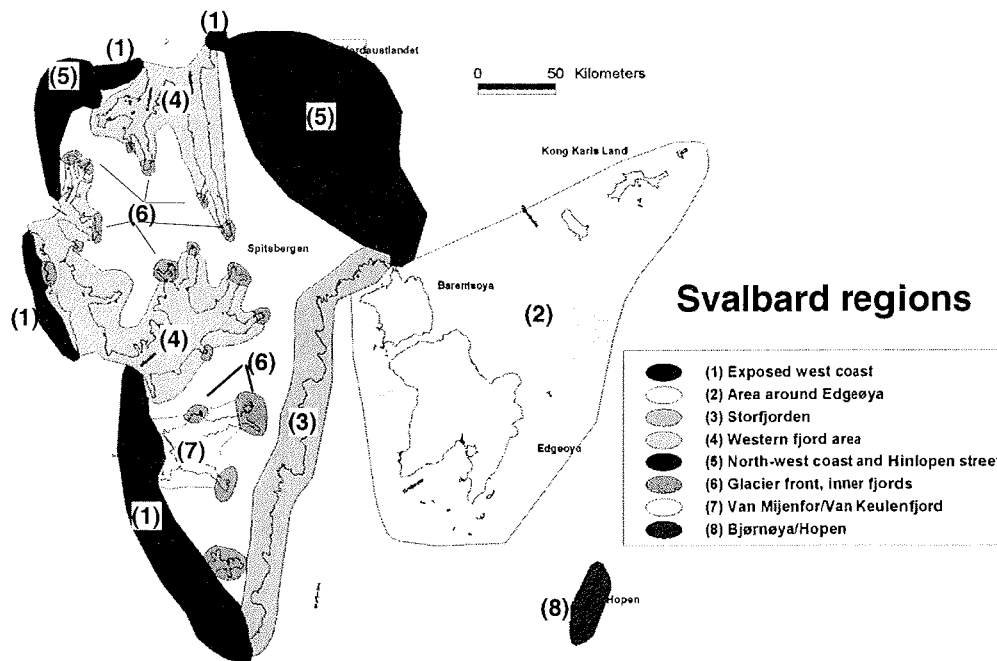


Figure 6. Proposed coastal regions on Svalbard, based on frequency analyses and subjective classification.

- 2) *Moderate wave exposed area at Barentsøya, Edgeøya and Kong Karls Land.* The coast is moderately exposed to waves because of land fast ice during most of the year, and active erosion in bedrock is supposed to be low.
- 3) *Coast dominated by calving glaciers - the Storffjorden area:* Glacier fronts and wide sediment beaches, showing lower wave action and sediment supply by the glaciers, dominate this area. Rocky shores and rock cliffs are more seldom.
- 4) *Coast dominated by rock cliffs with a narrow beach - the western fjord areas:* Rock cliffs behind a narrow beach, indicating active coastal erosion in bedrock, dominate the area. Grain size of the beach is often more sandy, reflecting the dominance of Mesozoic and Tertiary sedimentary bedrock in the area.
- 5) *Coast dominated by rock cliffs and rocky shore with low amount of beach sediments - the north-west coast of Spitsbergen/Hinlopenstretet:* This area is dominated by metamorphic rocks and sea ice exposition towards north and northeast. Grain size is coarser, and the amount of unconsolidated sediments in the shore zone is low. Rocky shore and rock cliffs are dominating. This area is one with the lowest frequency of coast types developed in unconsolidated material.
- 6) *The inner fjord areas:* These areas are dominated by glacier fronts or glacier meltwater outlets. There is an abundance of deltas and sand-rich sediments. These areas have the highest abundance of clayey beaches and wide tidal flats, and the shore zone is considered to be more subjected to rapid changes than elsewhere on Svalbard. Wide beaches dominate, cliffs are not frequent and rocky shores absent.

- 7) *Coast dominated by unconsolidated sediments - Van Mijenfjorden/Van Keulenfjord:* Sandy to gravelly beaches dominate this area, with 20% of the area being classified as sediment cliffs. This area is potentially prone to coast erosion. Sea ice cover duration is longer than in other fjord areas.
- 8) *Coast dominated by high rock cliffs - the islands of Bjørnøya and Hopen:* These islands are almost totally dominated by high rock cliffs, with 70% of the shore area. Sediment beaches are seldom.

This rough classification gives an overall indication of coast types, applicable both for coast management and erosion considerations. However, an objective, statistical analyses of coast type distribution on Svalbard (clustering, factor analyses etc) remains to be done.

Table 1. Coastal classification for Svalbard.

Classification based on grain size distribution		
1. Clayey beach	C	Grain size less than 0.063 mm, beach width 50-500 m in delta areas and 10-20 m in lagoons.
2. Sandy beach	S	Grain size between 0.063 and 2 mm. Beach width 10-20 m.
3. Gravelly beach	G	Grain size ranging from coarse sand to coarse gravel. Beach width 5-20 m.
4. Gravelly beach with boulders	GB	As (3), but with boulders.
5. Boulder rich beach	B	Grain size more than 28 cm. Beach width 5-10 m.
Classification based on geomorphological parameters		
1. Rocky shore / abrasion platform	Rs	Rocky shore without cliff development
2. Low cliff, in unconsolidated sediments	LcS	Cliff in unconsolidated material, < 5 m high
3. High cliff, in unconsolidated sediments	HcS	Cliff in unconsolidated material, > 5 m high
4. Low cliff in bedrock	LcR	Cliff in exposed bedrock, < 5 m high
5. High cliff in bedrock	HcR	Cliff in exposed bedrock, > 5 m high
6. Talus cone	Tc	Talus cone which reach sea page
7. Beach ridge	Br	Beach ridge in unconsolidated beach material
8. Wide sediment beach	Sb	Flat beach in unconsolidated material, > 20 m width, without beach ridge development
9. Stacks	St	Isolated coastal cliff, common on Bjørnøya
10. Calving ice front	If	Calving ice front in the sea/fjord
11. Tidal flat	Tf	Wide tidal flat.
12. Lagoon	La	
13. Delta	De	
14. Ice on the beach	Ei	Exposed ground ice or glacier ice in the shore zone.

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