PART 1

Introduction

Chapter 1  Svalbard, 3
Chapter 2  Outline history of geological research, 16
Chapter 3  Svalbard’s geological frame, 23

Mid-season view of the glaciers Comfortlessbreen (on the left) and Aavartsmarkbreen (beyond). The rocks are Early Vendian with Varanger tillites. Stratigraphic sections are generally worked along the glacier margins either by portage from the shore (in this case Egelskbukta) or by sledge from the interior. Photo M. J. Hambrey (SP. 455).

Late season view from the east over the terminal crevassed glacier Monacobreen. In this case access up the glacier is almost impossible because the lower reaches are deeply crevassed and the glacier terminates in ice-cliffs in inner Liefdefjorden. The glacier beyond offers an easy route westward. Photo P. W. Webb, CSE 1989.
View from Ossian Sarsfjellet at the eastern end of Kongsfjorden towards the mountains of Brøggerhalvøya which are reflected in the fjord. The intervening fjord carries a scatter of small bergs which have calved from the glacier cliffs of Kronebreen and Kongsbreen respectively to north and south of the photographer. The concentration of ice depends on wind and tide and is navigable with care in a slow moving boat. The small bergs melt rapidly in the summer. Photo M. J. Hambrey (SP96.122) 1996.

The CSE motorboat Salterella in mid-Kongsfjorden seen when looking out to sea with the landmark Kapp Mitra to the right where the rocks are Caledonian metamorphosed basement of pre-Vendian rocks. This is a late summer scene in an outer fjord. Snow on land and floating ice have gone. Weather generally deteriorates at this time so this is unusually a calm evening scene. Eider duck are flying and on the water. Photo P. W. Webb, CSE 1989.
Chapter 1
Svalbard

W. BRIAN HARLAND

1.1 Geographical names, 3
1.1.1 Principal islands and fjords, 3
1.1.2 The lands, 7
1.1.3 Norwegian place names, 7
1.2 Topography and bathymetry, 7
1.3 The physical environment, 8
1.3.1 Latitude and daylight, 8
1.3.2 Marine influences, 8
1.3.3 Weather, 8
1.3.4 Sea ice, 8
1.3.5 Snow and ice cover, 10
1.3.6 Frozen ground, 10
1.4 The biota, 10
1.5 Political history, 11
1.6 The Spitsbergen Treaty, 11
1.6.1 Administrative consequences of the Treaty, 11
1.6.2 Strategic consequences of the Treaty, 11
1.6.3 Economic/political consequences of the Treaty, 11
1.6.4 Environmental consequences of the Treaty, 12
1.7 Settlements, 13
1.7.1 Longyearbyen, 13
1.7.2 Sveagruva, 13
1.7.3 Ny-Ålesund, 13
1.7.4 Barentsburg, 13
1.7.5 Pyramiden, 13
1.7.6 Other settlements, 13
1.7.7 Manned Norwegian radio and meteorological stations, 13
1.8 Official publications, 13
1.8.1 Bathymetric charts, 14
1.8.2 Topographic maps, 14
1.8.3 Geological maps, 15
1.8.4 Thematic maps, 15
1.8.5 Scientific serials of the Norsk Polarinstitutt, 15

An introduction to Svalbard is as necessary for a geoscientist as for any other student of the archipelago. The section on geographical nomenclature is illustrated by maps which are designed to locate many of the commonly used names. These and others are listed at the end of the volume where additional names used later are referred to. The regional context of Svalbard is shown in Fig. 1.1.

The present-day physical environment is mentioned, but treated more fully in Chapters 21 and 22.

Fig. 1.1. Regional geographical setting of Svalbard, with typical maximum and minimum limits of pack ice. Simplified and redrawn from Harland (in press) Norway. Svalbard in Encyclopedia of World Regional Geology, fig. 1.

The section on the present-day Svalbard biota is not by a specialist for specialists, but is intended to list those organisms commonly encountered in the field and of interest to most workers.

The political and treaty considerations are interwoven and have sometimes left the Norwegian administration in an ambivalent position. Happily however the resources forthcoming from the petroleum industry to the nation has enabled the administration to fulfil its responsibility admirably and latterly without the pressures from the Cold War.

Svalbard for its size has a small population, less than 4000 concentrated in relatively few settlements, but numbers are augmented by summer arrivals of construction/maintenance staff, tourists, students and scientists, while the residents often take their summer holidays on the mainland. The environmental threat from this expanding seasonal population presents one of the most serious challenges, while at the same time tourism is replacing coal mining as the principal economic resource. Provision of shipping facilities supplemented by air travel is transforming the economy, which however still requires substantial subsidy.

The international community has generated more than 3500 geoscientific publications of which about 2500 are listed in the references. The official publication series are outlined at the end of this chapter.

This work attempts to encompass the present geological nature of Svalbard and to interpret its history. It is mainly concerned with evidence from above sea level and this may be justified in part by some more recent interpretations of the Spitsbergen Treaty which claims for Svalbard not more than about 4 nautical miles offshore. The immense area of the submarine Barents Sea floor, the exploration of which resulted in enormous resources, is not treated here except for occasional mention. That would require another work on this scale and by another author. A recent convenient survey of what is known was provided by A. N. Nystad (1996) on the geology and petroleum resources of the Barents Sea; but as with so much knowledge obtained industrially, references to sources are not given. However this volume is mainly concerned with published information together with original thinking.

1.1 Geographical names

1.1.1 Principal islands and fjords

The archipelago, whose geology is the subject of this work, lies on the northwest corner of the Barents Shelf 650 km north of Norway.
Fig. 1.2. Principal islands and fjords of Svalbard.
The name Spitsbergen was given by the Dutch captain, Barents, who is generally credited with the modern discovery of the islands in 1596 and after whom the Barents Sea is named. Barents did not know that the name Svalbard (cool coast) was mentioned in the Islandskie Annaler in AD 1194 and in the Landnámabók (approximately AD 1230) from Viking exploration. It was supposed that this archipelago was the northern land referred to, although it was only much later that a clear distinction was made between Spitsbergen and Greenland. Also Russian hunters are claimed to have built huts in the fifteenth century and possibly earlier (Baron 1986). The name Spitsbergen refers to the pointed mountain peaks that the main island exhibits on approach from the sea. It had been used for the whole archipelago or for the main part of it excluding the outlying islands.

Spitsbergen was the name for the whole archipelago in the Treaty of Sevres in 1920, and in the Spitsbergen Treaty, which came into effect in 1925. The main island had been known as West Spitsbergen. The name Svalbard was formally introduced by A. K. Orvin in Place Names of Svalbard (1942), by the Norsk Polarinstitutt (the Norwegian Polar Institute in Oslo) in the first systematic and descriptive gazetteer. In Place Names of Svalbard Spitsbergen was redefined to comprise the main group of islands, excluding the outlying islands Storoya, Kong Karls Land, Hopen (Hope island) and Bjornoya (Bear Island). The nomenclature was revised again (Hjelle 1970) so that Spitsbergen now refers only to the main island and excludes Nordaustlandet (North East Land), Barentsaya, Edgeoya, and Prins Karls Forland (Fig. 1.2). Place Names was supplemented in 1958.

Until the Spitsbergen Treaty, which awarded the administration of the archipelago to Norway, the islands had been, in the words of Sir Martin Conway (1906), a ‘no man’s land’. There was no sovereignty and the principal competing nations first for whaling (1600 until the whale population was decimated around 1750) were Dutch and British; then for mineral rights American, British, Norwegian, Russian and Swedish. Scientific exploration went hand in hand with penetration beyond the coastline in a series of expeditions from Britain, (e.g. Scoresby 1820, Parry 1827), Norway (Keilhau 1831), Sweden (Torell 1859, Nordenskiöld 1863, Nathorst 1910), Monaco (1899) with increasingly international participation. Consequently most prominent features were named in various languages. Whereas systematization and Norwegianization of older place names led to a single standard for scientific and cartographic description, for geological use once a rock unit name has been established, its original name remains unchanged except for change of rank etc. For example, in the literature before 1940 a common name in English for a fjord in the northwest was Red Bay. This was Norwegianized to Raudfjorden in 1940 but the name Red Bay Conglomerate etc. still stands even if changed to Red Bay Formation or Group.

Place names of Svalbard (Anon 1942) is a mine of historical information as well as a systematic Norwegianization of place names, and some principal geographical suffixes from that work are listed below. In addition to names for physical features (islands, mountains, glaciers, fjords etc) the larger areas of Svalbard are divided into lands which are convenient for descriptive purposes (Fig.1.3).

Place names used in this work are listed at the end of the volume with figure numbers of some maps where they may be found.

It is generally a scientific convention (as in this work) to follow the official geographical nomenclature of the Norsk Polarinstitutt (Table 1.1). Geological nomenclature will, as far as possible, follow generally recognized international principles taking into account recommendations of the Stratigraphic Committee for Svalbard (SKS). Even when discussing early work present nomenclature is generally employed here.

Until about the middle of the nineteenth century there was little exploratory interest in the land. Indeed the prime concern was exploiting marine wealth. Fjords, anchorages and coastal hazards were the main concern. Thus the names of the principal accessible fjords were of great use in navigation. The Place Names of Svalbard recounts their early history. Therefore Fig. 1.2 also plots the present nomenclature of islands and coastal waterways.

**Fig. 1.3.** The ‘lands’ of Svalbard. The boundaries have not been defined and are indicated here without authority.

<table>
<thead>
<tr>
<th>Table 1.1. Geographical nomenclature for Svalbard</th>
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<tbody>
<tr>
<td>Present nomenclature</td>
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<tr>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Spitsbergen</strong></td>
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<tr>
<td><strong>Spitsbergen and associated islands</strong></td>
</tr>
<tr>
<td><strong>Nordaustlandet</strong></td>
</tr>
<tr>
<td><strong>Barentsaya</strong></td>
</tr>
<tr>
<td><strong>Edgeoya</strong></td>
</tr>
<tr>
<td><strong>Prins Karls Forland</strong></td>
</tr>
<tr>
<td><strong>Storoya</strong></td>
</tr>
<tr>
<td><strong>Kong Karls Land</strong></td>
</tr>
<tr>
<td><strong>Hopen</strong></td>
</tr>
<tr>
<td><strong>Bjornoya</strong></td>
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*Originally in many languages.
†Willem Barents, leader of Dutch expeditions 1594 to 1597.
§After Thomas Edge, early seventeenth century English whaler.
§§See by Barents and later named for Charles, Prince of Wales and later King of Britain and Ireland.
††Although discovered at least as early as 1617 by T. Edge this name was proposed by Petermann after Karl I (1823–91) King of Württemberg.
Fig. 1.4. Map showing the principal topographic features of Svalbard, approximate locations of mountains are indicated by triangles with elevation in metres. Ice-cover in white is demarcated by dotted lines.
1.1.2 The lands

The smaller islands need no further classification, but Spitsbergen and Nordaustlandet are now divided into lands for general descriptive purposes. These are not political units and have no precisely defined boundaries. Some names are as old as the island names in use and in many forms before the separate islands were distinguished as, for example, Ny Friesland. Other areas have been designated to complete the modern mosaic with the names of the Norwegian royalty, as for example Olav V Land which was introduced after the publication of *Place Names of Svalbard* as in Fig. 1.3.

The boundaries shown on Fig. 1.3 are diagrammatic and have no authority. In this work Ny Friesland will continue to describe the area which includes much of Olav V Land. Indeed for geological description Svalbard is classified in this work into sectors that are the descriptive Chapters 4 to 11 and also into terranes. These divisions are peculiar to this work. They are explained in Chapter 3.

1.1.3 Norwegian place names

Since 1942, with the publication of *Place Names of Svalbard*, all official names have been Norwegianized: descriptive names being translated; proper names being preserved and usually each is combined with a geographical term. The last one or two letters of the term indicate the definite article, which in Norwegian syntax may be omitted, but in international and especially geological application the name should be indivisible. The plural form may modify the suffix. The common terms used as suffixes in place names are listed here.

Mountains and hills, etc.: berget, fjellet, haugen, kammen, kollen, nuten, piggen, ryggen, tinden, toppen.

Valleys, passes: dalen, passet.

Plains etc.: sletta, vidda, oyra, flya, steinen (stone).

Glacial: corrie, glacier, icefield: botnen, breen, fonna, jekulen, morene.

Rivers and streams: elva bekken.

Lakes, tarns: vatnet, laguna, tjorna, tjernet.

Coastal inlets: hamna, pollen, bukta, vftgen.

Coastal promontories: halvoya, huken, neset, odden, pytten, tangen, kapp.

Shore: stranda.

Water: sjoen (sea or lake), fjorden, sundet, flatet (sea bottom).

Submarine features: banken, renna, flaket.

Shoal, reef and skerry: grunnen, revet, skja~ret.

Islet, island: holmen, oya.

Settlement, mine, hut, cabin: byen, gruva, hytta, varden (landmark or cairn).

Similarly the Norwegian geographical terms for north, northern etc. may constitute the first element in the place name thus: aust, austre; nord, nordre; sor, sare; vest, vestre.

There remain a number of (descriptive) names which stand on their own e.g. Lykta, Eplet, Krokodillen. Happily these are often brief. The geological use of place names is discussed in Chapter 3.

In maps and diagrams where space may be critical, contractions and abbreviations of the suffix are useful as -fit for -fjellet, -fja for -fjella, -dn- for fjorden, -bn for -breen.

1.2 Topography and bathymetry

The northwestern margin of the European continental lithosphere comprises the Barents Shelf (Fig. 1.5). Extending northwards from Norway and northwestern Russia, the shelf is covered by the Barents sea except at the northwestern margin where the Svalbard archipelago, and further east Franz Josef Land emerge.

The northern margin of the shelf is marked by the continental slope down to the Polar Ocean Basin. The western margin of the shelf similarly terminates along the oceanic Norwegian Greenland Sea.

Within the Barents Sea water depths rarely exceed 400 m. In the ocean basins they plunge rapidly from 500 m to 2000 m. On the shelf the bathymetry reflects Neogene and Quaternary history with a subdued drainage pattern.

The topography of Svalbard, while reflecting the detailed geological structure which determines many contrasting land forms, shows certain general features.

Sea-level changes have eroded and then exposed large tracts of nearly flat land or raised beach. A typical coastline consists of low cliffs seldom exceeding 10 m and a coastal plain (strandflat) of variable width behind which steep mountains rise.
The mountain peaks all fall within a general summit envelope representing an uplifted and warped peneplain almost regardless of the attitude of the strata, typically about 1000 m.

Land sculpture is a continuation of glacial erosion resulting in steep cliffs, valleys and glaciers. Other mountain contours typically result from a cold-desert environment with steep scree slopes and cliffs, where the rocks are resistant, giving little opportunity for vegetation to become established. Soft rocks give a more subdued landscape. The variety of land forms is typical of the Arctic as illustrated by Thorén (1969).

### 1.3 The physical environment

#### 1.3.1 Latitude and daylight

The main islands lie between 76° and 81°N. Many distinctive features of this Arctic environment derive from the angle of incidence of solar radiation (Table 1.2; Kosak 1967 p. 99).

#### 1.3.2 Marine influences

Svalbard is a relatively small archipelago and the climate is influenced by two sources of surface ocean water: (i) the West Spitsbergen Current, is the northern-most remnant of the Gulf Stream moving relatively warm water northwards along the west coast; (ii) the East Spitsbergen Current brings cold water and pack-ice southwestwards east of Spitsbergen and the eastern islands. These currents meet off Sorkapp and the cold water is deflected and continues northwards between the warmer current and the coast.

On the western approaches the upper Atlantic layer of approximately 200 – 900 m in depth has a fairly uniform temperature of about 3°C whereas the bottom layer may be about -1.0°C. The tides range between about 2 m for spring and 1 m for neap except where restricted by land.

#### 1.3.3 Weather

Annual precipitation is low. In the east it is almost all snow and may be as low as 10 mm per year. On the west coast the average precipitation is about 300 – 400 mm (with a maximum of about 1000 mm), most of which falls as fine snow or rain in summer and autumn. In summer the low humidity, cold land and warm air interact, often causing dense fog and low cloud over the glaciers and ice filled waters. In winter it is usually clear. The summer air temperature at sea level averages about 4 – 5°C and in winter about -12°C and commonly down to -20°C in the west. Temperatures are lower towards the north and east. Summer temperature may rise to 10°C, the extreme range may be - 50°C to + 22°C. There is usually some wind, which may be strong locally, especially in long fjords with direct access from inland ice. Mirages, haze, ice blink and white-out are all common.

#### 1.3.4 Sea ice

There is an inexhaustible supply of pack ice (often some years old) drifting from the polar basin with the East Spitsbergen Current. It depends for its subsequent distribution mainly on the marine currents but often and unpredictably on winds. It melts slowly in the warmer waters. The old, thicker, harder ice is a more serious factor in shipping especially when it drifts round the south of Spitsbergen and then northward along the west coast.

On the other hand the annual freezing and thawing in the fjords provides a bay ice (never exceeding a metre in thickness) that melts rapidly, becoming rotten in early summer.

A third floating hazard are the icebergs that come from calving glaciers. Larger bergs occur in many fjords and beyond, including some with direct access from inland glaciers.

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**Table 1.2. Arctic summers and winters in Svalbard**

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Number of days of continuous daylight</th>
<th>Darkness</th>
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<tbody>
<tr>
<td>80°</td>
<td>137</td>
<td>123</td>
</tr>
<tr>
<td>79°</td>
<td>107</td>
<td>94</td>
</tr>
<tr>
<td>70°</td>
<td>70</td>
<td>55</td>
</tr>
<tr>
<td>66.5°</td>
<td>23</td>
<td>0</td>
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</table>

**Fig. 1.6.** Prevailing surface currents of the Barents Sea and North Atlantic areas, abstracted from V. Hisdal (1985, fig. 12, p. 21) *Geography of Svalbard.*
long after the bay ice has melted. There is an increased supply of bergs from calving in the summer when glacier cliffs are undercut by warmer water. Their distribution is then a product mainly of tides rather than winds at least for the larger and deeper bergs. Figure 1.1 plots the extreme limits of pack ice in summer and winter (see Lunde 1965).

1.3.5 Snow and ice cover

In winter thin snow cover is general with bare patches and thick drifts. This melts throughout the summer leaving bare ice covering about 60% of the whole area above sea level. The larger islands all have ice caps from which glaciers flow, many reaching the sea (Fig. 1.7). The larger icefields are true ice caps, as in Nordaustlandet; the smaller are of 'highland ice' in which the subglacial topography is reflected in the surface contours of the ice. Most mountains also contain independent valley and corrie glaciers.

1.3.6 Frozen ground

Permafrost is defined as permanently or, more accurately, perennially frozen ground. The term is used in different senses. It is most usefully taken to mean that where seasonal melting at the surface occurs a distinctive active zone is separated from the permafrost by the permafrost table. Two terms, not in common use and of Russian origin, may be noted. Pereltek is a mass of anomalous frozen ground within the active zone, and talhte is a mass of anomalous unfrozen ground within the permafrost.

The formation, temperature, and depth of permafrost are the result of a complex interplay between the microclimatological conditions, the surface cover and the rock beneath, as are the movements that take place within the active zone to form many distinctive types of patterned ground (soil polygons). The sum of all these effects through many years yield a temperature curve with depth from which paleotemperatures may be inferred (section 21.8.4).

Permafrost does not occur beneath large bodies of water or ice, so that the underside of frozen ground reflects all the above circumstances in a complex manner. In Spitsbergen it is said to have an average depth of 300 m and on Bjornoya only 60 m.

Any disturbance of the equilibrium may lead to local phenomena such as pingos, and to frost heaving of man-made structures if adequate precautions have not been taken.

1.4 The biota

Flora and fauna reflect the above physical conditions. The land-based biota is fragile. About 160 species of flowering plants and a few other species occupy low ground and flourish as the snow cover recedes in the short summer, often with spectacular flowers. Grasses may exceed the 15 cm height of dwarf birch and willow. Vegetation directly supports a variety of insects, reindeer and ptarmigan and indirectly the arctic fox. Summerhayes & Elton (1928) made an early study.

The marine biota is perhaps the more remarkable. In winter, marine life continues, evident at the surface only by seal, walrus and the predatory polar bear; females hibernate in the snow. Bears number around 5000. With melting of the bay ice in summer, upwelling currents rich in nutrients coupled with continuous day-light generate a prodigious marine food chain exploited by many millions of migrant birds as well as by seal and bear. The birds nest on land and fertilize rich vegetation locally. Ptarmigan overwinter, and occasionally snow bunting and sand piper. The land mammals belong only to three species, fox, reindeer and the polar bear which lives largely off sea ice; voles are recorded at Grumantbyen.

A selective list of the more evident Svalbard species follows. Plants, birds, reindeer and bear are protected.

### The contemporary (evident) biota (typically visible)

#### Vertebrates

**Mammals**
- Arctic fox, Alopex lagopus
- Reindeer, Rangifer tarandus platyrhynchus
  - (Musk ox, Ovibos moschatus, recently extinct in Svalbard)
- Polar bear, Ursus maritimus
- Seals: hooded, Crystophora cristata; harp, Phoca groenlandica;
  - ringed, Phoca hispida; bearded, Erignathus barbatus
- Walrus, Odobenus rosmarus
- Whales: sperm, Physeter catodon; killer, Orcinus orca; blue,
  - Balaenoptera musculus; white (beluga) Delphinapterus leucas;
  - narwhal, Monodon monoceros; minke, Balaena acutorostrata

**Birds**
- Diver: red-throated, Gavia stellata
- Petrel: fulmar, Fulmarus glacialis
- Geese: barnacle, Branta leucopsis; pink-footed, Anser brachyrhynchus;
  - brent, Branta bernicla
- Ducks: eider, Somateria mollissima; king eider, S. spectabilis
- Waders: purple sandpiper, Calidris alpina; ringed-plover, Charadrius hiaticula; turnstone, Arenaria interpres; sandpiper, Calidris alba; grey phalarope, Phalaropus fulicarius
- Passerine: snow bunting, Plectrophenax nivalis
- Skuas: arctic, Stercorarius parasiticus; long-tailed, S. longicaudus;
  - great, S. skua
- Gulls: kittiwake, Rissa tridactyla; glaucous, Larus hyperboreus;
  - great black-back, L. marinus; Sabine's, L. sabini; ivory, Pagophila eburnea
- Terr: arctic, Sterna paradisaea
- Auks: puffin, Fratercula arctica; little, Plautus alle; black guillemot,
  - Cepphus grylle; Brünnich's guillemot, Uria lomvia; common guillemot, Uria aalge
- Svalbard ptarmigan, Lagopus mutus hyperboreus

**Fish**
- Arctic char, Salvelinus alpinus
- Bullhead, Cottus gobio
- Capelin, Mallotus villosus
- Cod, Gadus morrhua
- Halibut, Reindhardtius hippoglossoides
- Shark: Greenland, Somniosus; basking, Cetorhinus maximus

**Echinoderms**
- Echinoids, Stronglocentrotus cf. droebachiensis

**Asteroids**
- Ophiuroids

**Crinoids**

### Arthropods

**Crustaceans**
- Barnacles, Balanus balanoides
- Crabs and crayfish
- Ostracodes

**Arachnoids**
- Spiders and mites

**Myriapods**

**Insects**
- Spingtails
- Flies: mosquito; chironomid midges; dragonfly; damselfly; hoverfly; dipterids
- Beetles

**Annelids (oligochaets)**

**Nematodes**

**Molluscs**

**Bivalves**
- Astarte borealis; A. montagui; A. elliptica; Thysina flexuosa; Chiono- cardium ciliatum; Serripes groenlandicus; Macoma calcarea;
- Lysosoma fluviatilis; Saxicava arctica; Mya truncata
### 1.5 Political history

In the middle ages, Norwegian kings claimed sovereignty over all land in the Arctic Ocean from Greenland to the Russian arctic islands. In the sixteenth century Spitsbergen became a whaling centre with ships from Holland, England, Denmark–Norway, France and Hamburg. The Dutch settlement, Smeerenburg, on Amsterdamøya was the largest, with peak populations estimated at 200 (or even 1200) persons in the summer. The Greenland whale (Balaena mysticetus) was nearly exterminated in the fjords by 1640 and whalers had to make their catch in the open sea. Of the many claims in the early seventeenth century King Christian IV of Denmark–Norway claimed sovereignty over Spitsbergen, in opposition to the British and Dutch. The Basques of SW France specialised in exploiting the Northcap whale (Balaena glacialis) and in eighteenth century land-based whaling declined with the beginning of the twentieth century (Gjelsvik 1968).

Norwegians began sealing in Spitsbergen waters in the latter part of the eighteenth century and wintered to hunt polar bear, reindeer, fox and seal. Norwegians and whalers had to make their catch in the open sea until about 1800 when systematic whaling was finished.

From about 1715 to 1850 Russian ‘pomors’ went to Spitsbergen and wintered to hunt polar bear, reindeer, fox and seal. Norwegians began sealing in Spitsbergen waters in the latter part of the eighteenth century and after c. 1850 without competition. The exploitation of coal began at the close of the 19th and beginning of the twentieth century (Gjelsvik 1968).

Early claims to the sovereignty of Spitsbergen by Britain, Holland and Denmark were never followed up. However, competition for mineral wealth continued by many individuals and companies and the map of Spitsbergen was a patchwork of, often optimistic, claims. At the same time scientific exploration by British, French, German, Norwegian and Swedish bodies had heightened the interest in the sovereignty of the archipelago. Arlov (1994) described early negotiations between the Arctic nations in Oslo Conferences 1910 to 1914.

The Versailles Treaty makers set about clarifying competing national aspirations when they were arranging protectorates for former colonies. The result for Svalbard was the **Spitsbergen Treaty**.

The history of exploitation in and around Svalbard is outlined more fully in the handbook by Arlov (1989, 1994) and in detail by Hoel (1966).

### 1.6 The Spitsbergen Treaty

The Spitsbergen Treaty was signed in Paris on 9 February 1920 and Norway assumed administrative responsibility on 14 August 1925. The original signatories were Australia, Britain, Canada, Denmark, France, India, Italy, Japan, Netherlands, New Zealand, Norway, South Africa, Sweden and USA. Other nations followed. E.g. USSR 1924, Germany 1925 later totalling more than 40 signatories. The treaty provides that citizens of these other nations shall enjoy the same rights as Norwegian citizens and as the Norwegian government with respect to access and economic activities on the islands and in the territorial waters. The 10 articles are indicated as follows:

1. **defines by latitude and longitude, the boundaries of the archipelago, i.e. 74° to 81°N and 10° to 35°E;**
2. **provides equal fishing and hunting rights;**
3. **guarantees free access to all waters and to all lands to all signatories;**
4. **concerns the use of radio;**
5. **concerns meteorological stations;**
6. **recognises pre-Treaty rights of ownership and exploration;**
7. **guarantees equal treatment of all signatories in future acquisition of land and mineral rights;**
8. **outlines Norwegian intentions with regard to existing mining rights;**
9. **guarantees the neutrality of Svalbard;**
10. **provides for Russia, then without government, to enjoy the same rights as other signatories.**

Procedures for establishing existing claims were laid down under the jurisdiction of a commission to be nominated by the Danish Government (Sindballe 1927). Many other consequences followed from the Spitsbergen Treaty: administrative, strategic, economic/political and environmental.

### 1.6.1 Administrative consequences of the Treaty

Longyearbyen is the seat of the local administration where the Governor (Sysselmannen) has office and residence supported by police, now mainly helicopter borne.

The mining inspector (bergmesteren) is responsible not only for mining operations but also for granting and refusing claim applications and for inspection of claims.

The Norsk Polarinstitutt, under the Ministry of the Environment, is responsible for the geological survey of the island and is the Norwegian scientific (including geoscientific) arm mainly concerned with the islands. Its former responsibility for topographic and bathymetric survey has been taken over by the Norwegian Mapping Authority (Statens Kartverk).

Appropriate ministries oversee other aspects of the administration such as postal services, radio communications, meteorological stations, building standards and conservation.

### 1.6.2 Strategic consequences of the Treaty

The strategic situation of Spitsbergen, so evident during the war years 1939 to 1945, and then subsequently in the Cold War between the Warsaw Pact and NATO has been neutralized (Article 9) so that no military establishments nor activities have been permitted.
This was monitored by the Norwegian administration and from the Soviet settlements. The exception in World War II was mainly directed to the destruction and denial of facilities to the other side and to placing meteorological stations (Elbo 1952).

### 1.6.3 Economic/political consequences of the Treaty

The Treaty did not foresee the complications of the off-shore exploration and exploitation of petroleum—it being largely concerned with mineral rights on land. Mineral claims on land were easily regulated by the mining inspector (Bergmesteren) agreeing approximately rectangular parcels each of 10 km² area, not exceeding about 8 km in length and needing each to be staked, witnessed and claimed with specimens of a mineral to substantiate the claim. In effect this limits the seaward extension of any claim to within 4 nautical miles from a stake at the coastline.

At that time, Norwegian maps showed the treaty area delineated by the bounding lines of latitude and longitude (e.g. 1:2M NP map of Svalbard 1958). This area was accepted by USSR maps which thus claimed a sector boundary from the Norway-USSR frontier north along the line of longitude. It was shown to step eastwards between latitudes 74°N and 81°N to accommodate the Treaty area.

Subsequently with the advent of subsea petroleum exploration and extended fishing claims far beyond the original 3 mile territorial waters it seemed that the Barents sea (i.e. on the continental shelf) was Norwegian or Soviet. Differences then emerged. On the one hand Norway claimed a boundary to their part of the shelf based on the equidistant mid-line principle as applied elsewhere in offshore Europe. The USSR followed their meridional sector principle. This created a large disputed zone between the mid-line of the Norwegian government and the sector line of the former Soviet Union.

On the other hand the extension of Norwegian continental shelf was held in Norway to override the earlier Treaty area so that the seas 4 miles offshore of the islands within the original latitude, longitude frame were regarded by Norway as outside Treaty jurisdiction. Norwegian maps no longer show this Treaty frame. All these matters have still to be finally resolved, while in the meantime a cooperative spirit in practical economic developments is taking place between Norway and Russia. Figure 1.8 illustrates the political problem accentuated by the economic consequences.

The eastern margin of the Svalbard Treaty coordinate area (Long 35°E) passes midway between Kvitoya (Svalbard) and Victoria Island (Russia) so that applying the preferred Russian sector principle the sector line running due north from the Norwegian–Russian international boundary on the mainland must be deflected eastwards, as in most Russian maps, to accommodate the Treaty coordinate area. This boundary favours Russia whereas the line median between the national coasts (as applied in the North Sea) passes in a NE direction before joining the same line between the two islands. On the other hand if Svalbard be defined as the archipelago limited to 4 nautical miles offshore, and if the continental shelf, to say the 500 m isobath or 200 miles offshore, be applied most of the sea area in the archipelago would be Norwegian as is currently assumed.

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**Fig. 1.8.** Diagrammatic map to show boundaries of possible political interest.

**Fig. 1.9.** Map showing environmentally protected areas of Svalbard. Redrawn from leaflet issued at Longyearbyen Airport and published by Norsk Polarinstitutt.
1.6.4 Environmental consequences of the Treaty

Another unforeseen consequence of the Treaty that allows virtually free access by the world’s citizens without passport control has been the arrival of many nationalities in unprecedented numbers by cruise liners supplemented by the airport opened in 1975. The pressure on a fragile environment led to the establishing of national parks, bird sanctuaries and other environmental regulations. Thus while there is theoretical freedom of access this can only be permitted within the various necessary regulations and also within the limitations of very few tourist facilities except by sea. Figure 1.9 shows the national parks and nature reserves of Svalbard.

Three national parks and three nature reserves, fifteen bird sanctuaries and three plant reserves have been established in Svalbard (see map). No waste may be emptied or left behind in any of the protected areas. The flora and fauna must be protected against injury and unnecessary disturbance.

The use of cross-country vehicles is prohibited in the national parks and reserves. Nor are aircraft permitted to land in these areas without the permission of the Governor.

From 15 May–15 August it is not permitted to travel within a distance of 300 meters from the edge of the bird sanctuaries. In the Moffen National Reserve all traffic is forbidden from 15 May to 15 September, both dates inclusive. The ban also includes flying over the reserve at a height of less than 500 meters. All travel on Svalbard must take place in a manner that does not damage or unnecessarily disturb the natural environment. Special care should be exercised in the vicinity of lairs, breeding grounds and nesting sites. The use of motor vehicles is forbidden on thawed ground, and on ground covered by vegetation.

There are special regulations for economic or industrial activity on Svalbard. These regulations are printed in the ‘Regulations concerning Conservation of the Natural Environment in Svalbard’, adopted by Royal Decree of 16 December 1983.

1.7 Settlements

There is no indigenous population. The principal settlements are based on Norwegian and Russian coal mines with a total population of about 3300 winter inhabitants. There is a large exchange in the summer.

1.7.1 Longyearbyen

This is the seat of government of Svalbard and is situated at the head of Adventfjorden south of middle Isfjorden. The coal mine was founded by the American, J. M. Longyear, in 1904 and was worked till 1916. It was then sold to the Store Norske Spitsbergen Kulkompani A/S (SNSK). The earlier mines were in the mountain sides in Longyeardalen and Adventfjorden. Coal is mined throughout the winter and stored at Hotellneset for summer shipping when mining ceases giving place to maintenance work. Output has been about half a million tons or less pa. Good facilities for mining personnel have been developed with school, hospital and modern city services. The services are mostly company property. However, the company is increasingly providing for tourists, expeditions and shipping on a commercial basis. The Longyearbyen airport (opened 1975) with scheduled flights to Norway is situated at Hotellneset and there is a good internal road system. Longyearbyen is the principal base in Svalbard for the Norsk Polarinstitutt.

The coal reserves, easily accessible from Longyearbyen are being rapidly exhausted – the seams being high up in a series of mountains. At the same time Longyearbyen has been developed with an infrastructure, comparable to the best in Norway for a winter population of around 1200 including families. Whereas Sveagruva has coal reserves the investment in infrastructure in Longyearbyen could hardly be duplicated at Svea. The gantry ropeway system long used for transporting coal from mine to loading dock has been replaced by road transport. The University in Svalbard (UNIS) was established in 1995 for one-year courses in Arctic disciplines (biology, geology, geophysics and technology).

1.7.2 Sveagruva

Located at Braganzavågen at the head of van Mijenfjorden (in Bellsund) was mined for coal by a Swedish company from 1917 to 1925 when it was sold to SNSK. No mining was done for some years. The installations were destroyed in the war. Mining was resumed but abandoned in 1949 and extensive development (as a satellite mine for Longyearbyen) was planned in the late 1970s. Sveagruva is now the site of the main economic coal mining prospect in Svalbard with accessible reserves estimated at 25 million tonnes and contains one remarkable 5 m thick seam.

1.7.3 Ny-Ålesund

Located on the south side of Kongsfjorden, coal was first mined by the Kings Bay Kulkompani A/S (KBKC) in 1917 until 1929 and resumed in 1947. Fifteen men were lost in an accident in 1948, but work continued. In 1960 modernization and extension of the mine was planned but was terminated on 5 November 1962 after an accident in which a whole shift of 21 men were lost. The small town (never more than 300 inhabitants) was then reduced to a small (international) scientific station with a Norsk Polarinstitutt research centre. It has a winter population of 20–30, greatly expanded in the summer by 200 or more visiting scientists and participants in conferences, courses etc.

1.7.4 Barentsburg

Located on the western side of Gronfjorden south of the entrance to Isfjorden, is the principal Russian settlement based on a coal mine. It was founded in 1919 by De Russiske Kulfelter. Extensive building was carried out by a Dutch company between 1921 and 1926 who sold it to the Soviet organization Arktikugol in 1932. In the 1930s the settlement was the largest in Spitsbergen. It was destroyed in the Second World War. As the Russian 'Capital' with consul, scientific offices etc. it recently had a population of more than 1000, now 950. Its original reserves have been exploited and mining is extending, by arrangement, into the neighbouring Norwegian claim area. Its economic viability is in question.

1.7.5 Pyramiden

Located at the head of Billefjorden (from northern Isfjorden) was originally a Swedish concession and has been owned by Arktikugol since 1934 (1926?). Construction work began in 1938. The population of about 650 is largely Ukrainian.

1.7.6 Older settlements

Earlier settlements based on coal mines and now discontinued include Grumantbyen (FSU, west of Adventfjorden), Mushkamma (Norwegian) east of Adventfjorden, Tunheim (Norwegian) on the northeast coast of Bjørnøya.

1.7.7 Manned Norwegian radio and meteorological stations

These include the principal station for shipping at Kapp Linné, at the mouth of Isfjorden, operated from Longyearbyen; also
at Nordhamna on the north coast of Bjørnøya, and at Hopen. Telecommunication from all Norwegian settlements is integrated into the Norwegian system.

1.8 Official publications

Scientific literature on such a small remote area as Svalbard has multiplied not only because of its inherent interest but by virtue of the participation of groups from many nations. A selected bibliography of geoscientific publications appears in part 4 of this volume. Here the range of official publications is outlined.

1.8.1 Bathymetric charts

As is customary, charts are under frequent revision while detailed surveys proceed to more remote areas. 12 charts are issued by the N. P (Fig. 1.10). Most other charts are derived from this information. Hydrographic survey is now the responsibility of Statens Kartverk.

1.8.2 Topographic maps

Topographic maps of Svalbard, published by the Norsk Polarinstitutt (NP) are published on the following scales 1:2 000 000, 1:1 000 000 in single sheets; 1:500 000 in four sheets, and 1:100 000 in single sheets. A1 to A12, B1 to B12, C1 to C12, D1 to D12, E1 to E12, F1 to F12, and G1 to G12 are issued.

Fig. 1.10. Sheet lines of charts as originally published by Norsk Polarinstitutt, from catalogue.

Fig. 1.11. Sheet lines of maps (topographical and geological) in both 1:100 000 series and 1:500 000 series, published by the Norsk Polarinstitutt and redrawn from sales catalogue.
planned for 60 sheets (Fig. 1.11). 1:50,000 are available as working
deline prints, with and without place names, and as official maps of
various claims and 1:25,000 map of Bjørnøya. There are also some
local maps of settlements, mines etc.

Map projections are as follows: The 1:1,000,000 is a conical
projection, whereas all other larger scale maps are based on the
transverse Mercator projection which is conveniently fitted to the
rectangular grid on which the surveys have been based. The grid
(essentially the same as used by the British Ordnance Survey) is
defined as follows:

axis of projection meridian 15°E
origin of eastings 100 km west of axis
origin of northings 8500 km north of equator
Earth’s semi-diameters 6378 388 m and 6356 912 m.

The origin is therefore false, the point 100000 having the posi-
tion 15°E 76° 32.89’N. The 1:50,000 map shows 100 squares, but
not as above in order to conform to the international UTM series
of maps.

1.8.3 Geological maps

These follow the scales, sheet lines and names of the topographic
maps (see Fig. 1.11). At scales of 1:50,000, 1:100,000 and 1:1,000,000.
The principal series is published to the scale of 1:100,000 (Fig. 1.11).
It is planned for sheets to have companion outline texts. In due
course these will provide a systematic description of Svalbard
geology. In recent years the compilation of these maps and texts
from various surveys has been the principal work of the geologists
of the Norsk Polarinstutt, often with international collaboration.

1.8.4 Thematic maps

These are also available (on a variety of scales), especially
groundmorphological. A single sheet 1:400,000 map of mineral claim
rectangles is available.

1.8.5 Scientific serials of the Norsk Polarinstutt

After a number of changes of title the principal multidisciplin-
ary serial is Skrifter of the Norsk Polarinstutt for mono-
graphs published irregularly. Polar Research is for shorter
scientific contributions, and the Ark which continues for
internal reports etc. in Norwegian. Skrifter and Polar Research
are in English. Meddelelser is of more popular or general nature
and has reprinted some work published elsewhere, e.g. translated
from Russian.

The Polarhænbdiker series of small volumes are recommended
as introductory companions to this volume: No. 2 (V. Hisdal, 1985,
2nd Ed., Geography of Svalbard); No. 4 (T. B. Arlov 1994,
A Short History of Svalbard); and No. 7 (A. Hjelle, 1993. Geology of
Svalbard), is especially well illustrated with colour photographs and
maps. For further superb colour photographs and a further general
account see Worsley in Aga et al. (1986), which geological history
of Svalbard published by Statoil is a useful introductory supple-
ment to this work.

The Norsk Polarinstutt (NP in this volume) has its head-
quartet and research facilities currently at Middelthunsgate 29,
Postboks 5072, Majorstua, 0301 Oslo with an office in Long-
yearbyen. From 1997 the institute will move to a somewhat larger
organization in Tromsø.