DET NORSKE VIDENSKAPS-AKADEMI I OSLO

RESULTATER

AV DE NORSKE STATSUNDERSTØTTEDE SPITSBERGENEKSPEDITIONER

BIND I

Nr. 6

ADOLF HOEL:

THE COAL DEPOSITS AND COAL MINING OF SVALBARD (SPITSBERGEN AND BEAR ISLAND)

UTGITT PÅ
DEN NORSKE STATS BEKOSTNING
VED SPITSBERGENKOMITEEN

REDAKTØR: ADOLF HOEL

OSLO
I KOMMISSION HOS JACOB DYBWAD
1925

DET NORSKE VIDENSKAPS-AKADEMI I OSLO

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AV DE NORSKE STATSUNDERSTØTTEDE SPITSBERGENEKSPEDITIONER

(SKRIFTER OM SVALBARD OG ISHAVET)

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1929

A. W. BRØGGERS BOKTRYKKERI A/S

INTRODUCTION

BY

THE SPITSBERGEN COMMITTEE OF 1918

K. S. KLINGENBERG, JOHAN KIÆR,
CARL LUNDH

In 1920 an application was made to the Ministry of Church Affairs and Education by the following four Professors at Oslo University: W. C. BRØGGER, JOHAN KIÆR, V. M. GOLDSCHMIDT, and JAKOB SCHETELIG, concerning the publication of the results of the subsidised Spitsbergen Expeditions.

In the application a resumé was given of the material at hand, showing the desirability of its being worked out and published, and proposing that the "Spitsbergen Committee of 1918" should have at its disposal the means which might be granted towards the publication, and appoint an editor.

The Spitsbergen Committee was appointed by the Ministry of Church Affairs and Education on Dec. 5th 1918 as an expert advisory committee in the matters relating to Norwegian Spitsbergen Expeditions subsidised by the Government. As members of the Committee were appointed: Colonel N. J. SEJERSTED, Director of the Geographical Survey of Norway (President), Dr. JOHAN KIÆR, Professor of paleontology and historical geology at Oslo University, and CARL LUNDH, Barrister and President of the Board of Directors of "Store Norske Spitsbergen Kulkompani Aktieselskap". After Col. SEJERSTED's death in 1921 his successor as Director of the Geographical Survey of Norway, Major K. S. KLINGENBERG, was appointed member and president of the Committee.

The Ministry of Church Affairs and Education approved of the proposal and appointed the Spitsbergen Committee of 1918 to issue the publications. As editor of the publications the Committee accepted ADOLF HOEL, Docent at Oslo University, who, since 1907, had been connected with the Spitsbergen expeditions as scientist, and later as the leader of the expeditions.

The publication of the results of the expeditions is also due to his initiative.

The Norwegian Academy of Science in Oslo has given its consent to the publications appearing under its auspices.

The Spitsbergen Committee of 1918 has approved for publication all the papers submitted by the editor, which are as follows:

No. 1. HOEL, ADOLF, The Norwegian Svalbard Expeditions 1906—1926. A brief Review of the Expeditions.
„ 2. RAVN, J. P. J., On the Mollusca of the Tertiary of Spitsbergen.
„ 3. WERENSKIOLD, W. and IVAR OFTEDAL, A burning Coal Seam at Mt. Pyramide, Spitsbergen.
„ 4. WOLLEBÆK, ALF, The Spitsbergen Reindeer.
„ 5. LYNGE, BERNT, Lichens from Spitsbergen.
„ 6. HOEL, ADOLF, The Coal Deposits and Coal Mining of Svalbard (Spitsbergen and Bear Island).
„ 7. DAHL, KNUT, Contributions to the Biology of the Spitsbergen Char.
„ 8. HOLTEDAHL, OLAF, Notes on the Geology of Northwestern Spitsbergen.
„ 9. LYNGE, BERNT, Lichens from Bear Island (Bjørnøya).
„ 10. IVERSEN, THOR, Hopen (Hope Island), Svalbard.
„ 11. QUENSTEDT, WERNER, Mollusken aus den Redbay- und Greyhookschichten Spitzbergens.
„ 12. STENSIÖ, ERIK A:SON, The Downtonian and Devonian Vertebrates of Spitsbergen. Part I. Cephalaspidae. A. Text, and B. Plates.

The following publication grants have been made:

By the Storting	Kr.	32 000.00
„ „ Nansen Fund	„	2 000.00
„ „ State Research Fund	„	25 000.00
Further Accumulated interest	„	6 626.87
and by the sale of publications in the years 1925 and 1926	„	192.87
	Kr.	65 719.74

which sum has been used in its entirety.

The Committee herewith tenders its most grateful thanks to the Storting, the Board of Directors of the State Research Fund, and the Nansen Fund, for the courtesy with which they have received its applications for these grants.

The Committee also expresses its thanks to the above-mentioned explorers and scientists for the efficient way in which they have worked out and published the material collected by the expeditions, and to Docent HOEL, who has also undertaken the editorship of the publications.

When Norway assumed sovereignty over Svalbard, and its administration was vested in the Ministry of Trade, Shipping, Industry, and Fisheries, this department took direct charge of the publication of the

results of the subventioned expeditions. The Ministry of Trade has also taken over the administration of Svalbard.

The series of editions published by the Spitsbergen Committee are continued under the direction of "Norges Svalbard- og Ishavs-undersøkelser" under the general title of: "Skrifter om Svalbard og Ishavet" — "Papers on Svalbard and the Arctic Sea".

Spitsbergen Committee of 1918. Oslo, June 1929.

K. S. KLINGENBERG JOHAN KIÆR CARL LUNDH

Contents.

Note: From Nr. 12 the papers will not be collected into volumes, but only numbered consecutively.

No. 6.

THE COAL DEPOSITS AND COAL MINING OF SVALBARD (SPITSBERGEN AND BEAR ISLAND)

BY

ADOLF HOEL

WITH 8 PLATES, 16 TEXT FIGURES, AND 3 TABLES

Preface.

The present review of the coal deposits of Spitsbergen and Bear Island is based on information obtained from the following sources:

1. Published papers (see bibliography).
2. Data obtained from the coal companies operating in the islands and from Professor ERIK A:SON STENSIÖ, Stockholm.
3. Observations made during the scientific expeditions sent out by the Norwegian Government to Spitsbergen and Bear Island.

This paper was originally written for the First World Power Conference in London 1925, and has been published in part in the Transactions of this Conference.

Two of the sections of this paper has been written by special authors: Kings Bay Coal-Field by Mr. ANDERS K. ORVIN, and Bear Island by Messrs. ANDERS K. ORVIN and GUNNAR HORN. Dr. ing. JOHAN BRAASTAD, and Mr. SVERRE BLEKUM have also contributed to the present paper. All these contributors are mining engineers and are, or have been, members of the above-mentioned Norwegian expeditions to Svalbard.

I wish to extend my sincere thanks to all who have helped and advised me during the preparation of the paper, and to the Norwegian National Committee, World Power Conference, London 1924, for permission to publish it in "Resultater av de norske statsunderstøttede Spitsbergenekspeditioner".

The University, Oslo. *A. H.*
June, 1925.

Contents.

A. Introductory Remarks.

1. Situation, Subdivision, Area.

Spitsbergen, together with some adjoining islands and Bear Island — all collectively called Svalbard — form an archipelago situated between 74° and 81° N. Lat. and 10° and 35° Long. E. o. Gr. Spitsbergen proper includes 5 large islands and a number of smaller ones. The adjoining islands are White Island, Wyches Island or King Karls Land, and Hope Island. Bear Island lies outside this main group. The total area is about 65 000 square km. Spitsbergen and Norway lie on the same continental shelf, thus forming a geographical unit. The islands lie due north of Tromsø, the distance from Northern Norway being: 240 nautical miles to Bear Island, 360 nautical miles to South Cape on Spitsbergen, and 480 nautical miles to Ice Fjord.

2. Geography.

The west coast of Spitsbergen is indented by a number of large fjords with several good harbours. These fjords are mentioned below in order from south to north.

Horn Sound comes first, then Bell Sound with the branches Recherche Bay, Van Keulen Bay, and Van Mijen Bay or Lowe Sound with the innermost part called Braganza Bay. Then follows Ice Fjord, the largest fjord in Spitsbergen, with the following branches reckoned from the south side of the mouth of the fjord: Green Harbour, Coles Bay, Advent Bay, Sassen Bay, the innermost part of which is called Tempel Bay, Klaas Billen Bay, Dickson Bay, Ekman Bay, Tundra Bay, Ymer Bay, and Safe Harbour. Next is the Foreland Sound separating Prince Charles Foreland from the mainland. Further come Kings Bay, Cross Bay, and finally Magdalena Bay farthest north. On the north coast we have the following fjords reckoned from the west: Red Bay, Wood Bay, and Wijde Bay. The Hinlopen Strait separates North East Land from West Spitsbergen, and the Stor Fjord is a branch of the sea separating Barents Island and Edge Island from West Spitsbergen.

Spitsbergen is a mountainous country. Only at the coast do we meet with plains of any noteworthy extent. They form abrasion plains between the shore and the foot of the mountains. These are commonly

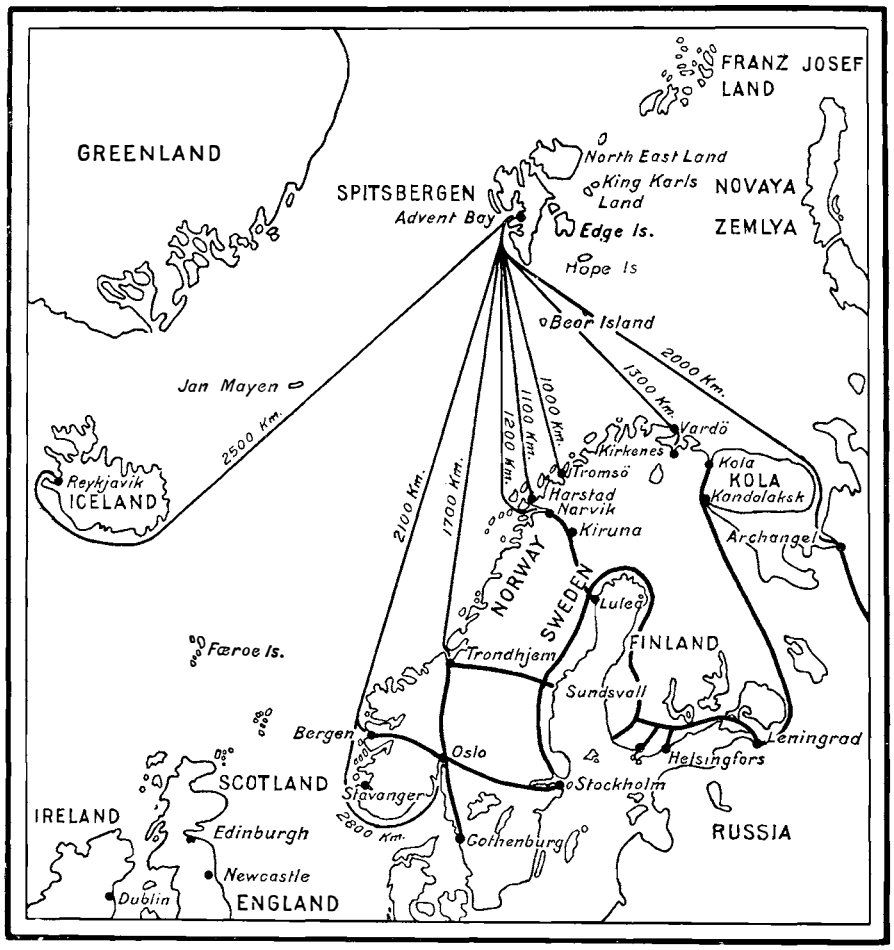


Fig. 1. Map showing the position of Spitsbergen and Bear Island in relation to the surrounding coal-consuming countries.

between 700 and 1200 metres high. The highest summit reaches an altitude of 1717 metres. Large parts of the country are covered by ice (v. section on geology p. 13).

The various mines and their locations are mentioned below (map p.16):

Sveagruvan, belonging to a Swedish company, lies at the mouth of Braganza Bay on the north side of the fjord. The mine and camp of the Dutch Company, called Barentsburg, are situated on the east side of Green Harbour, and those of the Anglo Russian Grumant Co., Grumant City, between Coles Bay and Advent Bay. On the west side of Advent Bay we have Longyear City, belonging to Store Norske Spitsbergen Kulkompani Aktieselskap, and Hiorthamn, belonging to A/S De Norske Kulfelter Spitsbergen, on the east side of the same bay. Finally, Ny-Ålesund, the seat of Kings Bay Kul Comp. A/S, is situated on the south side of Kings Bay.

Bear Island occupies an area of 178 square km.

The northernmost two-thirds of the island form a great plain reaching an altitude of 50 metres above sea level in its southern part. It is covered by hundreds of small lakes and ponds of which the most prominent are: Salmon Lake, Hauss Lake, and Ella Lake. South and south-east of the plain there are mountains. The south-eastern mountain area is called Mt. Misery, and it includes the highest summit in the island, 536 metres high. There are no glaciers on Bear Island, but perennial snow occurs. The island is lacking in harbours protected on all sides from storms. The best one is South Haven (Sørhamna), which is, however, open towards the south. The mining camp, Tunheim, is situated in the north-eastern part of the island. The coal is shipped from Østervåg, about one kilometre farther north.

3. Climate.

The climate of Spitsbergen is greatly influenced by two ocean currents: 1) A warm current, the Gulf Stream, running along the west and north coast, and causing ice-free waters to occur farther north (occasionally as far as 82° N. Lat.) than anywhere else on earth. 2) A cold current coming from the sea east of Spitsbergen, rounding South Cape, and continuing northward along the west coast between it and the Gulf Stream.

The summer with continuous daylight and the long dark winter are also important climatic factors, and have a considerable influence on the working conditions in Svalbard. (See table below).

	Light season Midnight sun			Dark season Sun continually below the horizon		
	First time	Last time	Duration	First time	Last time	Duration
Spitsbergen, Green Harbour 78° 2' N. Lat.	April 19	August 24	127 days	October 27	February 15	112 days
Bear Island 74° 30' N. Lat.	April 30	August 13	106 days	November 7	February 4	90 days

The annual mean temperature at Green Harbour [1] is ÷ 9,7° C. The coldest month is February with a mean temperature of ÷ 22,4° C, and July is the warmest month with a mean of + 4,3° C. The highest temperature observed is + 12,2° C and the lowest ÷ 49,2° C. The annual precipitation is comparatively low, 287 mm. The climate is very

[1] The following are averages for the years 1912—1918, v. BIRKELAND [2].

healthy, the air being practically free from germs outside the settlements.

The climate of Bear Island is of a more insular character than that of Spitsbergen. In the summer months there is much fog. The mean summer temperatures at Bear Island are about the same as those at Green Harbour. But the winter is much milder than in Spitsbergen. The coldest month is February, with a mean temperature of about ÷ 12° C. The thermometer seldom falls below ÷ 30°. The mean temperature of the year is about ÷ 4,3°.

4. Shipping Conditions.

I. Harbours.

On the west side of Spitsbergen the branches of the large fjords afford excellent harbours in a number of places. The outer coast, on the contrary, has very few harbours. In Bear Island there is only one fairly well protected harbour, South Haven. It is, however, exposed to southern winds.

II. Ice Conditions.

Two kinds of ice impede shipping from the fjords on the west coast of Spitsbergen.

In the first place, there is the ice covering the fjords during the winter and melting or breaking up in the spring. The large fjords do not freeze till January or February, and become open again in April—May; but in branch fjords like Advent Bay, Green Harbour, and Van Mijen Bay the ice sets in as early as October or November, and they do not become ice-free again till the end of June.

Then there is the pack-ice coming from the waters east and north-east of Spitsbergen, carried by the current that passes South Cape and continues northward along the west coast of Spitsbergen. It may extend as far north as the mouth of the Ice Fjord, rarely to Kings Bay, but it does occasionally reach the north coast. It comes at very irregular times, but most commonly in the spring from May to June. It forms a girdle along the west coast from 5 to 80 nautical miles wide. As a rule, it disappears about the end of June or the beginning of July, and there is then no ice during the remainder of the summer and autumn. It may also happen that this pack-ice seriously impedes shipping even in the middle of summer.

The westerly cold current from the sea east of Spitsbergen brings also ice to the sea around Bear Island. The ice conditions in these waters are subject to great variations. As a rule, there is no ice during the summer, autumn, and early winter. The ice is most frequently met

with in the months of February—May. In some years the ice may be troublesome even in the summer (June—September). On the other hand, there are years in which the island can be visited all the year round, and this has been the case for the last two years.

III. Shipping Season.

Experience gathered during the time active coal-trade has been carried on from Spitsbergen shows that the ordinary shipping season lasts about three months, beginning about the first of July and ending

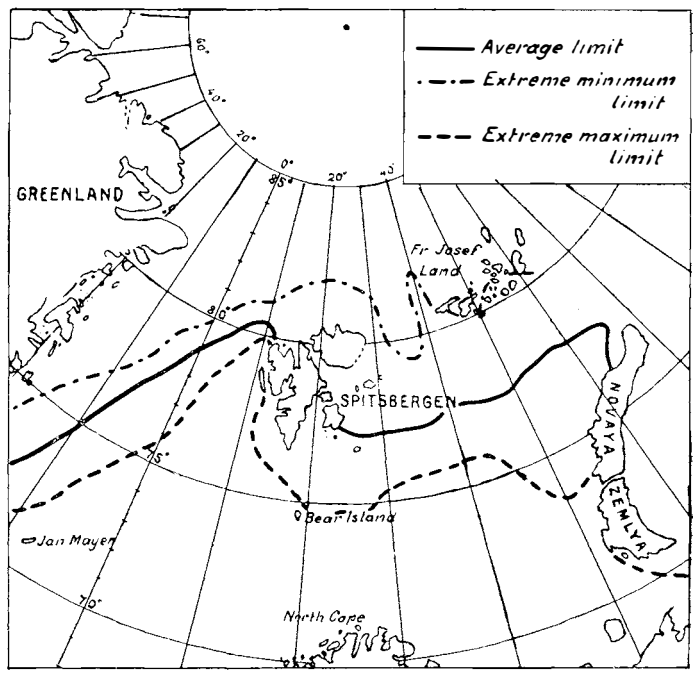


Fig. 2. Map showing ice limits in the month of August. Average of 20 years' observations. After C. I. H. SPEERSCHNEIDER [4].

about the end of September. The period stated refers to the Ice Fjord; it is somewhat shorter at Bell Sound and somewhat longer at Kings Bay.

With a powerful ice-breaker of 4000 or 5000 tons it will be possible to extend the shipping season very considerably, so that it may begin in March or April, and end in the middle of October when the darkness begins to be troublesome. The pack-ice is never so bad that an ice-breaker convoying merchant ships cannot force its way through it.

The average duration of the shipping season for Bear Island can be estimated at 6 months or more.

5. History. Political Relations.

Spitsbergen was probably discovered in 1194 by Norwegians, who called it Svalbard. In the Middle Ages the Norwegian kings extended their absolute sovereignty over all Arctic lands including Greenland and all islands north of Europe. However, these early discoveries of the Norwegians were forgotten, and these islands were rediscovered in 1596 by Willem Barents, a Dutch navigator. Shortly afterwards a period of very profitable whale hunting began. A serious dispute arose as to the hunting rights, and for some time Holland, England, and Norway all simultaneously claimed the sovereignty. As this whale hunting ceased in the 18th century the question of sovereignty lost its importance, Spitsbergen at that time having very limited economic interests attached to it. The country was only visited by Russians hunting polar bears, reindeer, foxes, and seals. This hunting by the Russians ceased in the middle of last century, but as early as fifty years before that time Norwegians had begun wintering on the islands, following the hunting trade like the Russians, and in the course of the 19th century they became masters of the hunting grounds.

The exploitation of the rich coal-fields of the archipelago commenced about the end of last century. Keen rivalry developed between the various occupiers of land representing Norwegian, American, British, Swedish, German, Russian and Dutch interests,and the question of the sovereignty of the islands again became of actual importance.

It was settled by a treaty signed on February 9th 1920 in Paris, in which the following powers recognised the full and absolute sovereignty of Norway over the archipelago of Spitsbergen and Bear Island (Svalbard) limited as indicated above: United States of America, Great Britain and Ireland, Dominion of Canada, Commonwealth of Australia, Dominion of New Zealand, Union of South Africa, India, Denmark, France, Italy, Japan, the Netherlands, and Sweden. Claims to land by nationals of other powers than Norway are fully protected by the treaty.

In 1924 Russia also recognised the sovereignty of Norway over Svalbard.

6. Exploration.

The coast line of the Spitsbergen archipelago was roughly mapped already in the 17th and 18th century by English and, mainly, Dutch whalers, but the scientific exploration of the country was commenced in 1827 by Professor B. M. KEILHAU of Kristiania (Oslo) University, and was continued largely by Swedish explorers partly supported by the Swedish Government. At the same time Norwegian sealing captains and wintering hunters made important contributions to the geography of Spitsbergen. In 1906 the Norwegians commenced systematical

explorations. Since that time well equipped scientific expeditions have been sent from Norway to Spitsbergen and Bear Island every year. Since 1909 the Norwegian Government has defrayed the expenses of the expeditions, either totally or in part. About 15 000 square km. of West Spitsbergen between the north coast and South Cape have now been mapped on a scale varying from 1 : 50 000 to 1 : 200 000, Bear Island is mapped in 1 : 10 000, and the seas off the west coast of Spitsbergen from Cross Bay southwards have been sounded and charts constructed on a scale of 1 : 100 000. The Norwegian Government maintains meteorological stations on Bear Island and in three places in Spitsbergen (v. p. 81). Besides the Norwegian and Swedish expeditions, important work has also been done by British, French, Russian, German, and Austrian expeditions.

B. Coal Deposits, Coal Mining and Exports.

1. Geology.

Spitsbergen presents a great variety of geological formations and structures. Fossiliferous strata occur from Downtonian (Upper Silurian) to Tertiary and Quaternary. We also find strongly folded and metamorphosed pre-Downtonian rocks, in many places cut by younger (yet pre-Downtonian) igneous rocks, mostly granites. Some of these rocks may possibly belong to the Archean or the Pre-Cambrian, but the bulk of them must be supposed to be of Ordovician-Silurian age (Hecla Hoek Formation). The main occurrences of these rocks are on the west coast (north of Horn Sound), east of Wijde Bay, and on the north side of North East Land. The Downtonian and Devonian strata are continental deposits consisting largely of red and green sandstones, shales and conglomerates, having a total thickness of about 10 000 metres. The Devonian is represented by all three subdivisions (Lower, Middle, and Upper Devonian). These systems are mainly found between the Ice Fjord and the north coast of Spitsbergen, and between Wijde Bay and Red Bay—Wood Bay.

The Upper Devonian strata are unconformably overlain by strata of the Carboniferous System containing three subdivisions. The Lower Carboniferous or Culm, consisting mostly of sandstones with some layers of shale, is nearly 1 000 metres thick and of continental origin. It contains in places 1—4 coal-bearing horizons. At Kings Bay beds of the Middle Carboniferous rest on the Culm, but in most places the Culm is directly overlain by Upper Carboniferous limestones, locally known as the Cyatophyllum Limestone, having a thickness of 600 metres. On the top of this rest Permo-Carboniferous beds of chert, 370 metres thick, which in turn are overlain by Permian strata, chiefly sandstones

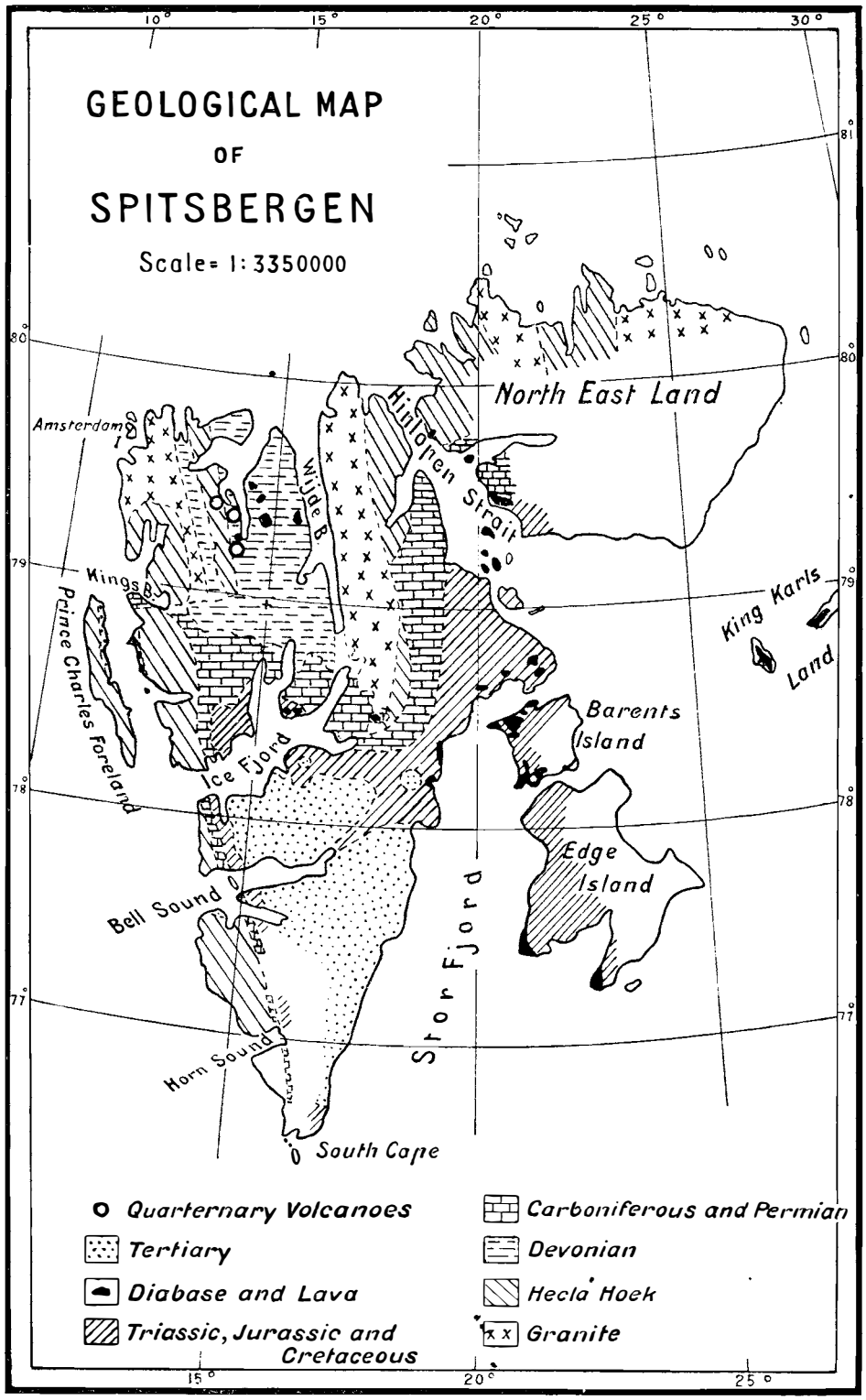

GEOLOGICAL MAP
OF
SPITSBERGEN
Scale= 1:3350000
10°
15°
20°
25°
30°
81°
80°
79°
78°
77°
North East Land
Amsterdam Ø
Wijde Bay
Hinlopen Strait
Kings Bay
Prince Charles Foreland
Ice Fjord
King Karls Land
Barents Island
Edge Island
Bell Sound
Stor Fjord
Horn Sound
South Cape
Quarternary Volcanoes
Tertiary
Diabase and Lava
Triassic, Jurassic and Cretaceous
Carboniferous and Permian
Devonian
Hecla Hoek
Granite

Fig. 3.

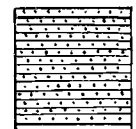
System	Sub-division	Formation	Section	Thickness in Metres	Description
Tertiary	Eocene	Upper Sandstone Series		500	Alternating beds of sandstones and shales with thin coal-seams.
		Middle Shale Series		350	Black shales.
	Paleocene	Lower Sandstone Series		620	Sandstones and shales with workable coal-seams in the lowest part of the formation.
		Unconformity			
Cretaceous	Albian Valangian			735	Shales and marls with thin layers and lenses of limestone and clay ironstone and beds of sandstones. Coal-seams in the middle of the strata.
Jurassic	Portlandian Kellaways			640	Sandstones, sandy shales, shales and marls with thin layers and lenses of limestones and clay ironstone.
		Hiatus			
Triassic	Upper Lower			605	Dark shales, marls, sandstones, and limestones.
Permian				245	Sandstones, shales, marls, limestones, and various transitional rocks.
Carboniferous	Permo-Carboniferous			365	Chert and silicious limestones.
	Upper Carboniferous	Cyathophyllum Limestone		600	Limestones and gypsum.
	Lower Carboniferous (Culm)			980	Sandstones with shales and conglomerates. Coal-seams in the lower part of the series.
		Unconformity			
Silurian Ordovician		Hecla Hoek			Schists, quartzites, and dolomites.

Fig. 4. Columnar section of the sedimentary series on the peninsula between Ice Fjord and Bell Sound.

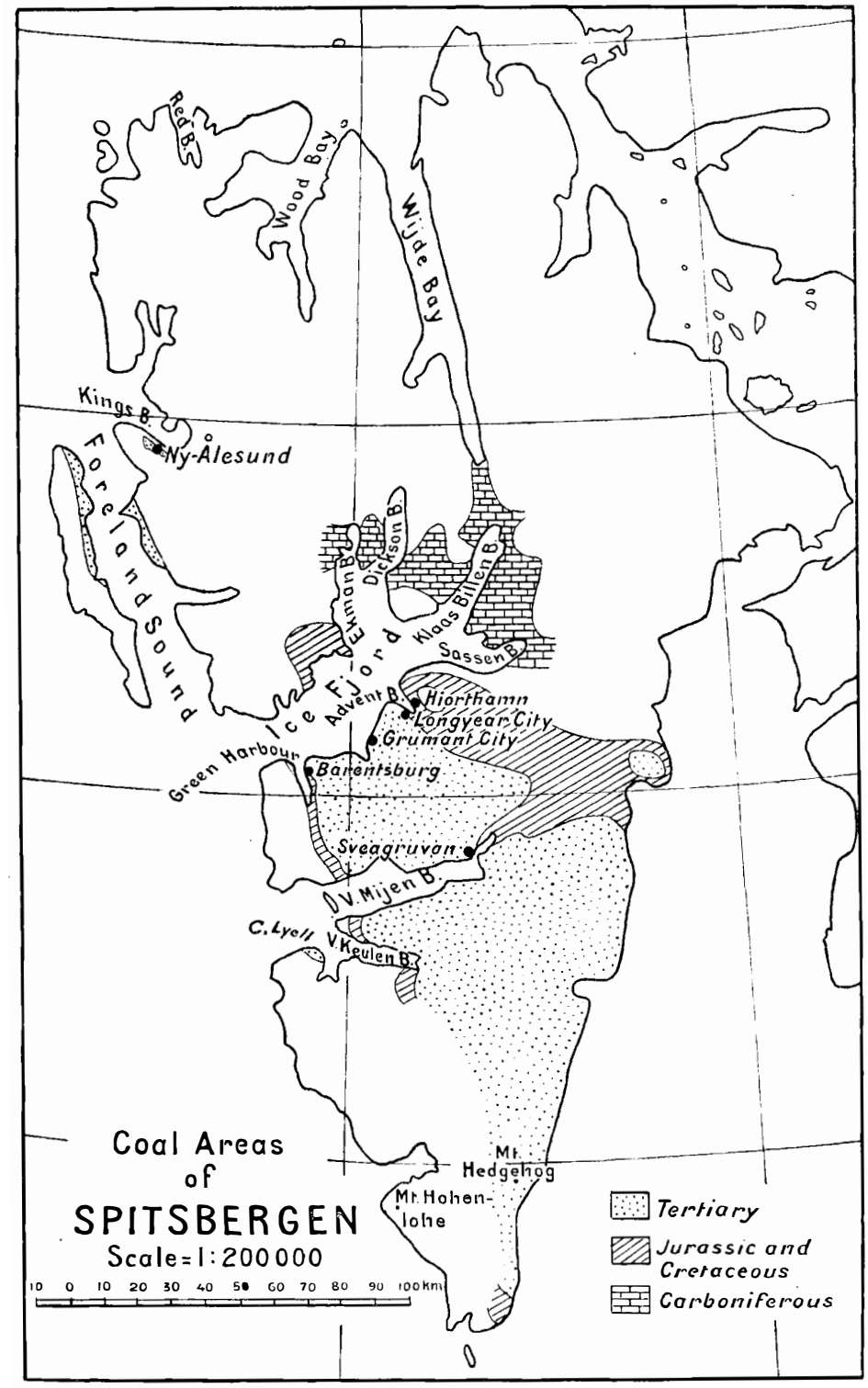

Red B.
Wood Bay
Wijde Bay
Kings B.
Ny-Ålesund
Foreland Sound
Ekman B.
Dickson B.
Klaas Billen B.
Sassen B.
Ice Fjord
Advent B.
Hiorthamn
Longyear City
Grumant City
Green Harbour
Barentsburg
Sveagruvan
V. Mijen B.
C. Lyell
V. Keulen B.
Mt. Hedgehog
Mt. Hohen-lohe
Coal Areas of SPITSBERGEN
Scale = 1:200000
10 0 10 20 30 40 50 60 70 80 90 100 km
Tertiary
Jurassic and Cretaceous
Carboniferous

Fig. 5.

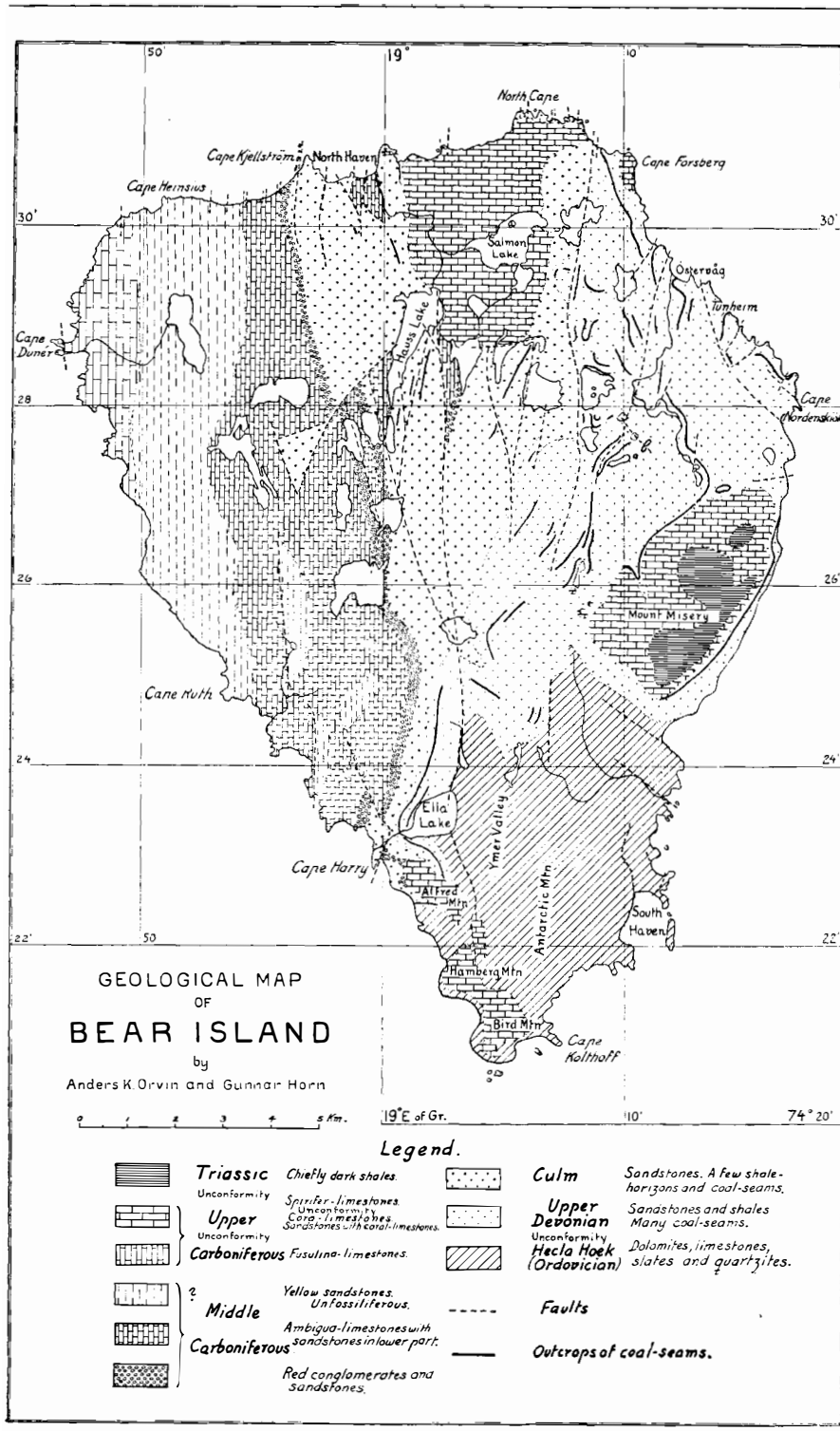

50'
19°
10'
North Cape
Cape Kjellström
North Haven
Cape Forsberg
Cape Heinsius
30'
Salmon Lake
Østervåg
Tunheim
Cape Duner
Haus Lake
28
Cape Nordenskiöld
26
26'
Mount Misery
Cape Ruth
24
24'
Ella Lake
Ymer Valley
Cape Harry
Alfred Mtn
Antarctic Mtn
South Haven
22'
50
Hambergs Mtn
Bird Mtn
Cape Kolthoff
GEOLOGICAL MAP
OF
BEAR ISLAND
by
Anders K. Orvin and Gunnar Horn
0 1 2 3 4 5 Km.
19° E of Gr.
10'
74° 20'
Legend.
Triassic
Chiefly dark shales.
Unconformity
Upper Carboniferous
Spirifer-limestones.
Unconformity
Cora-limestones.
Sandstones with coral-limestones.
Unconformity
Fusulina-limestones.
? Middle Carboniferous
Yellow sandstones. Unfossiliferous.
Ambigua-limestones with sandstones in lower part.
Red conglomerates and sandstones.
Culm
Sandstones. A few shale-horizons and coal-seams.
Upper Devonian
Sandstones and shales
Many coal-seams.
Unconformity
Hecla Hoek (Ordovician)
Dolomites, limestones, slates and quartzites.
Faults
Outcrops of coal-seams.

Fig. 6.

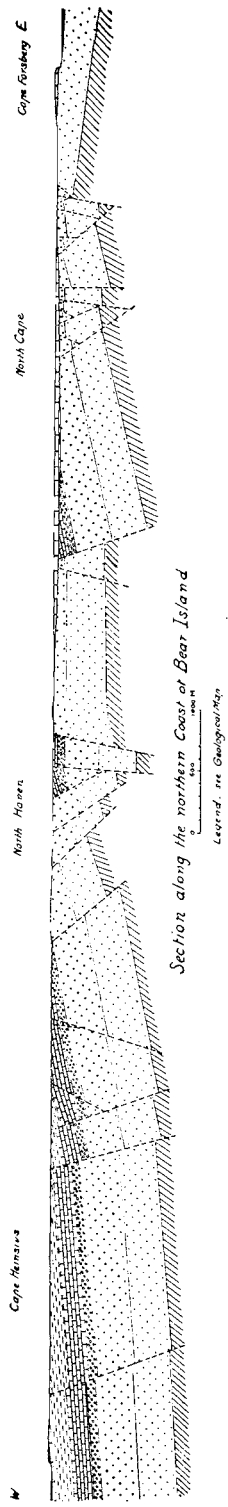


Fig. 7.

and shales of a total thickness of 250 metres. Then come Triassic strata (Lower, Middle and Upper Triassic) mostly shales, limestones and sandstones, about 600 metres thick, followed by the Jurassic System (from Kellaways to Portlandian) consisting of sandstones, limestones, shaly "blackbands", shales and marly shales of a total thickness of 600 metres, and finally the Cretaceous System (from Valangian to Albian) consisting largely of the same rocks as the Jurassic and attaining a thickness of 730 metres. This system has a coal-bearing horizon, which in the Advent Bay region lies 450 metres below the top beds of the formation.

Unconformably on the Cretaceous follows a series of Tertiary strata approximately 1500 metres thick. They are of Paleocene-Eocene age [21] and may be subdivided into three main series. The lowermost series, 620 metres thick, consists chiefly of sandstones, the middle part of which has a series of dark shales. The middle series is built up of black shales, 350 metres thick, and the uppermost series of sandstones, 500 metres thick. Immediately above the lower limit of the Tertiary System there are two, or in some places as many as four, coal-bearing horizons. At Grumant City there is, however, only one. These coal-seams are the most important in the entire group of islands. There is also a coal-seam in the uppermost part of the lower Tertiary series, but it is only 30 or 40 cm. thick. The upper Tertiary series also contain a number of coal-seams but, as far as is known, they are of no economic value. The thicknesses given apply to the region around Ice Fjord—Bell Sound.

In several places are found post-Neocomian but pre-Tertiary dykes and flows of diabase, and in the region between Wijde Bay and Wood Bay also flows of basaltic lava. West of Wood Bay there are also many volcanic necks and two volcanoes of Quaternary age. Connected with these are some hot springs containing water of a temperature of 28° C.

The Quaternary Period is chiefly represented by glaciers, moraines, marine terraces, and beach deposits reaching an altitude of 340 metres above sea level, and finally talus and river deposits. Nearly all the known types of glaciers occur in Spitsbergen. Some parts of the country are completely covered by ice caps or inland ice, in other regions perhaps two-thirds or three-fourths of the area is ice covered, whereas in other places, especially in the great coal-basin between the Ice Fjord and Bell Sound, there are only few and small glaciers.

Two distinct mountain-forming movements (besides the one in Archean or Pre-Cambrian time) have taken place: The Caledonian movement, compressing the pre-Downtonian strata into folds striking NNW, and one Tertiary movement, affecting particularly the strata from Carboniferous to Tertiary along the west coast, where the beds are strongly folded, partly forming overthrusts (e. g. at Kings Bay). The folds gradually vanish towards the east, so that the central regions, e. g., the region east of Green Harbour, have only gentle folds dipping from 0° to 15°. This Tertiary folding also strikes NNW and partly NW. Great fissure faults have been formed within the areas most strongly affected by the mountain-forming movements.

On Bear Island there is in its southern elevated part an older dynamically metamorphosed series: the Hecla Hoek Formation, which has been proved by the fossils present to be of Ordovician age. It is made up of limestones, dolomites, slates, and quartzites having, according to HOLTEDAHL [18], a total thickness of at least 980 metres.

Unconformably on the Hecla Hoek lies the Devonian System (Upper Devonian), closely connected with the lower part of the Carboniferous System (Culm), both having a continental development. Their thickness in the central part of the island is at least 600 metres. The Devonian consists of sandstones and shales, while the Culm chiefly contains sandstones and a few beds of conglomerate, but very little shale. Both systems contain coal-seams.

Above the Culm lie the Middle Carboniferous strata, with red conglomerates and sandstones at the base, followed upwards by limestones, conglomerates, and sandstones, having a total thickness of about 400 metres. Then come Upper Carboniferous limestones, which in Mt. Misery are overlain by beds of Triassic age. In many places there are big breaks in the sequence of these Carboniferous strata. Thus, Upper Carboniferous may rest directly on Culm or Devonian.

The tectonic features will appear from the map and section.

2. Coal Deposits.

I. Spitsbergen.

There is a large coal area in the central part of Spitsbergen where all the coal-bearing geological systems mentioned above occur. There are also a number of smaller isolated areas with coal deposits belonging to one or other of the systems mentioned.

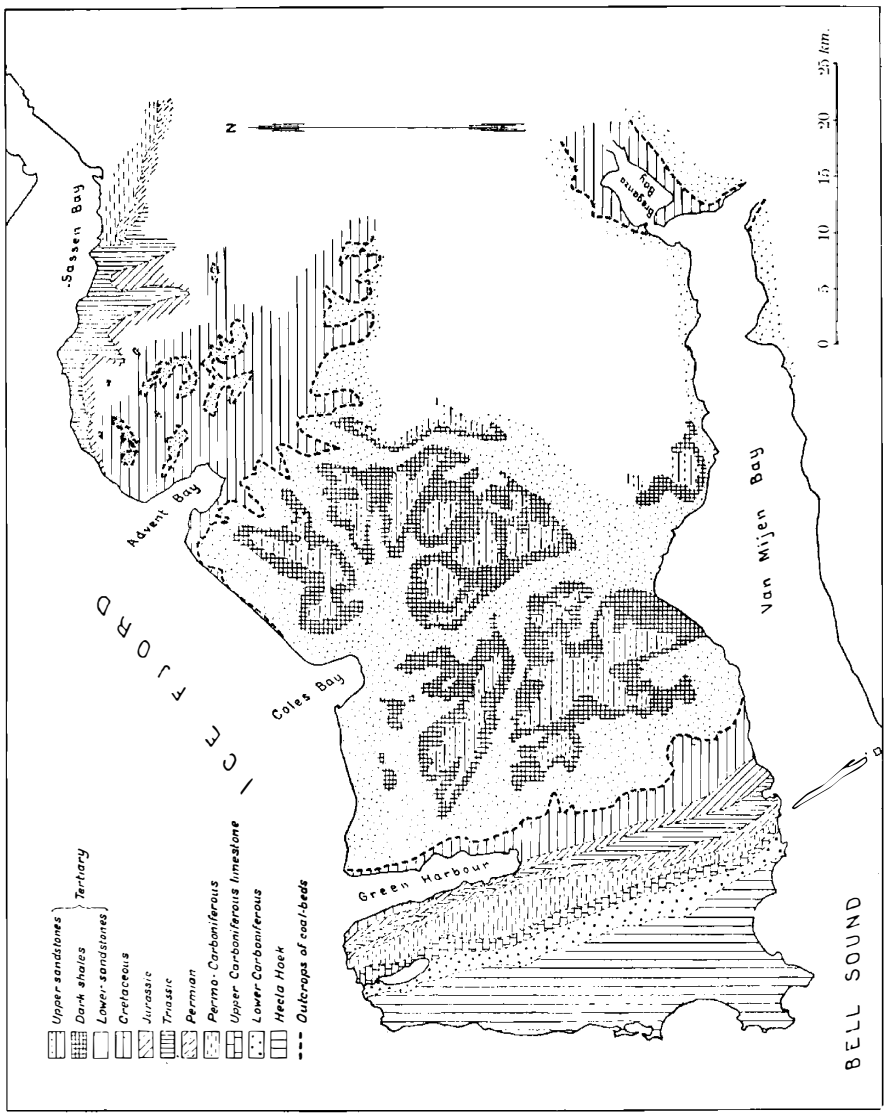
a. *The Great Central Coal Region.*

We begin with the central coal area. It extends from the south side of the Ice Fjord nearly to South Cape. Generally speaking, the strata form a syncline striking NNW or NW, the coal-seams thus outcropping in the extreme western and eastern parts of the area.

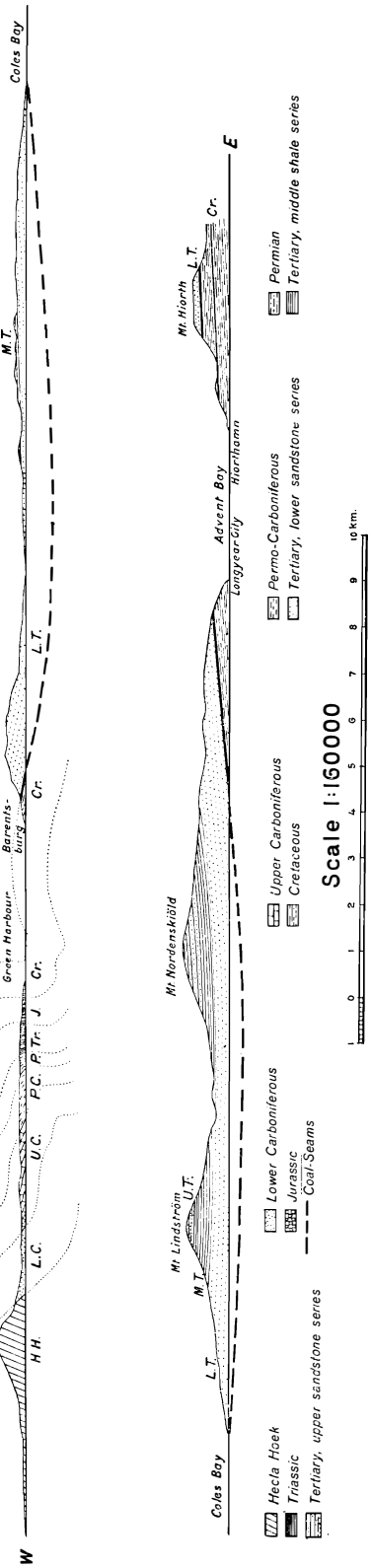
Only the part of the area lying between Ice Fjord and Van Mijen Bay has been thoroughly explored. Excepting the Kings Bay mine, all the coal mines of Spitsbergen lie within this part. Referring to the map and section (Pl. I and II) a brief outline of the geology of the area is given below. At the extreme west there are folded strata of the Hecla Hoek. Unconformably on these come the steeply dipping strata of the Culm. Then follow the other formations, also highly inclined, beautifully exposed in the cliffs from the mouth of the Ice Fjord to the west side of Green Harbour where strata of the Tertiary System form a small anticline. On the east side of Green Harbour we have another bigger anticline. At the beach there are beds of the upper part of the Neocomian followed upwards by Tertiary strata. Between the east coast of Green Harbour and Advent Bay we have a flat syncline with a smaller anticline developed on its eastern flank having its crest at Coles Bay. The axis of the syncline runs about 7 km. east of Green Harbour. At this place the boundary between the Cretaceous and Tertiary lies 510 metres below sea level. The boundary Cretaceous-Tertiary again appears at sea level at a point 3 km. east of Coles Bay, and still farther east the older systems in turn emerge from the sea. Here along the eastern edge of the syncline the Devonian System is also present in the inner branches of the Ice Fjord (Klaas Billen Bay, Dickson Bay, Ekman Bay).

α. *Deposits of Culm Coal.* The best known Culm coal-seams are in the eastern part of the area. Here explorations have been carried out on the west side of Klaas Billen Bay at Mt. Pyramide, at the inner part of the fjord, and between Klaas Billen Bay and Sassen Bay by Svenska Stenkolsaktiebolaget Spetsbergen, the Scottish Spitsbergen Syndicate, Ltd., and Professor ERIK STENSIÖ.

The following description is based on the papers by HÖGBOM [40, p. 167] and STENSIÖ [22], and on information received from Svenska



GEOLOGICAL MAP OF THE PENINSULA
BETWEEN ICE FJORD AND BELL SOUND – VAN MIJEN BAY.



SECTION ALONG THE SOUTHERN SHORE OF ICE FJORD.

Stenkolsaktiebolaget Spetsbergen and from Professor STENSIÖ, who has written a report on this region for a private company.

The coal-field around the inner part of Klaas Billen Bay forms a trough, in the main including Mt. Pyramide on the west side of the fjord and Mt. De Geer, Mt. Hult, Mt. Sfinx and Mt. Tricolor east and north of the fjord.

The stratigraphical relations are as follows: The Culm series which contains the coal deposits rests directly on Pre-Cambrian rocks.

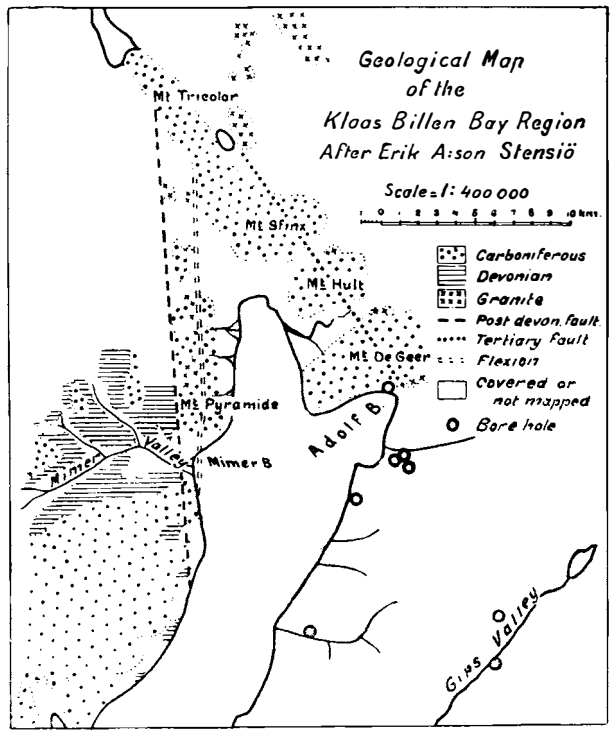


Fig. 8.

The total thickness of the Culm in Mt. De Geer, according to STENSIÖ, is about 200 metres. On the east side of Klaas Billen Bay the sequence from above is as follows:

Red sandstones and shales, thinly foliated	7	metres.
Purple or green sandstones	25	„
Light grey sandstones, partly with gypsum	9	„
Red sandstones, easily weathering	13	„
Light sandstones, grading downwards into dark-red sandstones	20	„
Light sandstone	6	„
Red sandstone	11	„
Light sandstones, with yellow weathering .	17	„

Coal-seam IV	?	metres.	
Light sandstones, with yellow weathering	12	„	
Coal-seam III	7	„	
Light sandstone	20	„	
Coal-seam II	4,5	„	
Yellow sandstone	?	„	about 30 metres.
Coal-seam I	?	„	
Coarse-grained sandstone partly conglomerates	?	„	
Pre-Cambrian			

Above the Culm strata there is a series of gypsum more than 200 metres thick, and then follows the Cyathopyllum Limestone (Upper Carboniferous), which forms the mountain tops around the inner part of the fjord.

The coal-bearing area is bounded on the east side by a fault line through Mt. De Geer, Mt. Hult, and Mt. Sfinx along which the area has sunk about 200 metres. Towards the west it is bounded by another fault line running from north to south through Mt. Pyramide. The strata have their lowest position in the fjord, rising towards the fault lines on either side of it.

Only in Mt. Pyramide and on the north side of Mt. De Geer are the coal-seams exposed.

In Mt. Pyramide a series of coal-seams have been proved, having an aggregate thickness of upwards of 10 metres and consisting chiefly of splint coal. (See the section p. 23 where the thickness and ash content are given). B. HÖGBOM held the opinion in 1914 that these coal-seams belonged to the Culm and extended over the entire field, but according to recent information from Svenska Stenkolsaktiebolaget Spetsbergen they lie immediately west of the great fault line through Mt. Pyramide and are consequently Devonian. If this view is correct, and granting that the Culm east of the fault line (according to STENSIÖ'S description) lies directly on the Pre-Cambrian, these seams will occur in a small part of the field only. The problem as to their distribution may most properly be considered unsolved as yet.

The lower part of the Culm in Mt. Pyramide is covered by talus, and it is therefore difficult to obtain a complete section of the coal-seams. The seams uncovered east of the fault line chiefly contain bright coal, and have not nearly the same thickness as the seams of splint coal mentioned above. According to the general opinion, the lower part of the Culm contains at least two coal-seams separated by beds of sandstone about 20 metres thick. These seams were partly uncovered in 1910 and 1912. According to HÖGBOM [40], p. 170 and 171, the sections recorded from three places were the following:

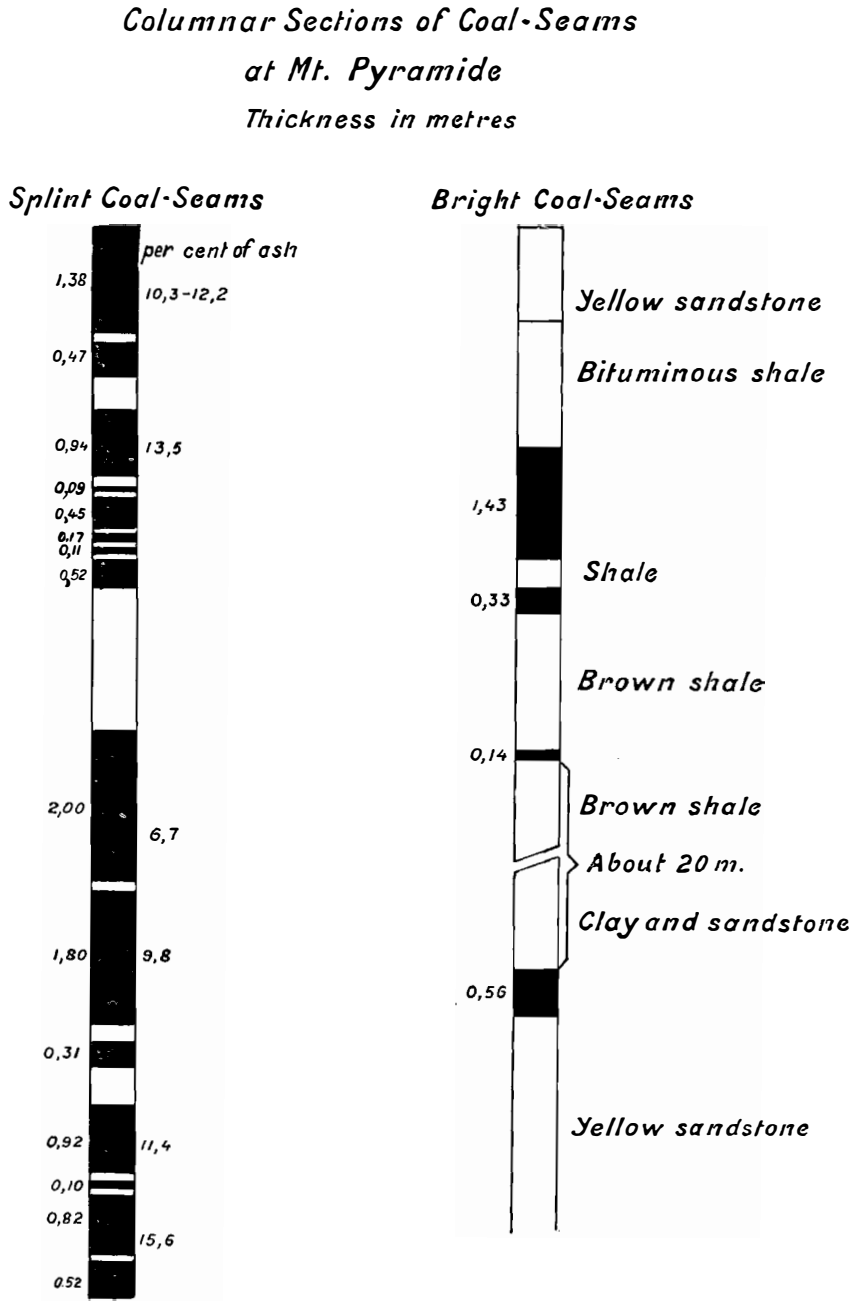


Fig. 9.
Left section from HÖGBOM [40], p. 170 and 171, right section from informations received from Svenska Stenkolsaktiebolaget Spetsbergen.

I. 2,48 metres of coal distributed on 6 benches separated by partings of a total thickness of 0,54 metres. The ash content determined on two average samples was 15,5 and 16,2 per cent.
II. 1,68 metres of coal separated by a parting of shale 0,41 metres thick. Ash content about 17 per cent.
III. From above: coal: 0,13 metres, shale: 0,12 metres, coal: 1,22 metres, shale: 1,10 metres, coal: 1,38 metres. The lowermost bench has an ash content of 11,9 per cent.

It is not known whether these three sections should be referred to one or several coal-seams.

It is impossible to estimate with any degree of accuracy the total amount of available coal in Mt. Pyramide before it is definitely decided whether the thick seams of splint coal underlie the entire field.

On the east side of the fjord STENSIÖ has exposed the three uppermost coal-seams outcropping on the north side of Mt. De Geer, about 4 km. from the shore.

The upper seam (seam IV in the section of the Culm given on p. 22) contained chiefly shale. Workable coal was not proved.

In seam III 3 benches, each 0,6—0,7 metres thick, were found. In seam II 2 benches, 1,40 metres and 0,65 metres thick, were exposed. They are separated by a thin parting. Immediately below there was another bench, the thickness of which could not be determined.

Seam I was not uncovered.

The Scottish Spitsbergen Syndicate have sent me the following extract of the results of their boring in Gips Valley between Sassen Bay and Klaas Billen Bay, and the inner part of Klaas Billen Bay (Adolf Bay and Ebba Valley). See table next page.

It is not known whether the coal-seams proved by the Scotch company can be correlated with any of those found by STENSIÖ.

On the west side of the syncline, west of Green Harbour and north of Bell Sound, there is also a coal-seam in the Culm, but it is not workable in either place. At the last-mentioned place the coal-seam is situated 600 metres below the upper limit of the Culm sandstone which is 980 metres thick. The thickness of this seam is only 60 cm.

β. *Deposits of Cretaceous Coal.* The next coal-bearing strata belong to the Cretaceous System, in which a coal-seam is known in the eastern part of the syncline: The east side of Advent Bay, Cape Boheman, and Erdmann Tundra. The coal is high in ash. This seam was mined on the east side of Advent Bay (Advent City) in 1905—1908 by an English company, The Spitsbergen Coal & Trading Co., Ltd. At Cape Boheman the Aktieselskapet Isefjord Kulkompani, was working on the same seam in 1920—1921. At both places work has now definitely been given up.

Results of Borings through Culm Coal-Seams on the Property of The Scottish Spitsbergen Syndicate, Ltd.

District	Number of known seams of coal	Distance of upper seam below the upper limit of the Culm sandstone	Distance between seams	Sections of seams
Gips Valley	1	About 130 m. A variable thickness of Gypsum intervenes between the Culm and the lower limit of the Cyathophyllum Limestone	—	Dark Shale Coal 90 cm. Fire-clay 2 cm. Dark Blaes.
Adolf Bay	2		55 m.	Upper seam. Blaes. Coal 23 cm. Blaes 35 „ Coal 68 „ Lower seam. Coal 46 cm. Fire-clay 8 „ Coal 41 „
Ebba Valley	2	About 140 m.	60 m.	Upper seam not proven. Lower seam. Coal 18 cm. Blaes 11 „ Coal 11 „ Parting 1 „ Coal 33 „ Parting 1 „ Coal 11 „ Parting 8 „ Coal 25 „

From the Erdmann Tundra, HÖGBOM [40], p. 181, reports the following section:

Light sandstone.
Coal . . . . . 16 cm.
Shale. . . . . 41 „
Coal . . . . . 13 „
Shale. . . . . 23 „
Coal . . . . . 65 „
Shale.

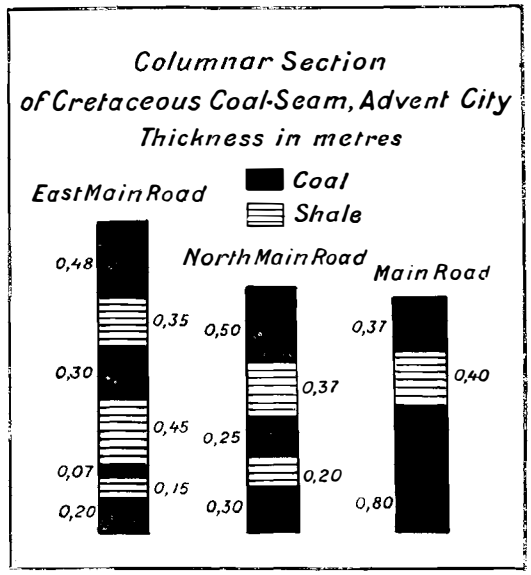


Fig. 10.

This coal-seam has also been traced at Sassen Bay and Braganza Bay and thus appears to have a large extension. In the western part of the area, however, the strata contain only some thin layers of coal in the places where this seam should be expected to occur.

γ. *Deposits of Tertiary Coal.* The tertiary coal-seams are differently developed in the western and eastern parts of the area. In the western part, on the east side of Green Harbour, the Tertiary begins with a basal conglomerate. About 9 metres above this there is a coal-seam of an average thickness of 1 metre. In most places this seam is homogeneous, but in some places it is split up into several benches. Another seam coming 20—40 metres above the one mentioned is always divided into several thinner benches.

These two seams are apparently best on the south side of Ice Fjord. Towards the south they seem to thin out and become less pure. Thus no workable seam has been found on the north side of Van Mijen Bay (Coal Mountain).

In the eastern part of the syncline there is no sharp boundary between the Cretaceous and Tertiary. The unconformity is so little marked as to be hardly noticeable, the rocks at the boundary being sandstones and shales devoid of fossils. It is therefore somewhat doubtful to which of the two systems the lowest of these coal-seams belongs. East of Coles Bay, at Grumant City, only one coal-seam occurs, but farther east in the Advent Bay area there are 4 or 5 seams. Some of these are split up into minor seams or benches. The lowermost seam is at one place (Mt. Hiorth on the east side of Advent Bay) more than 2,5 metres thick, and this seam, contains a coal which, strangely enough, is very similar to brown coal. The best seam is No. 2 from below (No. 3 in the section from Mine No. 1, Longyear City). This seam is no doubt identical with the lowermost seam in the western part of the syncline. It is on this seam that practically all the mining of the area has taken place.

In the south-eastern part of the syncline, at Braganza Bay, there also appear to be 4 or 5 seams, but these are rather close together,

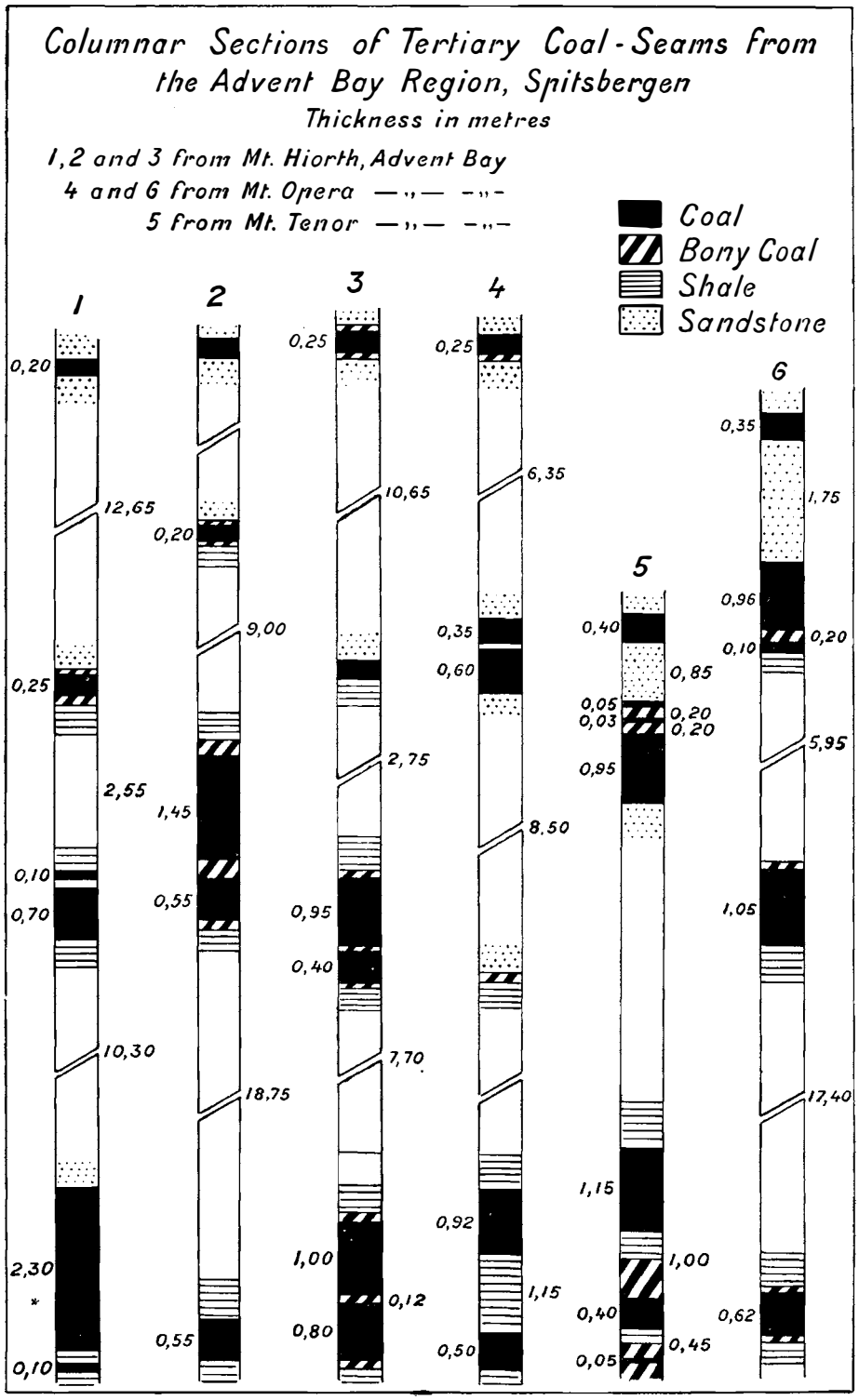

Columnar Sections of Tertiary Coal-Seams from the Advent Bay Region, Spitsbergen
Thickness in metres
1, 2 and 3 from Mt. Hiorth, Advent Bay
4 and 6 from Mt. Opera —„— –„–
5 from Mt. Tenor —„— –„–
Coal
Bony Coal
Shale
Sandstone
1
0,20
12,65
0,25
2,55
0,10
0,70
10,30
2,30
*
0,10
2
0,20
9,00
1,45
0,55
18,75
0,55
3
0,25
10,65
2,75
0,95
0,40
7,70
1,00
0,12
0,80
4
0,25
6,35
0,35
0,60
8,50
0,92
1,15
0,50
5
0,40
0,85
0,05
0,20
0,03
0,20
0,95
1,15
1,00
0,40
0,45
0,05
6
0,35
1,75
0,96
0,10
0,20
5,95
1,05
17,40
0,62

Fig. 11.

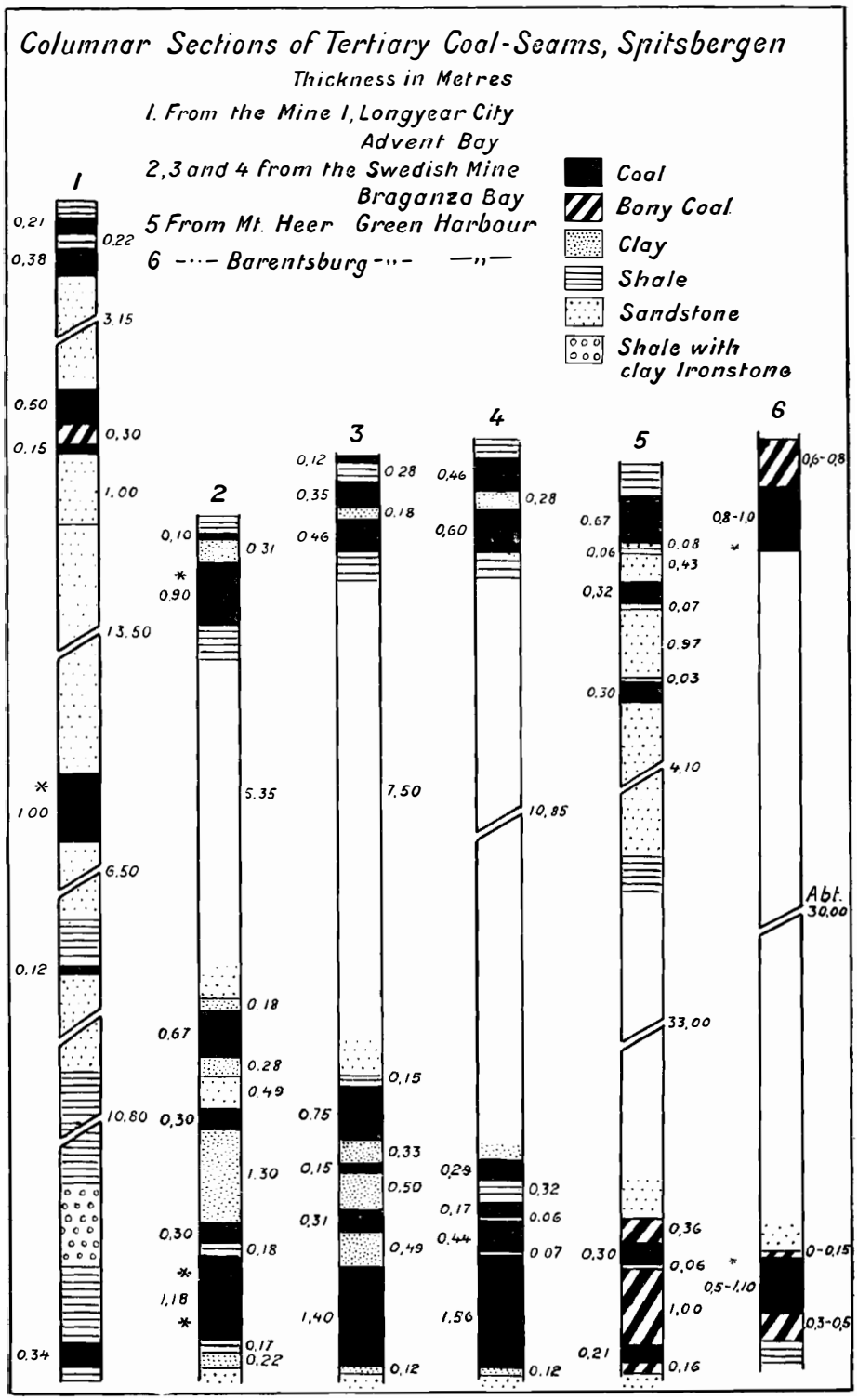

Columnar Sections of Tertiary Coal-Seams, Spitsbergen
Thickness in Metres
1. From the Mine 1, Longyear City Advent Bay
2, 3 and 4 from the Swedish Mine Braganza Bay
5 From Mt. Heer Green Harbour
6 -·-·- Barentsburg -·-·- —"—
Coal
Bony Coal
Clay
Shale
Sandstone
Shale with clay Ironstone
1
0,21
0,22
0,38
3,15
0,50
0,15
0,30
1,00
13,50
*
1,00
6,50
0,12
10,80
0,34
2
0,10
0,31
*
0,90
5,35
0,18
0,67
0,28
0,49
0,30
1,30
0,30
0,18
*
1,18
*
0,17
0,22
3
0,12
0,28
0,35
0,18
0,46
7,50
0,15
0,75
0,33
0,15
0,50
0,31
0,49
1,40
0,12
4
0,46
0,28
0,60
10,85
0,29
0,32
0,17
0,06
0,44
0,07
1,56
0,12
5
0,67
0,08
0,06
0,43
0,32
0,07
0,97
0,03
0,30
4,10
33,00
0,36
0,30
0,06
*
0,5-1,10
1,00
0,21
0,16
6
0,6-0,8
0,8-1,0
*
Abt.
30,00
0-0,15
0,3-0,5

Fig. 12.

making it doubtful whether there are 2 seams, each with partings, or a great number of individual seams.

There is very little information about those regions of the great central coal area that lie outside the peninsula between the Ice Fjord and Van Mijen Bay, just described. Along the western edge of the syncline there are no workable seams, neither on the south side of Van Mijen Bay nor on the north or south side of Van Keulen Bay. In the eastern part of the syncline workable coal-seams occur on the south side of Braganza Bay.

On the east coast of Spitsbergen, around the Stor Fjord, coal has been found in several places, but as far as is known only one place has been closely examined, viz. at Mt. Hedgehog on the west side of the Stor Fjord due east of Horn Sound. Here the Northern Exploration Co. uncovered a coal-seam of excellent quality upwards of 1 metre thick. The poor harbour and most difficult ice conditions, however, are factors which seriously tend to diminish the value of this field.

We shall now consider the smaller coal-bearing areas.

b. *The Coal-Field at Kings Bay.*

The Kings Bay coal-field is situated on the south-west side of Kings Bay on a plain declining towards the fjord. The field is 6 to 7 km. long and at most 1 km. broad.

Although the coal-field is situated in latitude 78° 55′ North, thus being the northernmost productive coal-field in the world, the conditions for shipping are very favourable, as Kings Bay and the ocean outside it are, as a rule, free from ice during the summer months (July—September).

Geology. The coal-seams are of Tertiary age (Paleocene or Eocene). The strata consist chiefly of sandstones, with subordinate layers of conglomerates, shales, carbonaceous shales, and coal. The maximum total thickness of the Tertiary strata is here about 190 metres. The strata from the bottom about 80 metres upwards consist of drab or buff sandstones, while the strata towards the top consist of green and greyish-green sandstones and sandy shales.

In the eastern part of the field the Tertiary strata rest on a series of Cretaceous shales (Neocomian) 30 or 40 metres thick. The Cretaceous is missing in the western part, and the Tertiary strata rest directly on Permo-Carboniferous beds of chert, 250 metres in thickness. Below this lie Upper Carboniferous beds of limestone (Cyathophyllum Limestone) about 450 metres thick, and these are underlain by strata of the Culm, Devonian, and Hecla Hoek Formations.

The structure of the Kings Bay coal-field is rather complicated, and is of great consequence in the estimation of its workability.

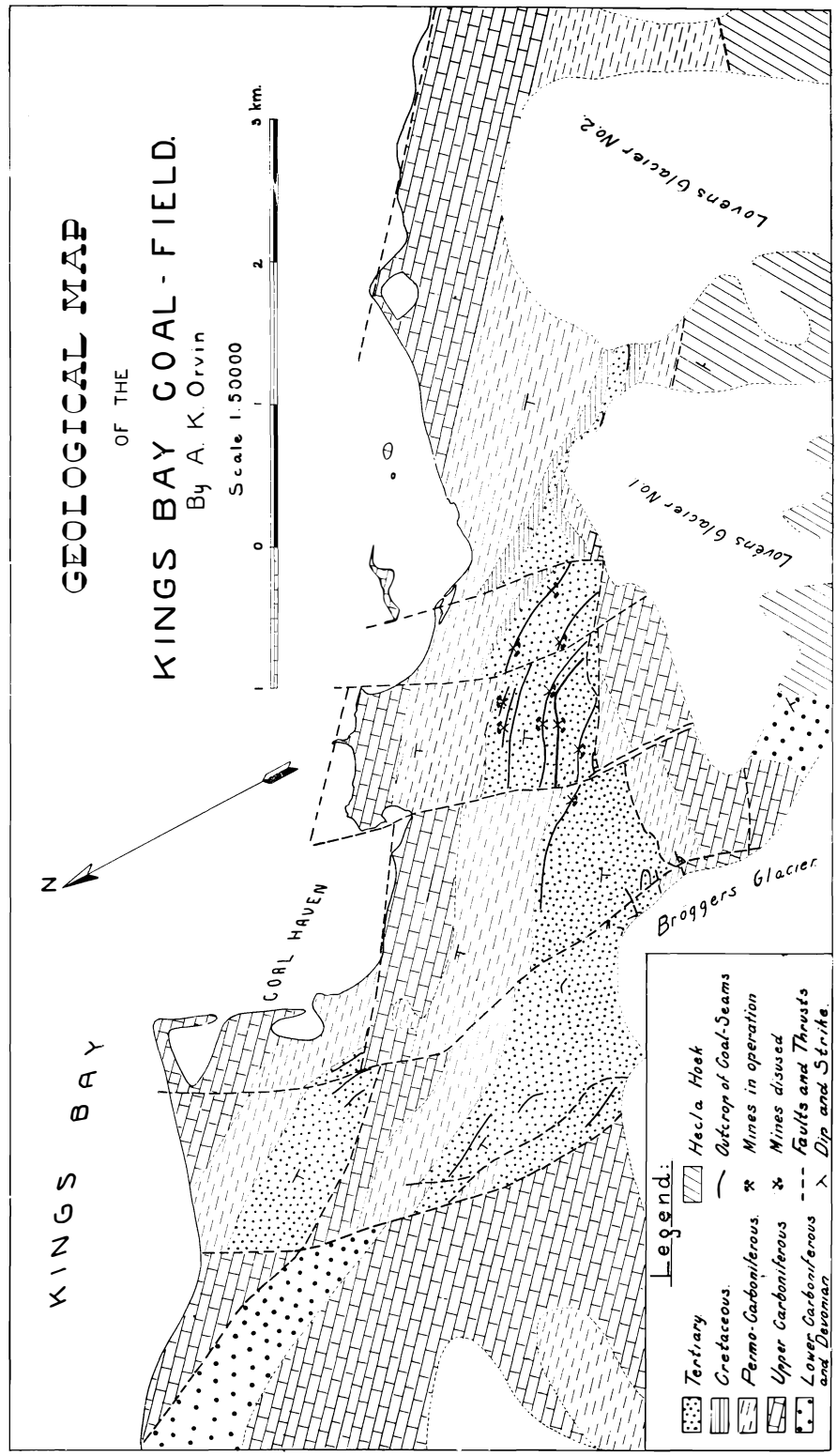

GEOLOGICAL MAP
OF THE
KINGS BAY COAL-FIELD.
By A. K. Orvin
Scale 1:50000
0 1 2 3 km.
KINGS BAY
COAL HAVEN
N
Lovens Glacier No.1
Lovens Glacier No.2
Broggers Glacier
Legend:
Tertiary
Cretaceous.
Permo-Carboniferous.
Upper Carboniferous
Lower Carboniferous and Devonian
Hecla Hook
Outcrop of Coal-Seams
Mines in operation
Mines disused
Faults and Thrusts
Dip and Strike.

Fig. 13.

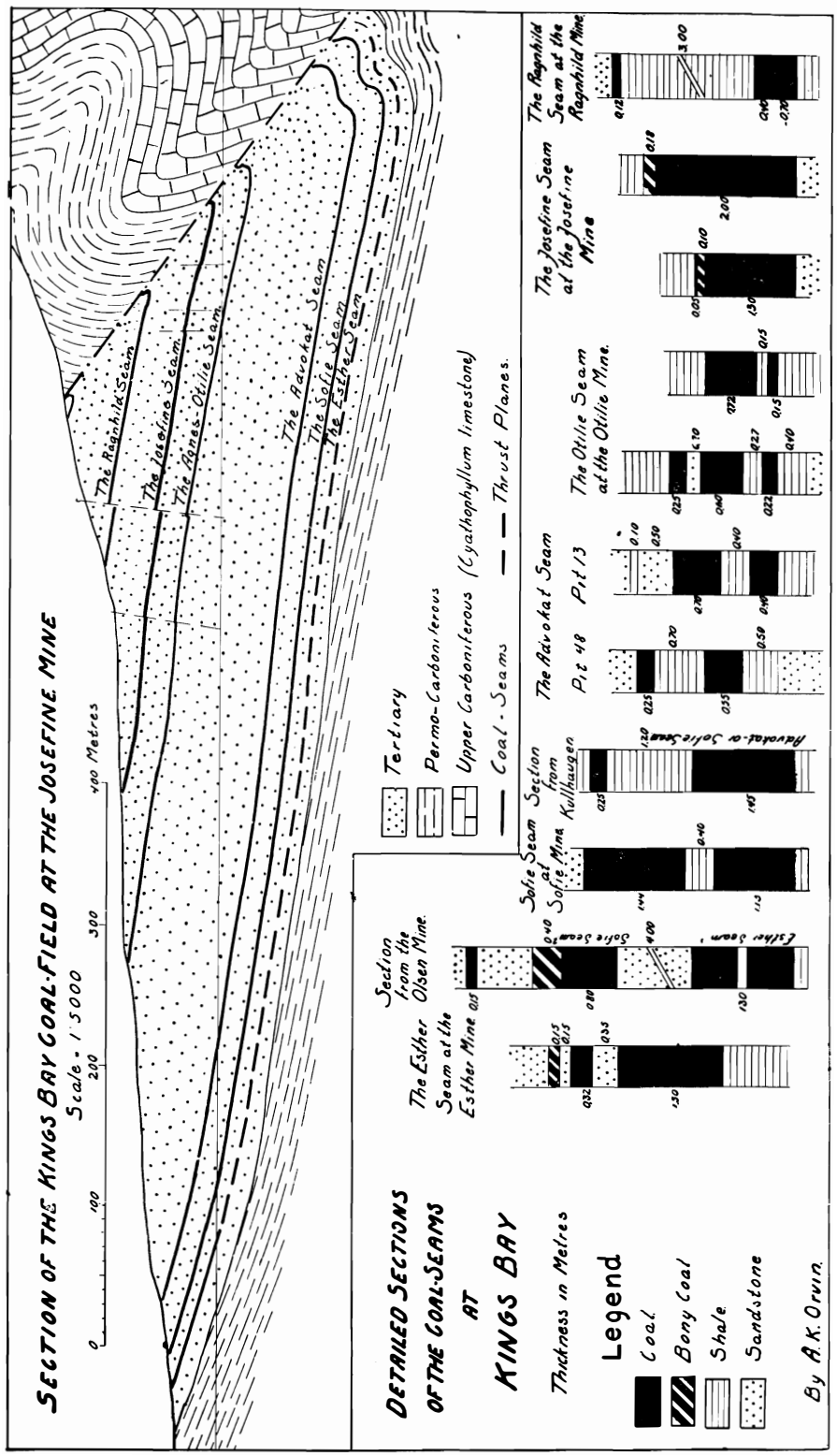

SECTION OF THE KINGS BAY COAL-FIELD AT THE JOSEFINE MINE
Scale - 1:5000
0 100 200 300 400 Metres
The Ragnhild Seam
The Josefine Seam
The Agnes-Otilie Seam
The Arvokat Seam
The Sofie Seam
The Esther Seam
Tertiary
Permo-Carboniferous
Upper Carboniferous (Cyathophyllum limestone)
Coal-Seams
Thrust Planes.
DETAILED SECTIONS OF THE COAL-SEAMS AT KINGS BAY
Thickness in Metres
Legend
Coal
Bony Coal
Shale
Sandstone
By A.K. Orvin.
The Esther Seam at the Esther Mine
Section from the Olsen Mine
Sofie Seam
Esther Seam
Sofie Seam at Mine
Section from Kullhaugen
Arvokat-or Sofie Seam
The Arvokat Seam
Pit 48
Pit 13
The Otilie Seam at the Otilie Mine.
The Josefine Seam at the Josefine Mine
The Ragnhild Seam at the Ragnhild Mine

Fig. 14.

The tectonic disturbances to which the strata have been subjected have taken place some time in the Tertiary Period, but the time cannot be fixed in relation to any definite subdivision. These disturbances must have proceeded in about the following way: A mountain folding has taken place with the pressure coming from the south-west. All the strata of the System have become folded, those south-west of the coal-field to the extent of being inverted. Then the southern part has been pushed over the northern part along a plane about parallel to the folding axis and dipping about 40^0 SW. The strata of the Tertiary which have taken part in the overthrust movement have later been removed by erosion. Finally a fault has been formed through the mountains south of the Tertiary field, the north-eastern part, in which the remaining Tertiary strata are found, sinking about 500 metres. The preservation of the coal-field up to the present time is thus due to the overthrust and the fault.

A number of north-and-south faults, probably formed simultaneously with the great fault mentioned above, cross the coal-field. These faults have throws amounting to as much as 100 metres, and they divide the field in at least 6 different parts, which must be worked separately.

Coal-Seams. Within the Tertiary strata there are many coal-seams of which at least five or six seem to be workable. The coal is exclusively a cannel containing up to 20 per cent of crude oil, and having a comparatively high content of ash. Some of the shales next to the coal-seams are also oil-bearing, with as much as 8 to 9 per cent of oil.

The seams show a somewhat varied development with regard to thickness and quality. Only in the central part of the field is the thickness of the coal-seams fairly well known, whereas in the other parts the amount of investigation done is not sufficient for any exact valuation of the field.

The Esther seam is the lowermost. It was found in the summer 1924 in the central part of the field, lying 10,5 metres above the Permo-Carboniferous strata. Near the outcrop the seam was 1,80 metres thick with a layer of sandstone, but the thickness appears to vary considerably. The seam extends probably over an area of about 4,4 square km. It is now being worked. The coal is rich in oil, contains much sulphur, and cakes very easily.

About 10—15 metres above the Esther seam is the Sofie seam. Its presence was not proved with certainty till the summer of 1923. In the central part of the field the pure coal of this seam is from 1,25 to 1,50 metres thick. The seam extends over an area of 4,35 square km., but the thickness is not known in the western part of the field. It contains probably 6,5 to 7 mill. tons of coal.

The Advokat seam occurs about 14 metres above the Sofie seam. Some exploratory workings have been started on this seam. The thickness is from 0,8 to 1,3 metres including 2 or 3 beds of coal with interbedded layers of oily shale. It has an area of about 3,8 square km. and contains probably a total quantity of coal of about 5 mill. tons. The percentage of ash is high, the coals are therefore best suited for oil production.

The Agnes-Otilie seam lies about 70 metres above the foregoing. In the Otilie mine the thickness is about 1 metre, divided on 2 or 3 beds with interbedded layers of shale and sandstone. At the new workings farther west the thickness is reported to be 1,5 and 2,3 metres respectively. The total area of this coal-seam is about 2,16 square km. and the probable total quantity of coal about 3,1 mill. tons. About 75000 tons have been exported from this seam.

The Josefine seam, which lies about 21 metres above the preceding one, is now being mined in the central part of the field. The thickness has averaged 1,4 metres but with considerable variations. The area may be estimated at 1,2 square km. and the quantity of coal at about 2,5 mill. tons. Up to the autumn of 1924 about 265000 tons of coal were exported from the Josefine seam.

The Ragnhild seam about 30 metres above the foregoing appears to have an average thickness of about 60 to 80 cm. The total area is about 0,8 square km. and the estimated amount of coal about 700000 tons.

The total amount of coal present in the Kings Bay field is probably 18—19 mill. tons[1], but as this field has not yet been sufficiently examined the figure cannot be fixed with certainty.

From what is mentioned it will be seen that the lower coal-seams cover the largest areas, and these seams, therefore, will play the most prominent part in the future development of the field.

c. *The Coal-Field at Mt. Kiær.*

At the shore between Kings Bay and English Bay to the west of Mt. Kiær on the Brøgger Peninsula a coal-seam belonging to the lowest part of the Lower Carboniferous (Culm) outcrops about 15 metres above sea level. The Kings Bay Kul Comp. A/S states the total thickness of this seam to be about 3 metres. Nothing is known about the area occupied by it. The coal is of a poor quality, being very impure.

d. *The Coal-Field on the East Side of the Foreland Sound.*

At this place there is a small Tertiary area, bounded on the east side by a fault line. It stretches from St. Johns Bay to English Bay,

[1] Not including the Esther seam, which is little known.

a distance of 23 km., and is 2 or 3 km. wide; the area is 42 square km. Chips of coal have been found at this occurrence in the moraine on the north side of Aavatsmark Glacier (11 km. south of English Bay) and in a brook on the north side of the glacier. Coal is also met with in solid rock in the bed of the brook mentioned. Here was found a band about 10 cm. thick and only a few metres long, included in a sandstone, and looking like a charred tree trunk. The peculiar woody structure that becomes distinct in this coal after being burnt for some time, may indicate that at least some of it originates from such charred tree trunks. Considering the great quantity of the pieces of coal found it is very probable that the glacier has cut through a non-exposed coal-seam.

e. *The Coal-Field on the West Side of the Foreland Sound.*

In this locality there is a narrow area bounded on the west side by a fault line and containing Cretaceous and Tertiary strata. It extend from the north end of Prince Charles Foreland about 40 km. towards the south, and has a width of 2 or 3 km. Traces of coal have been found within this area.

f. *The Coal-Field at Cape Lyell.*

This is a small detached area lying on the headland west of the mouth of Recherche Bay on the south side of the entrance to Bell Sound. The coal is found in a small Tertiary field stretching along the shore for about 3,7 km. and is about 700 metres wide. The strata dip 30^0 towards NE.

There are several coal-seams, but all are very thin, ranging in thickness from a few cm. to 30 cm. The exact quantity of coal is not known, but it is hardly large. An English company, The Northern Exploration Co., Ltd., has done some development work, but all work is now suspended. There are a few houses and a wireless station at the place.

g. *The Coal-Field at Mt. Hohenlohe.*

Mt. Hohenlohe, 614 metres high, on the south side of the mouth of Horn Sound is built up of Culm sandstone. Fragments of coal have been found in the talus covering the mountain, but no details of this occurrence are known.

II. Bear Island.

a. *Deposits of Devonian Coal.*

As far as Bear Island is concerned, only the coal deposits of the Devonian System occurring in the eastern part of the island have been closely examined. The coal-seams are well exposed in the cliffs

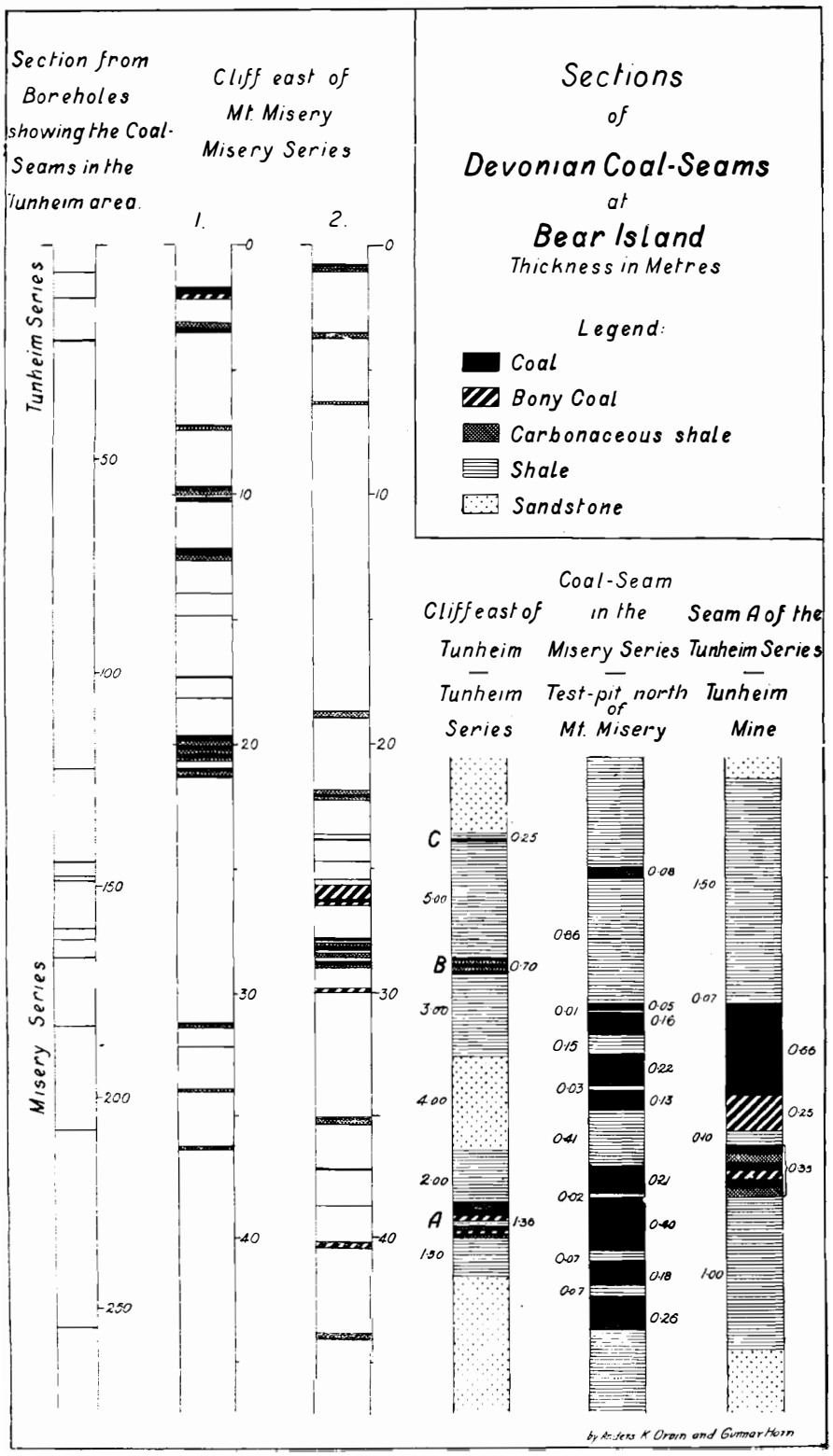

Section from Boreholes showing the Coal-Seams in the Tunheim area.
Cliff east of Mt. Misery
Misery Series
1.
2.
Tunheim Series
Misery Series
0
50
100
150
200
250
10
20
30
40
Sections
of
Devonian Coal-Seams
at
Bear Island
Thickness in Metres
Legend:
Coal
Bony Coal
Carbonaceous shale
Shale
Sandstone
Cliff east of Tunheim — Tunheim Series
Coal-Seam in the Misery Series — Test-pit north of Mt. Misery
Seam A of the Tunheim Series — Tunheim Mine
C
B
A
0·25
5·00
0·70
3·00
4·00
2·00
1·30
1·50
0·08
0·86
0·01
0·05
0·16
0·15
0·22
0·03
0·13
0·41
0·21
0·02
0·40
0·07
0·18
0·07
0·26
1·50
0·07
0·66
0·25
0·40
0·35
1·00
by Anders K Orvin and Gunnar Horn

Fig. 15.

on the east coast and in 4 places borings have been carried out. In this way a number of seams have been proved, but only one or two of them are workable. The Devonian coal-seams extend over nearly the whole island, excepting only the southern Hecla Hoek area. In the north-western part of the island they probably lie 500 or 600 metres below the surface, and their thicknesses are unknown there. At the Ella Lake 2 seams have been proved by a borehole and several trenches. The Devonian coal-seams are rarely more than one metre thick.

b. *Deposits of Culm Coal.*

In the Carboniferous strata a coal-seam has been proved by borings in three places viz, at the outlet of Salmon Lake, south of that lake, and at the southern end of the Hauss Lake. The depths of the coal-seam are 97, 87 and 35 metres respectively. It is, however, doubtful whether the seam is workable. It extends over that part of the island which lies west of a line running from Ella Lake towards, and across, Salmon Lake.

III. Hope Island.

Coal is also found in this island, which is composed of flat-lying beds of sandstones and shales probably of Cretaceous age. In 1924, Mr. THOR IVERSEN, leader of the Norwegian State's Fishery Investigations at Svalbard, brought back from Hopen chips of these coals, but they were not found in situ. Otherwise nothing is known about these occurrences.

3. Coal Reserves.

I. Spitsbergen.

We shall only take into account the seams lying within 600 metres of the surface, having a minimum thickness of 0,75 metre, and a maximum ash content of 12 per cent.

a. *The Great Central Coal Region.*

α. *Reserves of Culm Coal.* Workable coal-seams have only been proved around the inner branches of the Ice Fjord. From the previous statements it is evident that the seams vary a great deal in thickness and number. Thus while the seams of Mt. Pyramide may be as much as 10 metres thick, those occurring north and east of this point are of a more moderate thickness. On account of the variable thickness of the seams it is difficult to give any approximately correct figure for the amount of coal present in the Culm Formation. The estimates of HÖGBOM in "The Coal Resources of the World" of 1913 [41] are certainly far too

high. He based his calculation on the great thickness found at Mt. Pyramide, figuring with that thickness over an area of 930 square km. and thus arrived at the total of 6000 mill. tons.

The only region from which an estimate based on more detailed investigations is available is the region to the north and east of Klaas Billen Bay. In the above-mentioned report of STENSIÖ, this geologist estimates the aggregate thickness of workable coal-seams in Mt. De Geer at about 5 metres at least, and the total quantity of coal as follows:

In Mt. De Geer.....	80	mill. tons.
„ „ Hult.....	50	„ „
„ areas to the north.	150	„ „
Total east and north of Klaas Billen Bay about	280	mill. tons of coal.

In Mt. Pyramide the thickness of the coal-seams is great, and this mountain no doubt contains large quantities of coal.

About the remaining part of the area occupied by the Culm strata the only information available concerning the coal-seams is the result of the borings of the Scottish Spitsbergen Syndicate at the inner end of Gips Valley. The investigation appears to indicate that the seams here are less in number, and thinner. For this region we can hardly reckon more than 1 or 1,5 ton of coal per square metre. From the rest of the Culm area nothing is known of the coal deposits.

The Culm Formation occupies an area of slightly more than 1000 square km. around the inner part of the Ice Fjord. As far as our present knowledge goes, a fair estimate of the total quantity of coal in this region should not run higher than 1500 mill. tons.

β. *Reserves of Cretaceous Coal.* The amount of coal in the seam of the Cretaceous System may be calculated on the basis of an average thickness of 1 metre, and the seam must be presumed to extend over an area of about 1500 square km. in the eastern part of the central coal area in the region east of, and a little west of, a line from Advent Bay to Braganza Bay. If, to be on the safe side, only 1 ton per square metre is reckoned with, this will give a total amount of Cretaceous coal of 1500 mill. tons.

γ. *Reserves of Tertiary Coal.* These are best known from the great basin between the Ice Fjord and Van Mijen Bay. Here two coal-seams most probably extend throughout the area. East of Coles Bay, however, there is locally only one. The two seams at Green Harbour correspond very likely to seams 2 and 3 from below in the region around Advent Bay. The area occupied by these seams is upwards of 2000 square km. The thickness may be fixed at 1 metre for each seam in the west, and considerably more in the east. An

average of 2 tons per square metre will be about correct for the north-western part of the field; it is possibly somewhat high for the south-western part (on the north side of Van Mijen Bay), but too low for the eastern part of the field (Advent Bay and Braganza Bay). On 2000 square km. there will thus be 4000 mill. tons of coal. To this should be added a considerable quantity contained in two or three seams occurring in the eastern part of the field, but not in the western part. Without entering into the details of the calculation this quantity can be estimated at 1000 mill. tons. The total quantity occurring in the relatively well examined Tertiary field between the Ice Fjord and Van Mijen Bay thus amounts to 5000 mill. tons of coal.

The central coal basin thus contains the following quantities of coal between the Ice Fjord and Van Mijen Bay and around the inner parts of the Ice Fjord:

Tertiary coal ...	5000	mill. tons
Cretaceous coal.	1500	„ „
Culm coal	1500	„ „
	Total 8000	mill. tons

This central area has, however, also considerable coal deposits south and south-east of Van Mijen Bay and Braganza Bay. In the western section of the syncline no workable coal-seams have been proved between Van Mijen Bay and Van Keulen Bay, but in the eastern section coal-seams of a thickness up to 1,25 metres have been found, although it is not certain whether there are one or more seams. As mentioned before, coal has also been found at the Stor Fjord, where Mt. Hedgehog is the locality best known, containing coal-seams considerably more than 1 metre thick. It is impossible at present to make any definite statement regarding the quantities of coal occurring in the large Tertiary basin situated south of Van Mijen Bay and extending on the east side of West Spitsbergen as far as towards South Cape and having an area of about 6300 square km. Neither the topography nor the geology of this basin is yet sufficiently known to warrant such a statement. It may be said, however, that this basin contains very large reserves of Tertiary coal, and probably also of Cretaceous coal.

b. *Other Coal-Fields.*

Outside the large central area there are the smaller coal areas previously mentioned, viz., the Kings Bay field, the field at Mt. Kiær, the fields on either side of the Foreland Sound, the field at Cape Lyell, and the field at Mt. Hohenlohe. Of these only the Kings Bay field

has been properly examined, and it is no doubt the most important of those mentioned, containing about 20 mill. tons of coal.

It is apparent, then, that the quantity of coal occurring in these fields is insignificant compared with the quantities of the large central coal area.

II. Bear Island.

The coal-bearing strata of Bear Island occupy an area of 145 square km., or 81 per cent of the total area of the island. Several coal seams occur, but, as their thicknesses and quality are not sufficiently known, it is not possible for the time being to give any definite figure as to the quantity of coal in the island.

4. History of Coal Mining.

Since the beginning of the 17th century coal has been known to occur in Spitsbergen, but not till the beginning of the 20th century did the idea of a commercial exploitation of these coal occurrences arise. Four Norwegians, Messrs. SØREN ZACHARIASSEN, HENRIK B. NÆSS and B. PEDERSEN, all sealing captains from Tromsø, and Mr. IVAR STENEHJEM, a merchant from Vardø, share the honour of having started the first companies and claimed land with the object of exploiting the coalfields of Spitsbergen as a commercial enterprise. The four companies founded by these people in the years 1900 and 1901 had not a very strong financial backing, however, and after a certain amount of exploratory work had been done their properties passed into foreign hands. The company started by Mr. NÆSS (Trondhjem—Spitsbergen Kulkompani) sold their field (on the west side of Advent Bay) in 1904 to the Arctic Coal Co., an American company registered at Boston, whose moving power was Mr. JOHN M. LONGYEAR. Together with Mr. FREDERICK AYER, the other main stockholder in the company, Mr. LONGYEAR founded still another company, Ayer & Longyear, which claimed large areas between Coles Bay and Green Harbour, between De Geer Valley and Sassen Valley, and at Cape Boheman. The Arctic Coal Co. turned out to be a factor of the greatest importance to the Spitsbergen coal-mining industry. The mine of the company, located on the west side of Advent Bay, was worked on Tertiary coal of the second seam counted from the base of the formation. In the course of a few years the mine was developed at such a rate that at the beginning of the Great War it had an annual production of 40 000 tons, the operations showing such good economic results that a profitable enterprise could be hoped for as soon as the output was large enough.

At about the same time as the American purchase of the fields of the Trondhjem company on the west side of Advent Bay took place, an English company, The Spitsbergen Coal & Trading Co., Ltd. was

formed in Sheffield for the purpose of buying the fields which Mr. B. PEDERSEN, acting on behalf of a company in Bergen, had claimed on the east side of Advent Bay. This English company started its workings on the Cretaceous coal-seam at Advent City. The company was not a success, however, and withdrew as early as 1908.

The year 1916 saw great changes in the proprietorships of the coal-fields of Spitsbergen. On account of the difficulties caused by the War the Americans sold their fields to a Norwegian company, Store Norske Spitsbergen Kulkompani Aktieselskap, which also bought three Norwegian claims on the east side of Green Harbour.

In the same year The Spitsbergen Coal & Trading Co. also sold its field to a Norwegian Company, A/S De Norske Kulfelter Spitsbergen.

By these sales the most important coal-fields of Spitsbergen again passed to Norwegians.

While these company formations and transactions were going on vast areas were claimed by new companies. The more important of these claims are mentioned below.

I. Norwegian Claims. In 1909 the coal-field at Kings Bay was claimed by Mr. CHR. ANKER, Fredrikshald, who sold it in 1916 to a Norwegian company, Kings Bay Kul Comp. A/S of Ålesund.

In 1908 a syndicate represented by Mr. CHR. ANKER took over the field east of the middle part of Green Harbour which had been claimed previously in the same year.

In 1918 Mr. F. HIORTH of Oslo, acting on behalf of a syndicate, arranged the claiming of the country east of the southern part of Green Harbour.

In 1909 the company A/S Kulspids claimed coal-fields between Green Harbour and Coles Bay.

The three claims just mentioned all passed to Store Norske Spitsbergen Kulkompani, when it was formed in 1916.

In 1911 The Norwegian Exploration Co. claimed coal-fields east of Coles Bay and on both sides of Sassen Bay.

In 1912 a syndicate from Stavanger claimed coal-fields east of the northern part of Green Harbour, south of Coles Bay, on Prince Charles Foreland, and south of Van Mijen Bay. In 1914—1915 the fields east of Green Harbour were sold to a Russian company, while the remaining fields were taken over by a company named A/S Stavanger Spitsbergen.

In 1916 the company A/S Svalbard Kulgruber was founded. Partly by purchase of older rights, and partly by claims made that year it acquired coal-fields south-west of Advent Bay and south-east of Green Harbour.

2. Foreign Claims. In 1905 two Englishmen, Mr. ERNEST MANSFIELD and Rev. F. T. GARDNER, made claims which were later

taken over by the Northern Exploration Co., Ltd., London. This company subsequently extended its claims quite considerably, and is now claiming the proprietorship of vast areas in a number of places in Spitsbergen. The company is an exploring and landholding company and has never exported anything.

In 1910 a Swedish expedition, sent out by Jernkontoret and Grängesbergsbolaget, under the leadership of B. HÖGBOM, took possession of several coal-bearing areas near the Ice Fjord and Van Mijen Bay. These fields were afterwards transferred to the Svenska Stenkolsaktiebolaget Spetsbergen of Stockholm.

In 1906 Mr. W. S. BRUCE, the Scotch Polar explorer, made claims which were afterwards taken over by The Scottish Spitsbergen Syndicate, Ltd. of Edinburgh. These claims have later been considerably extended. The company is a landholding and exploring enterprise.

In 1912 a Russian company sent out an expedition led by Mr. RUSSANOV, a geologist. This expedition claimed land on the south side of Ice Fjord to the east of Coles Bay. The field was subsequently transferred to an English company, The Anglo Russian Grumant Co. Ltd. of London.

In 1919 a Dutch syndicate bought the stock of the Kulgrubekompagniet Isefjord founded in 1900 by Mr. SØREN ZACHARIASSEN (one of the four pioneers mentioned above). Mining operations were started in 1920 on the Cretaceous coal-seam at Cape Boheman, but gave poor results, and were discontinued already in 1921. Then the Dutch shareholders founded the N. V. Nederlandsche Spitsbergen Compagnie in 1920 for the purchase of coal-fields situated east of the northern part of Green Harbour. These fields had originally been claimed by various persons and companies, chief among which were Kulgrubekompagniet Isefjord and the Stavanger company already mentioned (founded in 1912). After some dispute these holders agreed to sell their rights to a Russian syndicate, Russiske Kulfelter i Green Harbour (Russian Coal-Fields at Green Harbour), and the latter sold the western part of the fields in 1921 to the Dutch company, keeping the eastern part adjoining Coles Bay.

Besides the companies mentioned, a number of other companies and private persons have claimed coal-fields. All told, Spitsbergen has nearly 100 different claimholders.

In Bear Island, too, the first coal-field territory was claimed about the end of last century. Here the Germans were pioneers, the first claim being made in 1898 by Mr. THEODOR LERNER, a German publicist. This claim did not originally apply to coal-deposits, but to territory for hunting purposes. The next year, however, Mr. LERNER returned with an expedition and took possession of the greater part of the coal-bearing territory of the island on behalf of a Hamburg company.

In the same year another German company, Deutsche Seefischerei-Verein of Bremen, also tried to acquire coal-fields on the island. A lively contest ensued, but finally the two parties combined, and sent a joint expedition to the island in 1900, whereupon the enterprise was given up. The Germans, however, paid brief visits to Bear Island in 1912 and 1924.

In the autumn of 1915 the whole of Bear Island was claimed by a Stavanger syndicate, which started exploring and working the coal deposits. In 1918 the island was transferred to a joint stock company, Bjørnøen A.S., which has continued mining ever since.

From what has been stated above, it will appear that the history of occupation and mining of the coal-fields of Spitsbergen and Bear Island falls into three periods:

1. 1899—1904. A period with Norwegian interests dominating. The first companies were founded and the first occupations and explorations took place.

2. 1904—1915. An American-British period. Commencement of mining, the first exports taking place in 1907. The pioneer work of the Americans, in particular, proved that coal mining on a commercial scale is possible in Spitsbergen. During this period claims were made by Britishers, Swedes, and Russians.

3. 1916. The year 1916 is noteworthy as being the year in which Norwegians again got the lead in coal-mining operations in Spitsbergen. The change was brought about by the transfer to Norwegian companies of all American coal-fields and one British. The richest and most favourably situated fields are now in Norwegian possession, and Norwegian mines rank also first as regards output. In addition to the other countries Holland must now also be taken into account.

The War, with the enormous coal-prices, gave a strong impetus to the coal mining of Spitsbergen and Bear Island, and the excellent ice conditions prevailing from 1918 onwards have further helped to give it a rapid growth during these years.

5. Mining Ordinance for Spitsbergen and Bear Island (Svalbard).

Chapter I.

Introductory Provisions.

1.

The present Mining Ordinance shall apply to the entire Archipelago of Spitsbergen (Svalbard), comprising, with Bear Island, all the islands situated between 10° and 35° longitude East of Greenwich and between 74° and 81° latitude North, especially West Spitsbergen, North East Land, Barents Island, Edge Island, Wiche Islands (Kong Karls Land), Hope Island (Hopen) and Prince Charles Foreland, together with all islands great or small and rocks appertaining thereto.

2.

1. The right of searching for and acquiring and exploiting natural deposits of coal, mineral oils and other minerals and rocks which are the object of mining or quarrying, subject to the observance of the provisions of this Mining Ordinance and on equal terms with regard to Taxation and in other respects belongs, in addition to the Norwegian State, to:

a. All nationals of those States, which have ratified or adhered to the Spitsbergen Treaty.
b. Companies that are domiciled and legally established in any of the said States.

A company is considered as domiciled in the State in which its Board has its seat.

2. That a person or a company fulfils the conditions here stipulated, must at the demand of the Commissioner of Mines be verified through a proper affidavit of a competent authority in their home country, and the competency of such authority if it is not a Norwegian authority, must be certified by a Norwegian Legation or Consulate in the country concerned, or by the Legation or Consulate in Norway of such country.

3. Any dispute as to whether a mineral or rock is of such nature as mentioned, sub Section 1, shall be finally settled by the Government Department concerned on report of the Commissioner of Mines.

3.

1. Persons who have no domicile, nor any permanent place of residence in Norway or in Spitsbergen (Svalbard), and Companies, the Boards of which have not: their seat in Norway or in Spitsbergen (Svalbard), in order to be able to acquire and exercise the rights mentioned in Paragraph 2, must have an attorney permanently resident in Norway or in Spitsbergen (Svalbard), whose name, position and place of residence have been reported to the Commissioner of Mines, and who is empowered to represent them in Court and towards the authorities in all cases concerning searchings, claims or mining operations in Spitsbergen (Svalbard).

2. Upon a failure to comply with this requirement, the Judge of the Inferior Court, at the place where the Commissioner of Mines has his office, at the request of any one interested, may name an attorney. Such attorney shall have the same authority as mentioned sub Section 1, until the party concerned reports the appointment of another attorney.

4.

1. Any application to Norwegian authorities that has to be made within a certain term, pursuant to this Mining Ordinance, must be filed with the Authority concerned before the expiration of such term.

2. If an application be not worded in the Norwegian language, the Authority concerned may demand a translation thereof, duly certified, to be submitted within a certain term and, upon a failure of the applicant to comply therewith, may refuse to consider the application.

5.

1. The powers which according to the Mining Ordinance are conferred upon the Commissioner of Mines, the Government Department concerned, to such extent as needed, may transfer to inferior officers of the Mining service.

2. The decisions of such officers may be submitted to the Commissioner of Mines for reconsideration and the decisions of the Commissioner of Mines likewise to the Government Department, provided the decisions have not been given during a claim survey in which case the procedure of Paragraph 13 applies.

3. The decisions of other inferior administrative Authorities, with reference to the Mining Ordinance, also may be submitted to higher Authority for reconsideration.

6.

Members of the Public Service of Spitsbergen are not allowed to notify any discoveries, to obtain any claims or to be proprietor of, or partner in any claims, nor to be agents for sale of discoveries or claims in their districts.

Chapter II.

On Search and Discoveries.

7.

1. The search for natural deposits of the minerals and rocks mentioned in Paragraph 2 may be made on one's own property as well as on that of any other party, and on the Public Lands.

2. Any person who desires to search on the property of some other party or on the Public Lands, must have a licence from the Commissioner of Mines or from the Chief of the Police, and he is bound to produce such licence on request.

3. The licence shall be valid for two years from the date of issue, and confers upon the searcher the right of undertaking any work considered necessary or expedient in order to search for the minerals and rocks mentioned in Paragraph 2, or in order to examine discoveries already made, also including work, the object of which is to make a preliminary examination of the deposit in order to decide whether it is worth working.

4. No search must be made within the claim of any other party, unless the holder of the claim has given the permission.

5. No search must be made within a distance of 500 metres from any factory or industrial establishment under construction or in operation, any line of transport or quays or from any dwelling house, not including huts for hunting, fishing or whaling expeditions which are only occasionally used, unless consent be given by the proprietor and tenant of the plants or the building. Nor must any search be made within any such distance from any public or scientific establishment, church or cemetery.

8.

1. The searcher is bound to indemnify any damage which, through the search, is caused to the proprietor of the ground or any other party.

2. Any one preventing any party from lawful search shall indemnify any provable loss which the searcher has suffered through any futile journey or otherwise.

9.

1. Anybody who, by lawful search, shall discover a natural deposit, containing or supposed to contain minerals or rocks as mentioned in Paragraph 2, acquires thereby, in preference to subsequent discoverers, a right to the discovery, provided he, in the presence of two witnesses, by marks in solid rock or, by other lasting and satisfactory means, visibly locates a discovery point, and besides, not later than 10 months after having located the discovery, through a written notification informs the Commissioner of Mines thereof.

A discovery notice may also, before the expiration of this term, and with full legal effect, be filed with the Chief of Police, who in that case as soon as possible shall transmit it to the Commissioner of Mines.

2. The discovery notice must be signed by the claimant and shall contain:

a. The name, domicile and nationality of the claimant and the witnesses, and—in the cases mentioned in Paragraph 3—the name and address of the appointed attorney.
b. Accurate description of the situation of the discovery point and of the kind of marks used, accompanied by a sketch-map on a scale of not less than 1 : 100 000 on which the discovery point shall be marked.
c. Exact statement of the moment when the discovery was marked.
d. Information of the nature of the discovery under reference to a sample, handed over at the same time, of the minerals or rocks found.
e. Reference to an enclosed declaration from the witnesses that the discovery point was marked in their presence and when and how the marking took place.

3. Anybody who wants to notify several discoveries must for each of them file a separate discovery notice.

4. If a discovery notice which does not comply with the prescriptions of Sections 2 and 3 has been filed in due time, the right to the discovery is preserved if the defects are remedied within a term to be fixed by the Commissioner of Mines.

5. The provisions in Sections 1—4 are correspondingly applicable when any party wil take up a deposit which has reverted to the Public Lands, whether it has been worked or not.

10.

1. The right to a discovery which has been acquired by a discoverer according to Paragraph 9, besides the right of carrying out on the place of discovery the operations mentioned in Paragraph 7, Section 3, also entitles him, in preference to subsequent discoverers, to demand a claim on the discovery point.

2. The right to the discovery lapses if an application for a claim survey has not been filed with the Commissioner of Mines within 5 years after the discovery was marked, or if any other party before the expiration of the said term has obtained a claim on the discovery point comp. Paragraph 12, Section 2 d.

3. The right to a discovery that has been filed for record may be transferred. The transfer is not valid before having been notified to the Commissioner of Mines.

Chapter III.

On Claim Patents.

11.

1. The claim survey shall be made by the Commissioner of Mines at the latest within 2 years after an application has been filed, if natural conditions or any other circumstances do not make it impossible.

2. The time for such survey shall be notified in the official Gazette designated for the purpose within the end of the month of March of the year in which the survey is to be held.

The notification shall contain:

a. The name, the domicile and nationality of the applicant.
b. Information concerning the situation of the discovery point and the time reported for the marking of the discovery.
c. The time and the place for the survey.
d. Summons to all, who claim to possess a better right to the claim to meet and look after their interests during the survey.

The Commissioner of Mines besides should send reprints of the notification to those who are supposed to be interested in the survey.

It is, however, of no consequence for the furthering of the survey, that such information has not been transmitted or not been received by the party interested.

3. Kr. 500,00 shall be paid for the dealing with an application for a single claim.

If an applicant asks for several claims in the same neighbourhood and at the same time, or if several applicants jointly ask for claims in the same neighbourhood and at the same time, kr. 200,00 shall be paid for each additional claim stated in the application. The claims applied for are considered as lying in the same neighbourhood, when between the discovery points which are lying farthest from each other the distance does not exceed 30 kilometres.

Payment for a claim survey shall be made to the Commissioner of Mines simultaneously with the application for same.

12.

1. On making the claim survey the Commissioner of Mines first decides whether the applicant is entitled to obtain any claim.

2. If so, he makes the survey observing the following provisions:

a. The discovery point must lie within the boundaries of the claim.
b. If several discovery points that are recorded are situated so near to each other that the right to get a claim on one of the discoveries is dependent on the manner in which a claim is given for another discovery, he who first has marked a discovery point may choose in what manner he wishes the survey to be undertaken. If he does not attend the claim survey, the Commissioner of Mines shall decide in what manner the claim for his discovery is to be subsequently given, if he demands a claim.
c. The claim shall be given as a plain superficies having a square content as per the request of the applicant and the character of the deposit up to 1000 hectars. Ordinarily the claim shall be given in the form of a rectangular parallelogram, the length and breadth of which are fixed by the applicant himself, the limitation being that the length may not be more than 4 times the breadth. Dispensations from the rectangular form should be given by request of the applicant, when this is dictated by the configuration of the coast-line or other natural boundaries, and provided that the claim in no direction exceeds a length of 7 kilometres. The boundaries are comprised within vertical planes passing through the boundary lines on surface and projected indefinitely downwards.
d. If the claim covers several discovery points the right to obtain claim for the rest lapses.

3. The claim survey shall be entered in an authorised book.

The Commissioner of Mines, when requested shall supply a verified extract of the book against a fee of kr. 2,00 per sheet or part thereof.

4. When a claim has been granted, the Commissioner of Mines shall send to the applicant a patent for each separate claim which according to the claim survey has been allotted to him.

A proclamation of the issuing of such patent shall be published in the public Gazette instituted for that purpose.

13.

1. If any party intends to contest the decisions of the Commissioner of Mines in a claim survey, proceedings must be commenced within 6 months after proclamation of the issue of the patent has appeared in the public Gazette, or if survey has been refused within 6 months after such refusal.

2. The claim is final when the time for beginning an action has expired without such action having been instituted or when an action instituted in proper time has been validly decided, withdrawn or dismissed.

14.

1. When the claim has become final the holder of the claim has acquired the sole right to extract all the minerals and rocks mentioned in Paragraph 2 through mining operations within the claim, provided that he complies with the requirement to work made incumbent on him in Paragraph 15.

2. The holder of the claim is entitled to mine and retain other minerals and rocks to such extent as is necessary or expedient for the operations. What has been mined but not used in the said manner may be disposed of by the proprietor of the ground.

3. Any voluntary or compulsory transfer of the right to a claim and any voluntary or compulsory establishment or transfer of mortgage rights or any other rights to a claim can with full legal effect only be done in the manner stipulated for real estate.

4. On the application of the holder of the claim the Commissioner of Mines may divide a claim by making part of it a special claim. The division is to be made without a claim survey on the spot. Otherwise Paragraphs 12 (3 and 4) and 13 are to be applied.

The fee is kr. 200,00 for each claim to be divided from the original claim.

15.

1. When 4 years have elapsed from October 1st of the year after the claim became final the holder of the claim is bound to commence mining operations within the claim to such an extent that in the course of each succeeding period of 5 years at least 1 500 men-days work are employed in mining operations in the claim.

2. For a number of not more than 25 claims, which in their entirety are lying within a distance of not over 15 kilometres from a fixed point, indicated by the claim-holder to the Commissioner of Mines, such obligatory work of the claim-holder shall be considered as having been performed when he inside one or more of these claims performs as many days' work as imposed upon him by art. 1 for all claims aggregately.

3. Reports concerning the number of days' work performed during each working year, counting from October 1st one year until September 30th the next year, shall be delivered to the Commissioner of Mines before the following 31st of December.

4. When a petition is delivered to the Commissioner of Mines in the course of a period, or at the latest on December 31st of the year in which the period elapses, the Government Department concerned on the report from the Commissioner of Mines, may dispense from the provisions in Sections 1 and 2 for the period in question by exempting from the duty of working, or by reducing the number of days' work required for the fulfilment of such duty.

The conditions for such dispensations are:

a. that the holder of a claims proves that essential hindrances for which he cannot be made answerable are or have been checking the operations, such as special and passing circumstances connected with the operations, or with the utilisation or sale of the products or,
b. that the holder of a claim proves that one or more claims which he wishes to be left out of consideration in the calculation of the days' work are necessary as a reserve for claims which are being worked.

16.

1. Should any holder of a claim fail to comply with the requirements for work according to Paragraph 15 Sections 1 and 2 without having in due time applied for and obtained dispensation, his claim lapses at the end of the calendar year following, provided he does not in the course of same make up for lost work besides performing the average number of days' work which belong to one year of the new period.

2. If sufficient work has been done to maintain the right to one or more of the claims, but not to all of them, the Commissioner of Mines shall decide which claims are to be considered as lapsed, provided the holder of the claim has not made his choice and stated same to the Commissioner of Mines within the expiration of the year mentioned in Section 1.

3. When a claim has lapsed according to the above provisions, neither the claim nor any part thereof can again be allotted to the

holder of the claim nor to any Company in which he possesses a majority of the shares, in case another holder of a registered discovery makes an application for a claim within the said area before the expiration of the current period of 5 years.

17.

1. When the claim has become final, the annual due to be paid by the holder of the claim is up to kr. 500,00 for each claim. For this due the State shall have a first priority mortgage right in the claim concerned, and the due may be collected in accordance with the rules fixed for the collection of taxes on real estate.

2. If, by sale of the claim in execution, sufficient covering of outstanding dues is not obtained, the claim lapses. Then it may not again be allotted to the holder of the claim, nor to any Company in which he possesses a majority of the shares, unless the dues outstanding together with costs have first been paid including also the dues which have accrued in the meantime.

18.

Besides in those cases mentioned in Paragraphs 16 and 17 a claim lapses when the claim-holder, after having paid the dues owing, through a written declaration to the Commissioner of Mines, abandons his right to the claim. In that case the provisions in Paragraph 16, Section 3, have a corresponding application.

Chapter IV.

On the Relation to the Proprietor of the Ground.

19.

1. The proprietor of any private ground on which a claim has been given is entitled to a participation in the operations for not exceeding one-fourth. If he desires to make use of this right he must notify the holder of the claim of the share which he claims, within one year after the patent was published in the official Gazette. He may then also demand that a corresponding part of what has been extracted is to remain on the spot until an agreement has been established as to the terms of participation.

If a claim has been given on the ground belonging to several the proprietors are entitled to participate jointly in the operations for not exceeding one-fourth, the expenditure and income being divided equally amongst them. If any of said proprietors is unwilling his interest shall become the property of the others.

2. When the proprietor of the ground or any other party to whom he may have transferred his rights has declared his willingness to parti-

cipate in the operations, a written contract shall be made concerning the terms, on the basis, that the proprietor of the ground or the holder of his rights is bound to participate proportionately to the share he demanded in all the costs of the operations and the establishments for the utilisation of the output and with a right to participation in the profits, in both cases from the commencement of the operations.

If the parties do not agree, either of them, within 6 months after the expiration of the time mentioned sub section 1, may demand the Commissioner of Mines to fix the terms. If the proprietor of the ground will not accept the decision of the Commissioner of Mines he may, within 6 months after it was made known to him, either transfer his rights to someone who accept the terms or withdraw from any participation in the operations.

20.

1. A claim-holder has the right to demand the assignment by the Commissioner of Mines of the ground needed for footpaths, roads, railways, tramways, aerial ropeways, dumps, surface buildings, stores, quays and other establishments connected with the working of the mines.

2. Within the areas mentioned in Paragraph 7, Section 5, no other cession can be claimed than that which is needed for the operations of any claim-holder for footpaths, roads, railways, tramways, aerial ropeways, power transmissions and quays. For the acquisition of the control of the ground in such places the permission of the Commissioner of Mines must be obtained in default of an agreement. Before any decision is made, the Commissioner of Mines shall give the proprietor of the ground and other holders of rights the opportunity of being heard. A permission must not be given unless the Commissioner of Mines finds that the interest of other parties be not thereby materially prejudiced, and conditions for the security against such prejudice shall be made if necessary.

3. For any damage and inconvenience caused through cessions i accordance with Section 1 or 2 the proprietor of the ground as well as any other holders of rights may claim an indemnification which, failing an agreement, shall be fixed by a Survey.

4. The ground ceded by a proprietor according to Section 1 or 2 shall revert to the main ground as a full property when the use has been finally waived, or when the claim has lapsed.

After the final discontinuation of the operations the holder of a claim has a period of 3 years to clear the ground to such extent as he may desire. What has not then been removed shall belong to the proprietor of the ground. If, however, within the time mentioned, any party has obtained a new claim on the abandoned mine, the previous holder of the claim has the right to transfer to the new holder his establishments, houses and machines.

Chapter V.

On Mining.

21.

The provisions in this chapter concerning mines shall have a corresponding application to surface working as far as they are suitable.

22.

1. The working of a mine shall be effected in a minerlike manner.

2. He, or those, who are to superintend the technical management on the spot, must have the necessary professional knowledge and experience.

3. No mine workings must be commenced in those places where search is prohibited according to Paragraph 7, Section 5, except by permission of the owner or the user of the ground; nor may underground work take place on these premises, unless the work, exclusively to the judgment of the Commissioner of Mines, is of such nature or is carried on in such a way that no subsidences are caused thereby or no other damage is inflicted on buildings or plants on the surface. No permission as mentioned above is needed, however, if such buildings or plants have been erected after the claim has become final.

In order to commence or carry on underground work within the distance mentioned in Paragraph 7, Section 5, from public or scientific establishment, church or cemetery, permission is required of the King

4. At any establishment employing workmen who are not Norwegians, at least one officer must be appointed who understands Norwegian and can make himself understood in the Norwegian language and contingently also in the foreign language commonly used at the mine.

23.

1. At every mine there shall, if the Commissioner of Mines deems it necessary, be kept a record in which shall be entered monthly a report on the operations and everything happening of interest to the mine, and to the conditions of the deposits.

Of this record an extract — made in accordance with a form prescribed by the Commissioner of Mines — shall be sent for each working year, before December 31st, to the Commissioner of Mines.

2. For each mine, that cannot in its entirety be overlooked on the surface, there shall further be prepared a map (mine plan), which must be supplemented as the operations are advancing.

One copy of the map shall be kept at the mine, and another shall be forwarded to the Commissioner of Mines.

3. The information and the maps which the Commissioner of Mines receives according to this Paragraph should only be used for Government purposes and must not be made available to others.

24.

To such extent as may be done without special difficulties and expenses, endeavours should be made in the course of operations to avoid the destruction of any geological and mineralogical formations or any other natural curiosities or places which may be supposed to be of scientific or historical importance.

25.

1. If the holder of a mine for which surveying is prescribed, desires, temporarily or definitely, to discontinue the operations, he shall inform the Commissioner of Mines to that effect as soon as possible.

2. Any timbering and support provided for the safety of the mine, must in such cases not be damaged or removed without the permission of the Commissioner of Mines.

3. Mine openings must be filled or surrounded with a proper fence.

Chapter VI.

On the Protection of the Workmen.

26.

1. The statutory provisions regarding the protection of workmen at any time in force for mining in Norway shall also apply to mining in Spitsbergen (Svalbard), with such modifications and adaptations however as may be ordered by the King, due regard being had to the local conditions.

2. What has been stipulated in Paragraphs 27—33 concerning workmen shall also apply to any other person employed in the operations at the place.

27.

1. The employer is bound to furnish his workmen with healthy and proper dwellings, and, as far as circumstances permit, to provide sanitary arrangements.

Further instructions concerning the manner of building and the fitting up of the houses shall be issued by the Government Department concerned. The Department also may make it incumbent on the employer to provide for a meeting-hall and a proper collection of books in a language known by the workers.

2. The employer is bound to keep at the establishment a supply of the necessary medicines, surgical instruments and dressing articles.

Further instructions in this respect shall be issued by the Government Department concerned.

3. The Government Department may make it incumbent on the employer to maintain a hospital suitable for the purpose with an isola-

tion hospital and the necessary outfit and attendance, calculated to accommodate as large a number of patients as the Department may decide. When the Department finds it necessary, the employer shall also be required to supply medical attendance on the spot.

28.

1. At the time of the year when the communication with the outside world may be expected to be interrupted through ice, it is incumbent on the employer to take care that there is present at the establishment such supplies of food, clothing and other necessaries of life as his workmen shall need for at least one year's maintenance. The stores shall be distributed in safe depots.

Further instructions for the effecting of these provisions shall be issued by the Government Department concerned.

2. The Chief of Police, in case of emergency, may order, or himself effect, the sending home of as many workmen as he finds necessary in order to make the supplies suffice for the maintenance of those remaining.

Complaint does not cause postponement.

29.

Arms, munitions and explosives as well as alcoholic beverages and narcotics may be imported into Spitbergen (Svalbard) only in accordance with regulations fixed by the King, taking due regard to the needs of the Companies.

30.

1. The net proceeds of the trade which the employer himself or through others carries on with the workmen, or is interested in, at the place concerned, shall after audited annual accounts be used for the general welfare of the workmen. The application of these profits shall be decided by the employer in conjunction with a committee named by the workmen who, in the case of dispute, may demand that the matter be referred to the decision of the Chief of Police. In calculating the nett proceeds of such trade the employer is entitled to deduct a reasonable interest on the capital engaged in the establishment.

2. The provisions of Section 1 shall also be applicable if the employer has any profit on his maintenance of the workmen within Spitsbergen (Svalbard).

31.

1. The employer in the case of illness shall provide nursing of his workmen until they are cured, or at any rate in a condition to be sent home. The home-sending in this case shall be paid by the employer.

2. The employer, moreover, has the duty to render indemnification for the loss of working income during illsnes.

3. The King will fix the further regulations concerning the duty of nursing and concerning the conditions and the amount of the indemnification for loss of working income during illness.

32.

If any workman in doing his work, be hurt by an accident that cannot be ascribed to any intention on the part of the victim of the accident, it is incumbent on the employer, besides the obligations mentioned in Paragraph 31, to pay to the victim or, in the event of his death, to his survivors, an indemnification in accordance with regulations issued by the King.

33.

1. The employer shall give to the Government Department concerned, through a bank guarantee, insurance or in some other manner, satisfactory security for the claims of the workmen. The amount of the guarantee sum shall be fixed and the security offered shall be approved by the Department.

2. If the requirement to give security be not complied with the Government Department may fix a daily fine, running until the matter is settled. The fine shall be collected by distress. It is employed as stipulated in Paragraph 30.

Chapter VII.

Transition Provisions.

34.

1. Persons and Companies who make territorial claims on the basis of acts of appropriations or occupations that have taken place before the signing of the Spitsbergen Treaty, if their claims are notified in conformity with Paragraph 1, Section 1 of the Annex to the said Treaty shall be entitled, without any hindrance from the stipulations in this Mining Ordinance but also without this involving any acknowledgment of their claims, to carry on prospecting and mining operations within the areas claimed, as long as their claims have not lapsed or been rejected pursuant to the provisions of the said Annex. During this interval no other person has the right of prospecting or mining within said areas.

2. The provisions in Chapter V and VI shall also apply to mining operations, carried on according to Section 1, from September 1st of the year after the Mining Ordinance has come into force.

35.

1. The persons and Companies who, pursuant to the provisions of the Annex to the Spitsbergen Treaty, are recognised as proprietors of a certain territory, shall be granted as many claims as they desire within the boundaries of their property, subject to the following conditions:

a. that the act of appropriation or occupation upon which the acknowledged ownership is founded has taken place with a view to utilise the territory for mining operations, or has been followed by development or exploitation for that purpose;
b. that an application for a claim survey, containing information of the nature of the deposit under reference to a sample, contemporarily handed over, of the minerals and rocks found and accompanied by the stipulated fee, is filed with the Commissioner of Mines within 10 years after the claimant's title-deed for the property has been issued pursuant to the provisions in the Annex to the Spitsbergen Treaty Paragraph 1, Section 9, or Paragraph 2, Section 11, provided that the title-deed is or becomes definitive.

The fee to be charged is kr. 500,00 for the first, and kr. 200,00 for each succeeding claim within the boundaries of the same property.

In respect of the persons and companies referred to in this Section, the provisions of Paragraph 11, Section 1, and the last period of Section 3, and of Paragraph 12, Section 1, Section 2 Subsection c, Section 3 and Section 4, shall be applicable mutatis mutandis, while the other provisions of Paragraphs 9 to 12 are not applicable.

2. Until the expiration of the term mentioned in section 1 sub b and provided the application for a claim be filed in proper time, until the claim has become final, the recognised owner has the exclusive right to carry on prospecting and mining within his territory. During this period the provisions in Chapters V and VI are applicable.

3. Individuals and companies mentioned in Section 1 are exempted from the claim dues mentioned in Paragraph 17 for claims acquired pursuant to section 1. The same will apply to claims being asked for under reference to discoveries which they have notified during the 10-years period mentioned in Section 1 b. In other respects the Regulations of this Ordinance apply to the claims.

Closing Provision.

36.

This Mining Ordinance shall come into force from such time as shall be fixed by law.

6. Coal Mining and Coal Export.

I. General Features of Coal Mining in Svalbard.

The peculiar natural conditions of Spitsbergen extend to mining in that country several beneficial effects not enjoyed in other countries. These advantages are briefly indicated below.

The coal-seams usually outcrop in the mountain sides, this permitting their working by means of adits, which are not only cheaper than shafts in construction, but have also a lower cost of operation and larger transporting capacity. Besides, adits permit a simpler and more efficient ventilation.

The coal-seams have generally a low dip. In the large area of continous coal-bearing strata between the Ice Fjord and Van Mijen Bay the dip is generally 2°—3°, maximum 15°. The undisturbed state of the strata permit the extensive application of mining machinery. To these circumstances it is largely due that the output per man is now, after only a few years of operation, about three times as large in the mines of Svalbard as in Great Britain.

The ground is frozen down to considerable depths, presumably 300—400 metres. This is an advantage in several respects. The roof is firm and strong even in mines where it is made up of soft rocks that would hardly keep up in a thawed condition. Only very little timber is therefore needed to support the roof. For the same reason there is no water in the mines, and all pumping — always a cumbersome and expensive operation — is avoided. The temperature in the mines is constant all the year round, about ÷ 3° C. — quite a comfortable temperature for working. Fire-damp has not as yet been observed in Spitsbergen, but explosions caused by coal-dust have occurred.

As there are no buildings, railways etc. on the surface to be protected, no damage is done through the subsidence caused by the excavation of the coal.

All the mines are in the vicinity of export harbours, so that railway transport is avoided.

On the other hand, there are, of course, considerable difficulties attached to mining operations in a country like Spitsbergen. The long dark winter, and the fact that people are then cut off from the outside world may exert a certain depressing influence upon the people wintering, but with the establishment of settled communities this effect seems to vanish. The coal must be stored for several months on account of the short period of shipping. For the same reason the mining companies must import and keep in stock supplies of all necessities of life and all kinds of working materials.

Most of the facts mentioned above also hold good for Bear Island.

Experience has proved that the Norwegians are best capable of enduring the climate, darkness, and solitude of these islands. All coal companies therefore now exclusively employ Norwegian workers, except the Swedish company, who use people from their own country.

Judging from the experience gathered so far, it seems, however, that the advantages of coal mining in Svalbard more than outweigh the drawbacks.

II. Coal Mining and Export at the Mines at present in Operation.

In order to show the efficiency of the working and loading of the coal, a short description of the collieries actually in operation is given below.

a. *Kings Bay Kul Comp. A/S.*

The mines and plants of this company are situated on a level plain smoothly sloping down to the shore on the southern side of Kings Bay. The construction of the plants, and the mining operations, were commenced in the summer of 1917 after exploration work had been done since 1909. Two mines are now in operation, the Esther Mine and Sofie Mine; they were opened up in the winter 1923—24.

The establishment at Kings Bay includes the mines with hoists and other mining equipment, power plant, railway about 2,5 km. long with 4 engines and a large number of trucks, 2 steam-shovels, wharf, store-houses, kitchen for the miners, mess house for the staff, the directors' dwelling, houses for staff and workmen, baths; stables for horses, cows, and pigs, etc.

The pillar-and-stall system of working in used. Hand drilling and blasting without undercutting are used for getting the coal.

For the period from October 1st 1921 to September 30th 1922, the output per shift was 2,974 tons per man underground and 1,623 tons per employee of the company, all told. For the period from October 1st 1922 to September 30th 1923 the corresponding figures were 2,07 and 1 269 tons respectively.

During the winter season from October 1st 1922 to June 1st 1923 there were 115 men employed underground and 40 men at the surface, and a staff of 14 in Spitsbergen and Norway. The population of Kings Bay was 206. During the summer season from June 1st to September 30th 1923 there were 190 men underground and 98 at the surface, and a staff of 10. The production for that year was 89 279 tons.

The coal is brought to the surface through a main slope. The coal is cleaned at the tipplers and then stored at the mouth of the mine. During the shipping season the coal is transported by railway direct

Fig. 1. NY-ÅLESUND, KINGS BAY.
Looking north. A. Koller phot. 14/9 1921.

Fig. 2. NY-ÅLESUND WHARF.
Looking southeast. Hoel phot. 1923.

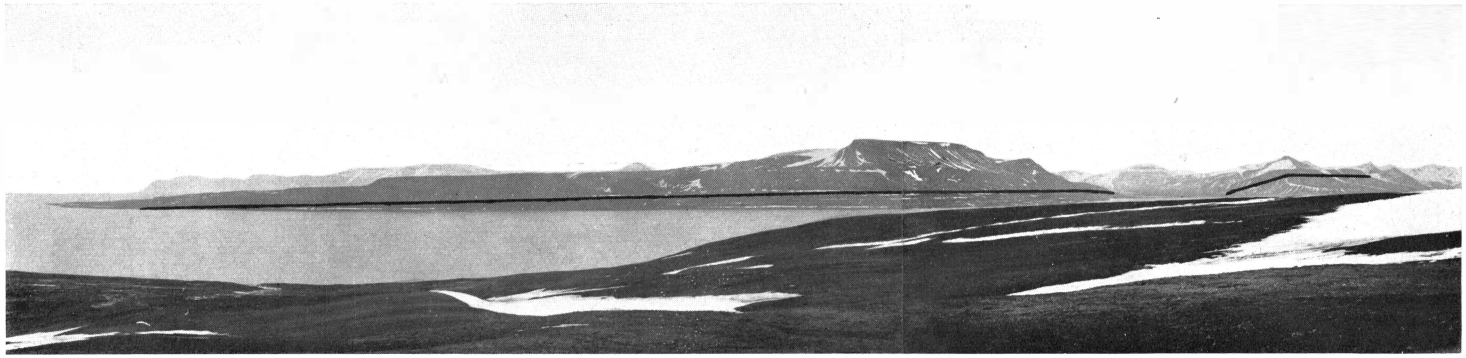


Fig.1. EAST SIDE OF GREEN HARBOUR.
The outcrop of the upper Tertiary coal-seam in black. A. Staxrud phot. 9/7 1912.

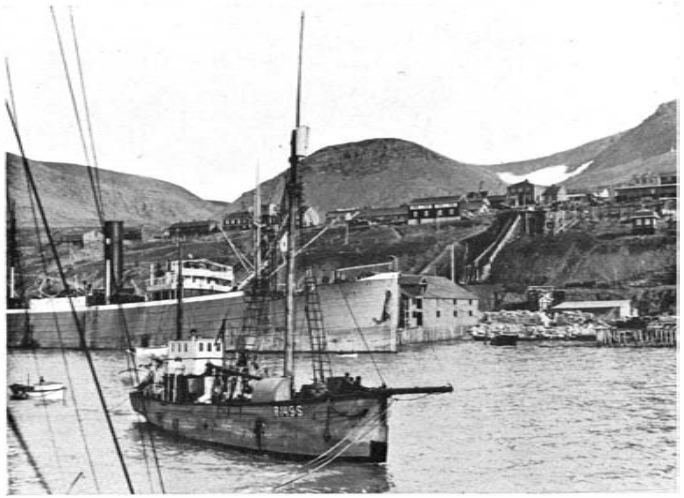


Fig. 2. BARENTSBURG, GREEN HARBOUR.
P. Berge phot. 6/8 1924.

Fig. 3. BARENTSBURG.
Looking SSW. P. Berge phot. 1924.

from the stock piles at the mine to the wharf. The loading capacity of the plant is about 2000 tons per day (24 hours), boats of up to 4000 tons capacity can be loaded.

b. *N. V. Nederlandsche Spitsbergen Compagnie.*

The mine and the plants of this company are situated on a slope on the eastern side of Green Harbour. The two coal-seams outcrop 88 m. and 109 m. above sea level. The distance from the shore is only 450 m.

Both seams are exploited and the coal is now exclusively worked by the longwall system with conveyors of the shaker type. A steam-shovel is used for the loading of the trucks from the stock pile at the entrance of the mine, whereas during the summer the wagons are emptied into a small pocket with a capacity of 45 tons, which directly feed the wagons of the endless-rope haulage leading to the wharf. Here the wagons are hoisted into a loading-tower and their contents dumped into the ship. The existing loading plant has a capacity of 80 tons per hour as a maximum, the average capacity being about 60 tons per hour.

During the development period of 11 months from November 1921 to September 1922 33935 tons of coal were won. The daily output was 2,47 tons per miner and 1,33 per head, all employees included. From November to May operations were confined to hand drilling and blasting without any undercutting, the work being chiefly done from cross-cuts and drifts. In June the use of mechanical coal-cutters was started and the working was restricted to the parts of the mine that were already opened up. With the mine fully developed an output of 3,0 and 2,5 tons per miner and employee respectively is figured on.

At present a new plant for a yearly net output of 250000 tons is under construction. The new installations are to be completed in the summer of 1925. The capacity of the loading-bridge under construction is to be 500 tons per hour and ships of up to 10000 tons capacity are to be employed.

c. *Store Norske Spitsbergen Kulkompani Aktieselskap.*

Longyear City is situated in a small valley running southwards on the south side of the inner end of Advent Bay. The original mine, Mine No. 1 (coal-seam marked with an *, sect. 1, p. 28), lies on the west side of the valley on a steep slope 231 m. above sea level. This mine was worked from 1906 to 1920, when a coal-dust explosion occurred and killed 26 men, and caused a temporary suspension of the work. A new mine on the same seam, Mine No. 2, on the opposite side of the valley 273 m. above sea level was then taken up.

The plants of Store Norske Spitsbergen Kulkompani comprise:

1. Dwellings for about 550 people, church, wireless station, telephone system, central kitchen, bakery, cinematograph, office, shop, storehouses, stable, and cowshed.
2. Steam power plant of the most modern type of 1500 H. P. supplying power to about 70 electric motors, with an older power plant of about 200 H. P. kept as reserve. A modern workshop.
3. Equipment for electric operation of the mine, coal-cutters, chain conveyors, and locomotives of the overhead trolley type.
4. A retarding cable conveyor and an aerial ropeway, 6 km. long, from the mine to the storage plant at Hotelnesset, capacity 100 tons per hour.
5. A modern American storage and loading plant with a storage capacity of nearly 150 000 tons, i. e. the entire winter output, and a loading capacity during the shipping season of about 4 000 tons a day (24 hours). The coal is shipped in steamers loading up to 9000 tons.
6. Aerial ropeway and wharf serving Mine No. 1.
7. 2 inclines with hoists for the raising of men and material to the entrance of the mines.

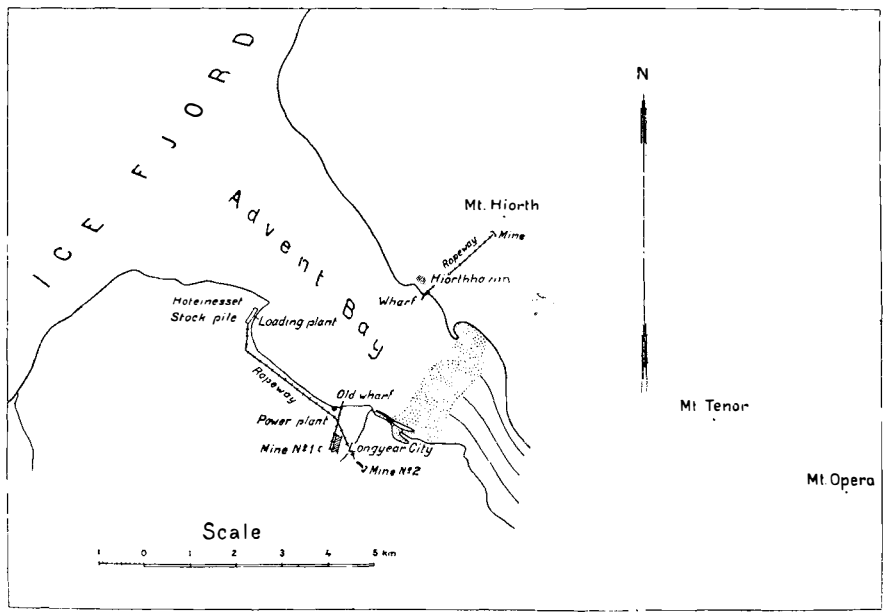


Fig. 16. Map of the surroundings of Advent Bay.

Fig. 1. GRUMANT CITY.
View showing the situation of the camp at the mouth of the Grumant Valley on the southern shore of Ice Fjord. Hoel phot. 11/8 1923.

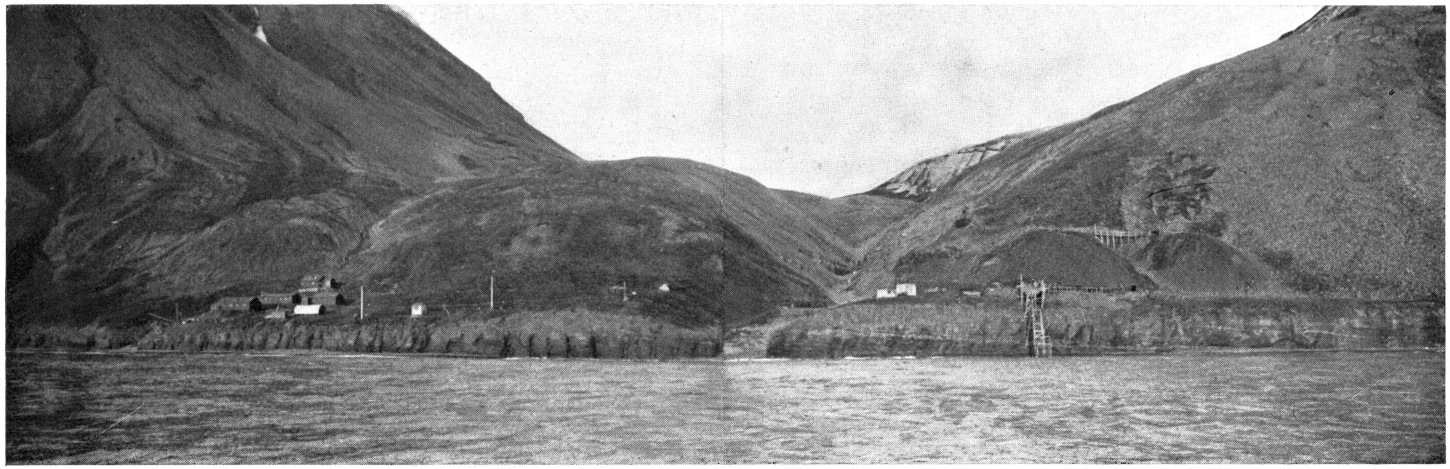


Fig. 2. GRUMANT CITY.
Dwellings to the left, mine and stock-pile to the right. Hoel phot. 11/8 1923.

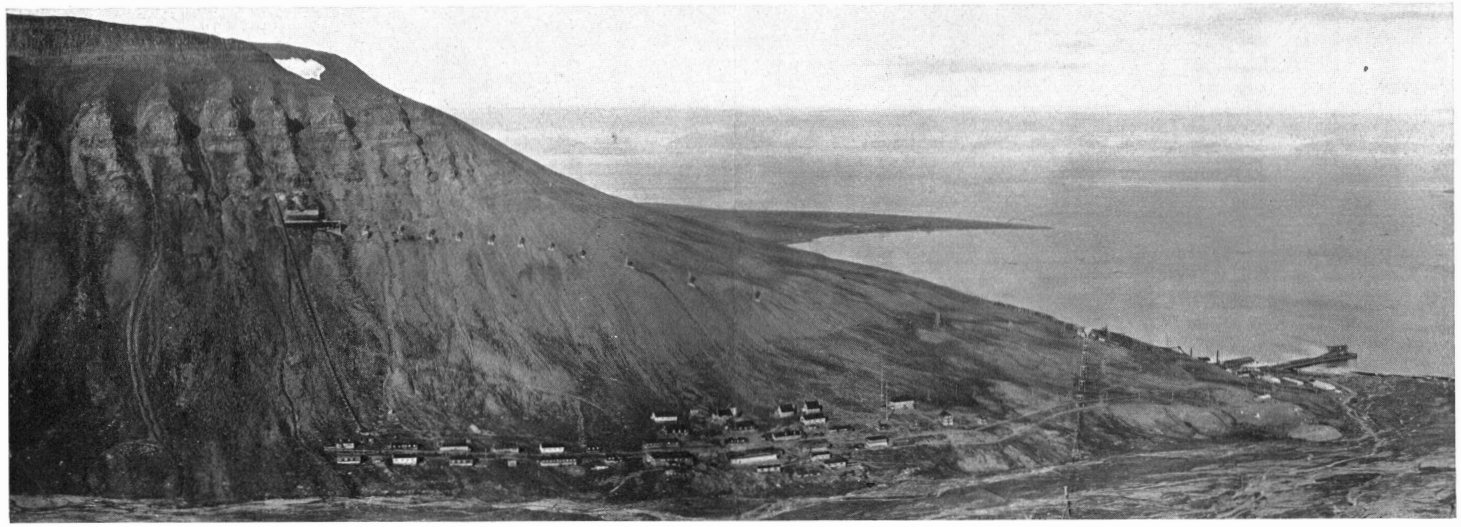


Fig. 1. LONGYEAR CITY.
Mine No. 1, aerial ropeway and old wharf; Hotelnesset in the background. Looking north-west. P. Berge phot. 1924.

Fig. 2. MINE NO. 2, LONGYEAR CITY.
P. Berge phot. 1924.

Fig. 3. STOCK-PILE AND LOADING PLANT AT HOTELNESSET, ADVENT BAY.
Looking south-west. L. W. Conradi phot. 1924.

In working the seam the longwall system has been adopted. The coal-cutting machines are of the chain type and the number of machines at present at work is 10. The removal of the cut coal from the face to the haulage road is effected by means of a conveyor with an endless chain, working along a face of 90 metres. At the present time 8 conveyors are at work. The distance between the haulage roads (crosscuts) is 180 metres. For the main haulage electric locomotives (13 tons) are used, capable of hauling 20 to 25 wagons, each wagon loading 2 tons. The gauge is 3 feet. There are now (1924—1925) 511 people wintering in Longyear City. Of these 433 are on the pay-roll.

The production for the period from July 1st 1923 to June 30th 1924 was 152 502 tons. The average working-force on the pay-roll of the company amounted to 356 persons, of which 270 were employed underground. This gives an annual output per paid person of about 428 and 566 tons respectively. The lost shifts amounted to about 10 per cent.

d. *A/S De Norske Kulfelter Spitsbergen.*

The coal-fields belonging to this company are situated on the north-eastern side of Advent Bay. The company, formed in 1916, has taken over the fields from The Spitsbergen Coal and Trading Company, Ltd., Sheffield, which had worked on the Cretaceous coal-seam at Advent City (at the entrance of Advent Bay). The new proprietors opened up a new mine on the lowest Tertiary coal-seam in Mt. Hiorth just opposite to Longyear City. At the mine, situated at an altitude of 583 metres above sea level, the thickness of this seam is 2,5 metres. The old settlement at Advent City was removed to Hiorthamn, and new barracks and buildings for office, stores, administration, for a total number of about 100 men were erected. A power plant, a wharf for small steamers, and two small temporary aerial ropeways from the mouth of the mine to the storage ground near the shore were put up. And endless-rope haulage brought the coal from the stock pile to the wharf. Coal-cutting machines and everything necessary for the construction of a plant with a yearly production of 150 000 tons, were purchased and brought to Hiorthamn. But after a few years of work the company did not prove a profitable enterprise. It got into financial difficulties and had to suspend operations in 1921. Since that year only a few men have wintered there to protect the interests of the company and take out some coal. This winter (1924—25) the mine is being worked by 10 men.

e. *Svenska Stenkolsaktiebolaget Spetsbergen.*

The mines and camp (Sveagruvan) of the company are situated on the northern side of the inner end of Van Mijen Bay. At the mines, Nos. I and II, the coal-seams outcrop in altitudes of 80 and 70 metres above sea level respectively. The distance to the shore is about 1 km. The erection of the plant and mining operations was commenced in 1917. The upper seam (marked with an * sect. 2, p. 28) has been worked since that year (Mine No. I). The lower seam (marked with ** sect. 2, p. 28) was found in 1920, 10 metres below the upper, and exploitation of this seam was started the same year (Mine No. II).

The mines are worked somewhat differently: In Mine No. I the pillar-and-stall method is used. There is a main adit running approximately along the strike of the coal-seam with crosscuts at right angles to it. The stalls are laid out parallel to the main adit and are 6 metres wide leaving pillars between of from 6—9 metres. These are afterwards extracted. The coal is won by hand-boring and blasting.

Mine No. II is worked by the longwall method. At one working-face an electrical coal-cutter of the chain type is in operation. Otherwise electrically driven boring-machines and blasting are used. In Mine No. I the thickness of the coal-seam is 0,90 metre. In Mine No. II the thickness is considerably more: in the northern workings it is from 1,30—1,70 metres and in the eastern 3—4,50 metres increasing towards the east.

In 1923—24 24,2 per cent of the total output came from Mine No. I and 75,8 per cent from Mine No. II. During the same period the average production per hewer per shift was 4,02 tons in Mine No. I, and 5,18 tons in Mine No. II; per underground hand the figures were 3,2 and 3,4 tons.

In the summer of 1924 the working-force averaged 240 men and this winter (1924—25) there are 216 persons at the mining camp. For the underground haulage both stationary engines and locomotives, electrically driven, are used.

At the mine entrance there is a pocket with a capacity of 600 cubicmetres. From this the coal is transported by an aerial ropeway to the storage-ground near the wharf. The aerial ropeway has a capacity of 50 tons per hour. There is storage accommodation for 80 000 tons. From the stock-pile the coal is transported to the wharf by endless-rope haulage, the wagons being loaded by means of a steam-shovel and an electric crane whith a capacity of 100 tons per hour. The depth at the head of the pier is 7 metres at low water. Power is supplied by a plant of 800 kw.

A wireless station enables the company to keep in direct communication with Sweden (Boden).

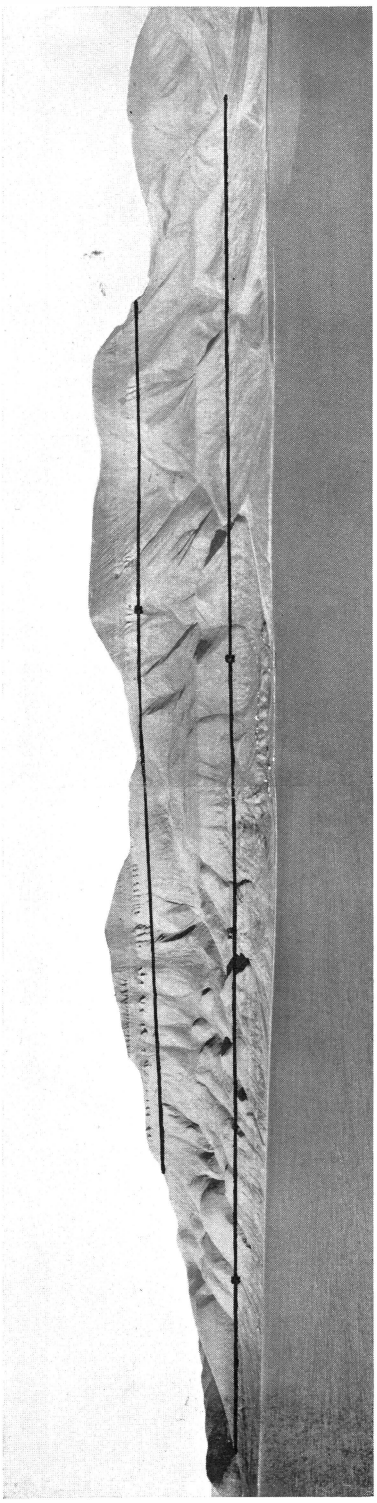


Fig. 1. NORTH-EASTERN SIDE OF ADVENT BAY.
Coal-fields belonging to A/S De Norske Kulfelter Spitsbergen. Cretaceous and lowest Tertiary coal-seams in black. The Advent City mine to the left, working-place on lower seam at Hiorthamn and mine now in operation to the right (upper line) shown in black squares.
A. Koller phot. 29/8 1920.

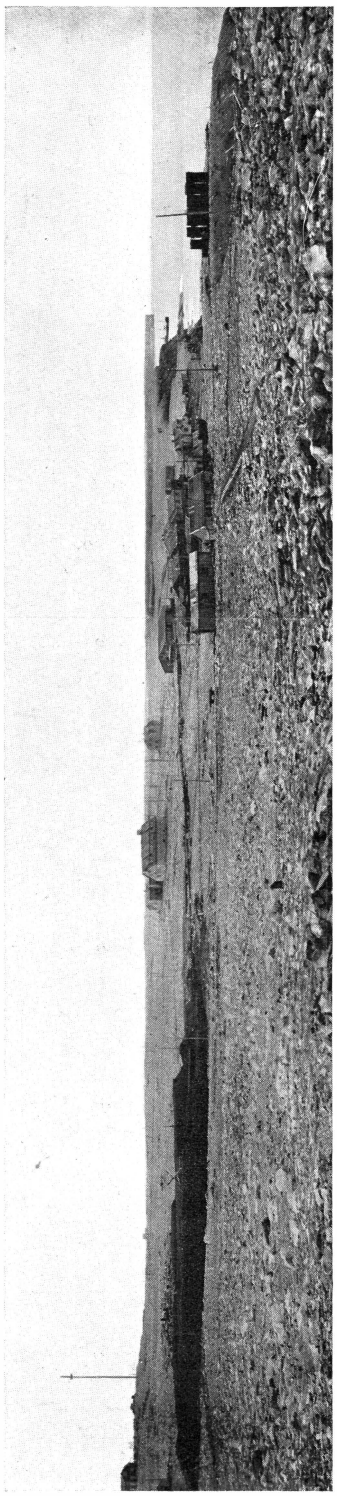


Fig. 2. TUNHEIM, BEAR ISLAND.
Looking north-west. A. Koller phot. 28/6 1921.

Fig. 1. SVEAGRUVAN, BRAGANZA BAY.
Part of mining camp. Looking north-west. Svenska Stenkolsaktiebolaget Spetsbergen phot. 1919.

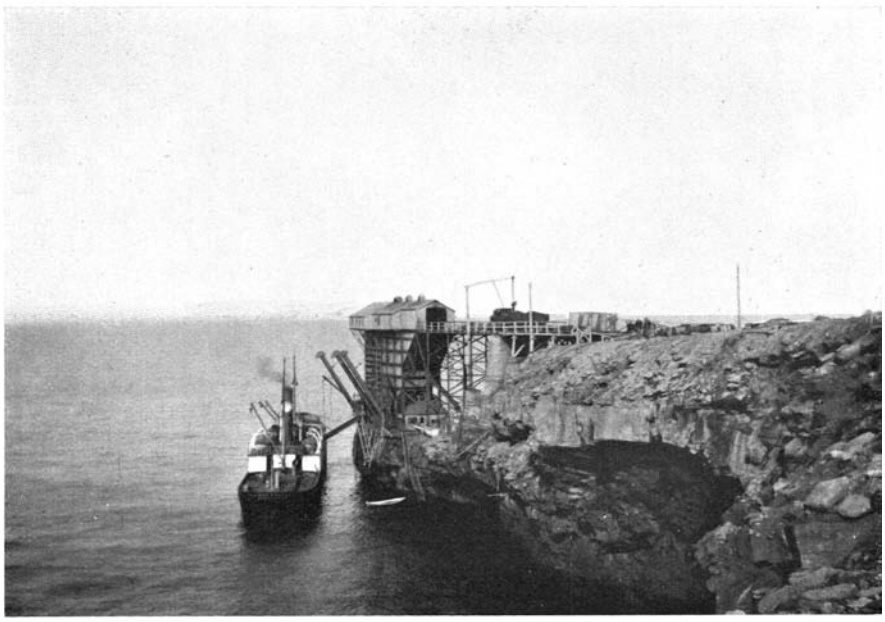


Fig. 2. STEAMER LOADING AT COAL-POCKET, ØSTERVÅG, BEAR ISLAND.
Looking east. G. Horn phot. 5/7 1924.

f. *Bjørnøen A.S.*

The mine and camp are situated on a level plain 30 metres above sea level in the north-eastern part of the island. Exploration and mining operations were commenced in 1915. The mine is equipped with hoists and other mining material, and for treatment of the coal from the mine there is a screening and cleaning plant. The equipment further includes: power plant with crude-oil engines and electric generators, a railway 1,2 km. long from Tunheim to Østervåg with engines and trucks, one steam-shovel, elevator and loading arrangement at Østervåg including a coal-pocket of 1100 tons capacity, workshop and smithy, wireless station, 7 oil tanks, dwellings and mess houses for the staff and miners, shop, bakery, kitchen, store, houses, stables etc. In mining the coal the longwall system is employed with hand-drilling and blasting. The average thickness of the good coal is about 66 cm.

During the winter 1923—24 the company had the following employees:

Underground workers, including 3 foremen	41
Workers at the screening plant	15
Other surface workers	14
Staff on Bear Island	8
— in Norway	4
	82

To these should be added mess servants, cook, baker, and steward, a total of 13 persons. These are, however, not on the pay-roll of the company as they are paid by the employees.

During the months of November, December, and January the output was 5915 tons in 75 working days. The number of day's work for underground workers was thus 3075.

Number of day's work of all employees	6 150
— - — — for new constructions deducted	170
Number of day's work used in production	5 980

The output per man per shift calculated from these figures are:

Per miner	1,92 tons.
- employee	0,99 —

When the coal is raised from the mine it is sorted on shaking screens into 3 sizes, stone and the poor coal from the bottom of the seam being removed on 2 picking belts. The amount of waste rock is about 17 per cent of the total quantity brought to the surface. The

stock pile is situated at the entrance of the mine. During the shipping season the coal is conveyed by rail directly to the loading plant which can accommodate boats of a capacity up to 1 200 tons. The coals are sold in Northern Norway.

7. Quality of the Coal.

All analyses given here are based on the ordinary English method of recording, viz. proximate analysis of moist coals, ultimate analysis of dry coals and calorific value as the gross value in dry coals.

Most of the analyses cited below, have been published by Dr. J. GRAM, Director of the chemical laboratory of the Norwegian State Railways, Oslo, v. his paper [32].

I. Spitsbergen.

a. *Culm Coal.*

The analyses of the coal from Mt. Pyramide are taken from B. HÖGBOM [40], p. 176. The analysis of the coal from Mt. De Geer obtained by courtesy of Professor ERIK STENSIÖ, Stockholm.

	Mt. Pyramide on the west side of Klaas Billen Bay		Mt. De Geer at the north-east end of Klaas Billen Bay
	Splint coal Mine sample Average of 9 analyses	Bright coal Mine sample 1 analysis	1,4 m. seam Mine sample 1 analysis
	Per cent	Per cent	Per cent
Moisture	3,82	2,30	1,40
Ash	11,05	11,90	10,70
Fixed Carbon	54,03	58,50	60,00
Volatile Matter	31,10	27,30	27,90
Carbon	—	—	77,70
Hydrogen	—	—	4,40
Sulphur	0,49	0,73	0,39
Oxygen + Nitrogen	—	—	6,65
Ash, dry	—	—	10,86
Calorific Value	7 352	7 140	7 570
B. T. U.	13 233	12 852	13 625

The splint coal does not give a firm coke; but the analyses show that they are well suited for use in a raw state in blast furnaces for smelting iron.

The Scottish Spitsbergen Syndicate, Ltd. has kindly sent me the following analyses of coal from their fields:

Gips Valley. — 90 cm. coal-seam.

	Per cent
Fixed Carbon	62,80
Gas & Tar	28,77
Sulphur	0,64
Ash	6,25
Water	1,54
Calories	7 520
B. T. U.	13 716

Heating Power Theoretical (lbs. of water at 212° F. evaporated by 1 lb. of coal) 14,21. Coking index equal to the best Scotch coking coal.

The 68 cm. layer of the upper seam at Adolf Bay contains coal of poor quality. From the lower seam at the same locality no analysis is available. At Ebba Valley the upper seam is not proven. The coal from the lower seam contains 10 per cent ash, full analysis is not available. Mr. CADELL [26] p. 8 states however that coal from this valley produces a hard coke, which seems to be of excellent quality.

A chemical analysis of pieces of the coal from the field at Mt. Kiær, made by Dr. GRAM in 1922, shows the following results:

	Per cent
Moisture	0,40
Ash	33,90
Fixed Carbon	48,80
Volatile Matter	16,90
Sulphur	8,17
Calorific Value	5 415
B. T. U.	9 747

The coke was firm and somewhat porous.

b. *Cretaceous Coal.*

	Mine samples		
	Advent City	Erdmann Tundra	Cape Boheman
	Per cent	Per cent	Per cent
Moisture	1,70	1,50	1,86
Ash	12,60	9,60	7,18
Fixed Carbon	64,45	51,60	54,35
Volatile Matter	21,25	37,30	36,61
Carbon	71,58	—	77,60
Hydrogen	4,11	—	5,55
Sulphur	0,47	3,10	0,87
Oxygen + Nitrogen	11,02	—	8,66
Ash, dry	12,82	—	7,32
Calorific Value	6 748	7 618	7 654
B. T. U.	12 146	13 712	13 777

The first analysis has been made by Dr. GRAM, the second is taken from HÖGBOM [40], p. 183, and the third from HOLMSEN [39], p. 41. The coke was soft.

c. *Tertiary Coal.*

α. *The Great Central Coal Region.* There are analyses available from 4 corners of this coal-basin: From the north-west corner at Green Harbour, from the south-west corner at Coal Mtn. on the north side of Van Mijen Bay, from the north-east corner at Advent Bay, from the south-east corner at Braganza Bay, and from the extreme south-eastern part of the region, Mt. Hedgehog at Stor Fjord.

At the east side of Green Harbour the Dutch company, N. V. Nederlandsche Spitsbergen Compagnie, has its property. This company has kindly communicated to me a report from 1923 on its coal, made by Professor S. J. VERMAES of the Technical University at Delft. From this report the following is taken:

Nature of Coal. The coal of both strata gives large lumps, rather firm and tough, and is not liable to break to any extent during transport. The coal from the lower seam is somewhat stratified, that of the upper seam more irregular in its structure.

Both kinds of coal are of a deep black colour, and give rather much dust when being handled, the coal of the upper stratum, however, much more so than that of the lower stratum.

Two kinds of coal can be distinguished clearly by the fact that when being crushed the lower seam gives a black powder, whilst that of the upper seam is clearly coloured brown.

There is also a difference in the specific gravity, viz., the lower seam 1,290, the upper seam 1,362.

According to the analyses both kinds of coal must be classified as bituminous coal, which burns with a very long sooty flame.

When being burnt in lumps the upper surface melts. This, however, is immediately followed by solidification of the molten layer on account of the loss of volatile substances. On account of this, the upper surface splits into a cauliflower form. On the heat forcing its way to the core the volatile substances escape from the core through the cracks until a heavily burst piece of coke is left, wich continues to burn very readily with an intense heat. This explains the good results obtained, in accordance with statements made, with the coal of the lower seam when used as bunker coal for steamers.

Although the proportion of volatile substances in the coal of the upper seam is considerably larger than that of the coal of the lower seam, it is very probable that also the coal of the upper seam, when used as bunker coal, will give good results.

Analyses of mine samples from Barentsburg (Sect. 6, p. 28).

	Lower seam	Upper seam
Sp. Gr.	1,290	1,362
	Per cent	Per cent
Moisture	1,48	0.87
Ash	7,68	7,45
Fixed Carbon	58,07	50,36
Volatile Matter	32,77	41,32
Carbon	79,08	76,75
Hydrogen	4,87	5,26
Sulphur	1,27	2,40
Oxygen + Nitrogen	6,99	8,08
Ash, dry	7,79	7,51
Calorific Value	7 857	7 895
P. T. U.	14 145	14 211

Composition of the ash:

	Per cent	Per cent
SiO_2	28,02	21,94
Al_2O_3	26,69	16,88
Fe_2O_3	8,17	27,91
TiO_2	0,38	0,53
CaO	17,30	12,46
MgO	2,47	3,30
SO_3	15,00	10,47
$K_2O + Na_2O$ (Balance)	1,97	6,51

Working Tests.

Coking at High Temperature (Gas-making):

	Coal of 1/2"—0 shows results of:	
Gas.....	336 cbm. per ton	333 cbm. per ton
Coke.....	69,00 per cent	62,80 per cent
Tar	7,40 „ „	10,00 „ „
Tar water.	4,80 „ „	5,30 „ „

Coke very firm and very close. Sp. Gr.: 0,932.
Coke firm and close. Sp. Gr.: 0.882.
Tar of both tests together. Sp. Gr.: 1,112.

The high-temperature tar gives the following fractions:

1st Fraction	120°—205° C.....	5,2	per cent
2nd —	205°—221° C.....	9,9	„ „
3rd —	225°—242° C.. ..	10,0	„ „
Asphalt		74,0	„ „

In 1921 I picked some pieces from a heap of coal at the foot of Coal Mountain. The coal had been taken from one of the 2 seams in this mountain, but I do not know from which of them. It is possible that the ash content is higher than the average of this seam. The analysis is by Dr. J. GRAM.

	Per cent
Moisture	1,09
Ash.....	36,73
Fixed Carbon	38,67
Volatile Matter.....	23,51
Sulphur	0,53
Calorific Value	5 055
B. T. U.....	9 059

On the next page will be found analyses of Longyear Spitsbergen coal from the mines of Store Norske Spitsbergen Kulkompani Aktieselskap at Advent Bay. Mine No. 1 and Mine No. 2 are both worked on the seam marked with an * in Sect. 1, p. 28. Analyses by Dr. GRAM, except the 6 analyses of mine samples from Mine No. 2, which are from the Chemical Laboratory of Dr. O. N. HEIDENREICH.

Mine No. 1.

	Mine samples. Average of 10 analyses made in the years 1915—1918	Run-of-mine. Average of 4 analyses of cargoes made in the years 1917—1919
	Per cent	Per cent
Moisture	2,28	1,87
Ash	5,35	6,40
Fixed Carbon	54,96	54,30
Volatile Matter	37,41	37,43
Carbon	78,41	77,55
Hydrogen	5,74	5,63
Sulphur	1,69	1,11
Oxygen + Nitrogen	8,69	9,19
Ash, dry	5,47	6,52
Calorific Value	8 034	7 802
B. T. U.	14 461	14 044

Mine No. 2.

	Mine samples. Average of 6 analyses made in 1922	Run-of-mine. Average of 10 analyses of cargoes (50 000 tons) 1923	Run-of-mine. Average of 9 analyses of cargoes (60 000 tons) 1924.
	Per cent	Per cent	Per cent
Moisture	1,64	2,53	1,93
Ash	4,24	5,92	5,80
Fixed Carbon	53,75	56,23	55,58
Volatile Matter	40,37	35,32	36,69
Carbon	80,03	—	—
Hydrogen	6,14	—	—
Sulphur	1,15	1,43	—
Oxygen + Nitrogen	8,37	—	—
Ash, dry	4,31	—	—
Calorific Value	7 790	7 780	7 977
B. T. U.	14 022	14 004	14 359

The coke from the samples was soft and bulky.

Composition of the ash of the coal from Mine No. 2 (RØDLAND [43]):

	Per cent
SiO_2	30,98
TiO_2	1,63
Al_2O_3	19,98
Fe_2O_3	23,29
MnO	0,03
MgO	2,04
CaO	6,00
Na_2O	1,81
K_2O	1,83
H_2O	1,18
P_2O_5	0,20
S	0,22
SO_3	9,26
Total	98,45

The low total is due to the incomplete combustion of the sample.

At the east side of the Advent Bay the A/S De Norske Kulfelter Spitsbergen has its property. The mine here is worked on the lowest Tertiary seam (marked with an * Sect. 1, p. 27) situated 583 metres above the sea at Mt. Hiorth at the east side of the bottom of Advent Bay. As will be seen from the analysis, this seam contains a kind of coal resembling brown coal. When treated with a KOH solution this is stained brown. The other analysis is from the uppermost Tertiary seam in Mt. Opera. Analyst: Dr. J. GRAM.

	Mine samples of seam No. I at Mt. Hiorth, 1917	Mine sample of seam No. IV at Mt. Opera, 1922
	Per cent	Per cent
Moisture	9,50	4,65
Ash	6,48	4,95
Fixed Carbon	47,90	52,65
Volatile Matter	36,12	37,75
Carbon	65,90	74,00
Hydrogen	4,84	5,84
Sulphur	1,26	1,52
Oxygen + Nitrogen	20,84	13,45
Ash, dry	7,16	5,19
Calorific Value	6 374	7 386
B. T. U.	11 473	13 295

These coals have no tendency to coke.

The Swedish company, Svenska Stenkolsaktiebolaget Spetsbergen, has kindly communicated to me the following analyses of their coals from the north side of the inner end of Van Mijen Bay.

Mine No. I. Upper seam (* Sect. 2, p. 28).

	Mine samples 0,90 m. layer	Run-of-mine Average of 5 analyses of cargoes 1920	Run-of-mine Analysis of 1 cargo 1920
	Per cent	Per cent	Per cent
Moisture	1,96	3,88	4,37
Ash	7,02	11,13	12,78
Fixed Carbon	58,75	54,49	53,46
Volatile Matter	32,27	30,50	29,39
Carbon	—	—	72,79
Hydrogen	—	—	4,33
Sulphur	—	—	0,65
Oxygen + Nitrogen	—	—	8,88
Ash, dry	—	—	13,35
Calorific Value	7 600	7 498	7 393
B. T. U.	13 680	13 496	13 307

Mine No. II. Lower seam.

Mine samples. 1,18 m. layer + 0,30 m. layer (** Sect. 2, p. 28).

	Per cent
Moisture	1,75
Ash	7,18
Fixed Carbon	64,72
Volatile Matter	26,35
Calorific Value	7 710
B. T. U.	13 878

Mixed Coal from Mine No. I and Mine No. II.

	Run-of-mine	
	Average of 19 analyses of cargoes 1922	Average of 13 analyses of cargoes (36 000 tons) 1923
	Per cent	Per cent
Moisture	3,56	3,48
Ash	12,00	9,10
Fixed Carbon	57,06	60,17
Volatile Matter	27,38	27,25
Calorific Value	7 410	7 676
B. T. U.	13 338	13 817

Mine sample of the 0,67 m. layer of the lower seam (Sect. 2, p. 28).

	Per cent
Moisture	3,3
Ash	2,4
Fixed Carbon	62,7
Volatile Matter	31,6
Calorific Value	8 027
B. T. U.	14 448

The coals from this region do not give a good coke.

In 1922 I collected a few pieces from some sacks of coal on the beach at Mt. Hedgehog. This coal had been taken from the Tertiary seam in that mountain by the Northern Exploration Co., Ltd., who are the proprietors of this claim. I consider the analysis to be a fair average of this coal. As will be seen, it differs very much from the ordinary type of the Tertiary coal of Spitsbergen. Analyst: Dr. GRAM.

Mt. Hedgehog.

	Per cent
Moisture	0,80
Ash	4,30
Fixed Carbon	73,57
Volatile Matter	21,33
Carbon	85,68
Hydrogen	4,95
Sulphur	0,60
Oxygen + Nitrogen	4,44
Ash, dry	4,33
Calorific Value	8 157
B, T. U.	15 483

The coke was light-grey and firm.

β. *The Coal-Field at Kings Bay.*

(Sections p. 31).

All the following analyses from Kings Bay are by Dr. GRAM.

	Esther Seam. Mine Sample. 1924.	Sofie Seam. Mine Sample. 1924.
	Per cent	Per cent
Moisture	1,45	1,70
Ash	9,62	9,67
Fixed Carbon	46,88	46,03
Volatile Matter	42,05	42,60
Sulphur	5,76	4,40
Calorific Value	7 654	7 575
B. T. U.	13 777	13 655

Low-temperature distillation 350°—500° C.

	Per cent	Per cent
Crude oil	20,8	19,6
Semi-coke	63,2	66,4
Water	5,6	4,0
Gas	10,4	10,0

Advokat Seam.

	Mine samples. Average of 3 analyses 1919	Mine samples 1919
	Per cent	Per cent
Moisture	1,10	1,00
Ash	14,72	15,40
Fixed Carbon	43,39	41,43
Volatile Matter	40,79	42,17
	Per cent	Per cent
Carbon	68,05	65,95
Hydrogen	5,62	5,80
Sulphur	4,74	4,38
Oxygen + Nitrogen	6,70	8,32
Ash, dry	14,89	15,55
Calorific Value	7210	7106
B. T. U.	12978	12791

According to statements by Dr. J. GRAM in his paper [24], p. 6 experiments made on the destillation of oil from the coal of the Advokat seam gave the following results:

The coal, which contained 18 per cent ash yielded by experiments, according to MUCH, 42,30 per cent combustible volatile substance. The output of oil was from 18 to 21,4 per cent. The other products were 4,12 per cent water. 66,47 per cent semi-coke, and 73 litres strongly luminous gas per kg. coal.

Fractional distillation and paraffin separation gave:

Light oil 80°—200° C. 5,52 per cent.
Medium „ 200°—300° „ 25,99 „ „
Heavy „ above 300° „ 63,25 „ „
including 5,24 per cent paraffin.

The content of phenol was 14,7 per cent in the medium oil and 11,7 per cent in the heavy oil. The content of sulphur was 4,5 per cent in the coal, 5,2 per cent in the residual semi-coke, and 2,7 per cent in the oil. The gas contained a considerable amount of hydrocarbons.

Agnes Mine.

	Mine samples. Average of 3 analyses 1919	Run-of-mine. Average of 14 analyses of cargoes 1920
	Per cent	Per cent
Moisture	1,40	1,99
Ash	12,73	17,98
Fixed Carbon	47,07	42,07
Volatile Matter	38,80	37,96
	Per cent	Per cent
Carbon	69,38	—
Hydrogen	6,26	—
Sulphur	3,12	2,89
Oxygen + Nitrogen	8,33	—
Ash, dry	12,71	—
Calorific Value	7189	6740
B. T. U.	12924	12132

Othilie Mine. Mine samples 1922.

	25 cm. coal. Upper layer	60 cm. coal Middle layer	22 cm. coal. Lower layer
	Per cent	Per cent	Per cent
Moisture	1,87	1,95	1,24
Ash	14,37	12,96	14,09
Fixed Carbon	41,78	42,64	47,39
Volatile Matter	41,98	42,45	37,28
	Per cent	Per cent	Per cent
Sulphur	3,72	4.80	2,39
Calorific Value	7052	7321	7079
B. T. U.	12694	13178	12742

Low-temperature distillation 350°—500°,

	Per cent	Per cent	Per cent
Crude oil	18,4	17,2	16,0
Semi-coke	65,2	64,0	68,4
Water	7,2	8,0	7,2
Gas	9,2	10,8	8,4

Othilie Mine. Mine samples 1922.

	72 cm. coal. Upper layer	15 cm. coal. Lower layer
	Per cent	Per cent
Moisture	1,95	1,82
Ash	13,20	18,03
Fixed Carbon	44,70	42.97
Volatile Matter	40,15	37,18
	Per cent	Per cent
Sulphur	4,23	4,98
Calorific Value	7198	6903
B. T. U.	12956	12425

Low-temperature distillation. 350°—500°.

	Per cent	Per cent
Crude oil	16,4	14,8
Semi-coke	66,8	69,2
Water	8,0	8,0
Gas	8,8	8,0

Josefine Mine.

	Mine samples. Average of 8 analyses 1922.	Mine sample 1922
	Per cent	Per cent
Moisture	1,74	1,85
Ash	10,93	11,60
Fixed Carbon	45,97	44.65
Volatile Matter	41,36	41,90
	Per cent	Per cent
Carbon	—	73,34
Hydrogen	—	5.79
Sulphur	1,40	1,37
Oxygen + Nitrogen	—	7,68
Ash, dry	—	11,82
Calorific Value	7401	7258
B. T. U.	13322	13064

Low-temperature distillation. 350°—500°.

	Per cent
Crude oil	19,27
Semi-coke	66,33
Water	6,70
Gas	7,50

Run-of-mine. Average of 21 cargoes. 1922.

	Per cent
Moisture	1,87
Ash	17,25
Fixed Carbon	43,74
Volatile Matter	37,14
Calorific Value	6 779
B. T. U.	12 202

Composition of the ash of coal from Josefine Mine; analysis of cargo (RØDLAND [43]).

	Per cent
SiO_2	31,02
TiO_2	2,09
Al_2O_3	17,13
Fe_2O_3	10,13
MnO	0,02
MgO	3,94
CaO	13,85
Na_2O	2,50
K_2O	1,38
H_2O	0,82
P_2O_5	1,55
S	0,11
SO_3	15.25
Total	99,79

Ragnhild Seam.
Mine Samples 1922.

	Per cent
Moisture	3,27
Ash	7,34
Fixed Carbon	50,71
Volatile matter	38,68
Sulphur	0,55
Calorific Value	7 188
B. T. U.	12 938

Low-temperature distillation 350°—500°.

	Per cent
Crude oil	16,4
Semi-coke	67,2
Water	8,4
Gas	8,0

The Tertiary coals from Kings Bay have no tendency to coke.

γ. *The Coal-Field on the East Side of the Foreland Sound.*

Analyses of pieces of coal from the north side of Aavatsmark Glacier. Analysed by Dr. GRAM 1922.

	Brittle coal	Pitch-like coal
	Per cent	Per cent
Moisture	2,95	5,90
Ash	6,85	4,80
Fixed Carbon	56,65	58,20
Volatile Matter	33,55	31,10
Carbon	76,10	73,16
Hydrogen	4,75	4,90
Sulphur	1,18	1,10
Oxygen + Nitrogen	10,81	14,57
Ash, dry	7,16	6,27
Calorific Value	7519	7188
B. T. U.	13534	12938

The coke from both samples was very firm.

δ. *The Coal-Field at Cape Lyell.*

Analysis of pieces of coal from the 30 cm. coal-seam at Calypso Bay.

Analysed by Dr. GRAM, 1922.

	Per cent
Moisture	7,15
Ash	8,82
Fixed Carbon	47,18
Volatile Matter	36,85
Carbon	69,22
Hydrogen	4,79
Sulphur	0,61
Oxygen + Nitrogen	15,70
Ash, dry	9,50
Calorific Value	6 952
B. T. U.	12 514

II. Bear Island.

All the analyses are by Dr. GRAM except the last one, which is by Dr. NAIMA SAHLBOM, Stockholm.

a. *Devonian Coal.*

The Mine at Tunheim (Section p. 35).

Run-of-mine. Analysis of 1 cargo 1920.

	Per cent
Moisture	0,90
Ash	16,25
Fixed Carbon	67,95
Volatile Matter	14,90
Carbon	72,08
Hydrogen	4,31
Sulphur	0,43
Oxygen + Nitrogen	6,78
Ash, dry	16,40
Calorific Value	7 139
B. T. U.	12 850

Analysis of 1 cargo 1923.

	Cleaned but unscreened	Smalls + nuts (below 2") from the foregoing	Smalls (below 1") from the foregoing
	Per cent	Per cent	Per cent
Moisture	0,81	1,53	0,52
Ash	14,93	20,82	24,98
Calorific Value	7294	6646	6540
B. T. U.	13129	11963	11772

Composition of the ash, analysis of cargo (RØDLAND [43]).

	Per cent
SiO_2	42,89
TiO_2	2,32
Al_2O_3	31,71
Fe_2O_3	15,89
MnO	0,02
MgO	0,81
CaO	0,53
Na_2O	0,81

	Per cent
K_2O	2,43
H_2O	0,73
P_2C_5	0,13
SO_3	0,29
Total	98,56

The low total is due to the incomplete combustion of the sample.

b. *Culm Coal.*

Analysis of sample from a test-pit near North Haven.

	Per cent
Moisture	0,70
Ash	12,10
Fixed Carbon	70,80
Volatile Matter	16,40
Carbon	77,29
Hydrogen	3,91
Sulphur	3,40
Oxygen + Nitrogen	3,22
Ash, dry	12,18
Calorific Value	7 629
B. T. U.	13 732

The sample was taken near the surface. The composition of the coal may therefore have been subject to changes caused by weathering influences.

Both the Devonian and Culm coal produce a good coke very suitable for use in blast furnaces for smelting iron.

III. Hope Island.

Loose pieces of coal, collected in 1924 by THOR IVERSEN. Analysed by Dr. GRAM.

Shore on the east side. The piece contained bright and dull coal.

	Bright coal	Dull, slaty coal
	Per cent	Per cent
Moisture	0,60	0,50
Ash	15,40	13,02
Fixed Carbon	48,90	50,38
Volatile Matter	35,10	36,10
Calorific Value	7 297	7 759
B. T. U.	13 134	13 976

	River-bed, House Valley	Summit of southernmost mountain
	Per cent	Per cent
Moisture	1,9	2,2
Ash	18,5	35,7
Fixed Carbon	47,4	37,5
Volatile Matter	32,2	24,6

8. Market and Uses.

The natural market for the coal from Spitsbergen and Bear Island is Northern Europe, and particularly Norway, Sweden, Northern Russia, and Iceland.

The imports of Norway are about 2,5 mill. tons annually, the imports of Sweden about 4 mill. tons and those of Iceland upwards of 100000 tons. The Russian imports via White Sea ports were only 70000 tons in 1913. To this must be added the imports to the Arctic coast of Finland, which may begin as soon as the country has finished the building of the railway to one of its ports on that coast. The imports of Finland were nearly 600000 tons in 1913.

The total demand for coal in the countries mentioned may be safely fixed at about 8 mill. tons annually.

Up to the present time coal has been exported from Spitsbergen to the following places: Norway, as far as Oslo; Sweden, partly Northern Sweden via Narvik, and Southern Sweden (Gothenburg, Malmö and Stockholm); Denmark (a single shipment of 400 tons to Copenhagen); Iceland (shipment in 1923 and 1924 of 2000 and 1500 tons to Reykjavik); Holland, and Archangel.

The coal from Bear Island has been exported exclusively to Northern Norway.

The Tertiary coal from the Ice Fjord—Bell Sound region are excellent steam coals. They have been chiefly used by steamships, factories, railways, and for domestic purposes. The Tertiary cannel coal from Kings Bay have been used for similar purposes. Plants for the extraction of oil from these coals are now being constructed. The coking coal from Bear Island have been used chiefly as bunkers by the coasting steamers of Northern Norway.

9. The Attitude of the Governments towards the Coal Industry in Svalbard.

The Norwegian Government has in various ways promoted the coal mining industry of Svalbard. The increasing activity of claiming and mining operations going on in this "no man's land" at the

beginning of the century soon led to intolerable conditions which made the establishment of law and order a necessity. On the initiative of Norway, the power most interested in these matters, international conferences were then convened to discuss the question of sovereignty. Such conferences were held at Oslo in 1910 and 1912, and Norway, Sweden, and Russia were represented. These powers agreed on an arrangement which was submitted to a larger conference held at Oslo in 1914, but no results ensued. As already mentioned, Norway finally succeded in 1920 in obtaining a recognition from the Allied and Associated Powers, and in 1924 also from Russia, of its sovereignty over the islands.

Norway has made considerable sacrifices to get the islands topographically mapped, and geologically explored. For the benefit of navigation in the waters surrounding the islands soundings have been made and oceanographic data collected. It has already been mentioned that since 1909 the Norwegian Government has each year defrayed all or part of the expenses of expeditions fitted out to explore the islands. It should also be mentioned that an expedition was sent out in 1923 and 1924 to investigate the fish resources in the sea around Spitsbergen. In 1911 the Norwegian Government established a large wireless station at Green Harbour by which communication between Norway and the stations of the coal companies is maintained. A meteorological station is connected with this wireless station. Also at Advent Bay, Kings Bay, and Bear Island the Government has established meteorological stations. At Quade Hoek, on the south side of the mouth of Kings Bay, a geophysical station was maintained from 1920—1924.

Norway has also provided for the mail service in Spitsbergen and Bear Island. There are post offices at Advent Bay (established in 1897), Green Harbour (1911), Kings Bay (1918) and on Bear Island (1918). The mail service between Norway and the islands is effected by ships calling at regular times.

The Norwegian Government has given direct support to the Norwegian coal companies working in Spitsbergen and Bear Island by granting advances on coal deliveries. In the autumn of 1924, these advances amounted to about 17 million Norwegian kroner.

The Swedish Government has undertaken the sounding of Van Mijen Bay, the fjord at which the mines of the Swedish company are located[1]. The Government has also supported this company by subscribing capital. The Svenska Stenkolsaktiebolaget Spitsbergen, has a share capital of 5 million Swedish kroner, of which the Swedish State owns 2 millions. In addition to this the Government has granted the company a loan of 1 500 000 kroner.

[1] Government support to the earlier expeditions was given for scientific purposes only, without any intention of helping the coal industry.

Summary.

The archipelago of Spitsbergen, Bear Island and some adjacent islands, which are collectively named Svalbard, is situated between 74° and 81° N. Lat. and 10° and 35° Long. E. o. Gr. The area is 65000 square km.

Spitsbergen is a mountainous country, in some parts much ice-covered, indented on the west side by many fjords affording good harbours. The coal-bearing areas are relatively ice-free. The northern part of Bear Island is a plain 30—50 metres above sea level. The southern part consists of mountains more than 500 metres high. The island is lacking in good harbours.

The climate is very healthy and is not very much more severe than that of Northern Norway. The ice prevents shipping for a certain time of the year. The shipping season for Spitsbergen is about 3 months; for Bear Island 6 months or more.

Spitsbergen and Bear Island were probably discovered in 1194 by Norwegians who called them Svalbard. The claiming of coal land and exploratory work was begun about 1900 by Norwegians. Coal mining on a large scale was first started by Americans in 1905. There now exist Norwegian, Swedish, British, Dutch, and Russian coal companies in Spitsbergen and Bear Island. There are 6 mines in operation. The sovereignty of the archipelago has now been transferred to Norway, who has issued a mining ordinance for the country. The mapping and the geological survey of the islands have mainly been done by Swedes, and since 1906 by Norwegians.

The coal deposits of Spitsbergen belong to three different Systems: The Carboniferous, the Cretaceous and the Tertiary System.

The Carboniferous seams, which are best known in the inner branches of the Ice Fjord, are 1—4 in number and are up to 10 metres thick. The content of volatile matter is 28—31 per cent and the calorific value is 7000—7600 calories. Some of these seams contain splint coal, suitable for use in a raw state for blast furnaces; the coal of other seams produces a firm coke. The reserves of Carboniferous coal are estimated at 1500 million tons.

There is only one Cretaceous seam known. Its thickness is 1—2 metres. This coal is a steam coal, which contains 21—37 per cent of volatile matter; the calorific value is 6700—7600 calories. The coke is soft. The reserves are estimated at 1500 million tons.

The Tertiary seams are mainly found in a great syncline south of the Ice Fjord. There are 2—5 coal-seams. The thickness of the seams is 1—2,5 metres. These coals are excellent steam coals, high in volatile matter, 30—40 per cent, and calorific value, 7400—8000 calories. Only the coal in the western part of this area produces a good coke. One seam contains locally a coal the quality of which approaches that of brown coal. The reserves in the region between the Ice Fjord and Van Mijen Bay are estimated at 5000 million tons, but there are large unexplored areas of these coals to the south-east of Van Mijen Bay.

Besides the fields mentioned, there are several smaller areas containing coal seams. The best known of these is the Kings Bay field, with 6—7 Tertiary seams. The thickness of these is between 1 and 2 metres. The coal is a cannel coal with a content of crude oil up to 21 per cent. The content of volatile matter is 37—41 per cent and the calorific value is 6700—7400 calories. The reserves of this coal are about 20 million tons.

On Bear Island coal has been mined since 1915. The coal belongs to the Devonian and Carboniferous (Culm) Systems. In the Devonian there are many seams, but only one is worked. It has a thickness of 60—70 cm. and is a good coking coal. The amount of volatile matter is 15 per cent and the calorific value is 7100—7300 calories. It produces a firm coke suitable for use in blast-furnaces. The coal-seam of the Culm is of a rather poor quality and hardly workable. At the present time it is not possible to give any definite statement with regard to the coal reserves of Bear Island, but they are certainly considerable.

Coal mining is much favoured by the frozen ground, the gentle dip of the strata, the absence of gas and water, so that the output per man per shift is greater than in Europe. It is from 1,16 to 2,80 tons per man, all counted, in Spitsbergen, and 1 ton in Bear Island.

The export of coal from Spitsbergen and Bear Island was 450000 tons in 1924. The total number of men this winter (1924—1925) is 1500. The total export from the archipelago is 1,78 mill. tons, the bulk of this quantity being Tertiary steam coal. The coal is exported mainly to Norway, Sweden, and Holland.

The capital invested in the principal companies is about £ 4270000 or about 80 million Norwegian kroner. The Norwegian and Swedish Governments have contributed capital to the extend of 17 million Norwegian kroner and 3,5 million Swedish kroner respectively.

Table I. *The Principal Mining Companies in Spitsbergen and Bear Island.*

No.	Name of company	Registered offices	Location of fields	Geological age of coal deposits	No.
1.	Bjørnøen A.S.	Stavanger	Bear Island	Devonian, Carboniferous	1.
2.	Store Norske Spitsbergen Kulkompani Aktieselskap	Oslo	Advent Bay, Green Harbour, Sassen Bay	Tertiary	2.
3.	A/S De Norske Kulfelter Spitsbergen	Bergen	Advent Bay	Tertiary, Cretaceous	3.
4.	Kings Bay Kul Comp. A/S	Ålesund	Kings Bay	Tertiary, Carboniferous	4.
5.	Svenska Stenkolsaktiebolaget Spetsbergen	Stockholm	Van Mijen Bay, Klaas Billen Bay, Erdmann Tundra	Tertiary, Carboniferous, Cretaceous	5.
6.	N. V. Nederlandsche Spitsbergen Compagnie	Rotterdam	Green Harbour, Cape Boheman	Tertiary,Cretaceous	6.
7.	Anglo Russian Grumant Co., Ltd.	London	Coles Bay	Tertiary	7.
8.	The Norwegian Exploration Co.	Oslo	Coles Bay, Sassen Bay, Klaas Billen Bay	Tertiary, Carboniferous	8.
9.	A/S Svalbard Kulgruber	Oslo	Advent Bay, Green Harbour	Tertiary	9.
10.	A/S Stavanger Spitsbergen	Stavanger	Coles Bay, Van Mijen Bay, Van Keulen Bay,	Tertiary	10.
11.	Russiske Kulfelter i Green Harbour Spitsb.	Oslo	Coles Bay	Tertiary	11.
12.	Northern Exploration Co., Ltd.	London	VanMijenBay,VanKeulen Bay, Stor Fjord	Tertiary	12.
13.	The Scottish Spitsbergen Syndicate, Ltd.	Edinburgh	Klaas Billen Bay, Sassen Bay	Carboniferous	13.

Numbers 1—7 are companies actually working, numbers 8—13 have hitherto confined themselves to exploration work.

Table II. *Capital invested in the Principal Companies up to 1924.*

No.	Name of Company	Subscribed Capital	Capital used in addition to subscribed Stock	In the respective currencies	In Norw. Kr. calculated at par	In £ calculated at par	No.
1.	Kings Bay Kul Comp. A/S.....	500 000 Norw. Kr.	8 000 000 Norw. Kr.	8 500 000 Norw.Kr.	8 500 000	486 000	1.
2.	Store Norske Spitsbergen Kulkompani Aktieselskap.....	9 600 000 —	4 400 000 —	14 000 000 —	14 000 000	770 000	2.
3.	A.S De Norske Kulfelter Spitsbergen	3 000 000 —	2 000 000 —	5 000 000 —	5 000 000	275 000	3.
4.	Bjørnøen A.S.....	4 000 000 —	6 000 000 —	10 000 000 —	10 000 000	550 000	4.
5.	Svenska Stenkolsaktiebolaget Spetsbergen	5 000 000 Swed. Kr.	3 000 000 Swed. Kr.	8 000 000 Swed. Kr.	8 000 000	444 000	5.
6.	N. V. Nederlandsche Spitsbergen Compagnie	12 000 000 Guld.	Hitherto expended 7 000 000 Gulden	12 000 000 Gulden	18 000 000	992 000	6.
7.	Anglo Russian Grument Co., Ltd....	80 000 £	10 000 £	90 000 £	1 634 000	90 000	7.
8.	Northern Exploration Co., Ltd.....	505 000 -	75 000 -	580 000 -	10 432 000	580 000	8.
9.	The Scottish Spitsbergen Syndicate, Ltd.	100 000 -		100 000 -	1 816 000	100 000	9.
				Total	77 382 000	4 269 000	

Table III. *Number*

No.	Company	1907	1908	1909	1910	1911	1912	1813	1914	1915	1916
1.	Bjørnøen A.S.	—	—	—	—	—	—	—	—	—	35
2.	Arctic Coal Co., 1907–1915	130	120	82	128	184	150	275	300	200	—
2 a.	Store Norske Spitsbergen Kulkompani Aktieselskap, 1916–1924	—	—	—	—	—	—		—		200
3.	Kings Bay Kul Comp. A S	—	—	—	—		—	—	—	—	—
4.	The Spitsbergen Coal and Trading Co., Ltd., 1907–1915	—	—	—	—	—	—	—	—	—	—
4 a.	A S De Norske Kulfelter Spitsbergen, 1916–1924	—	—	—				—	—	—	25
5.	A/S Isefjord Kulkompani	—	—	—	—		—	—	—	—	—
6.	Svenska Stenkolsaktiebolaget Spetsbergen	—	—	—	—	—	—	—	—	—	—
7.	Russiske Kulfelter i Green Harbour Spitsbergen, 1915–1920	—	—	—	—	—	—	—	—	—	—
7 a.	N. V. Nederlandsche Spitsbergen Compagnie, 1920–1924	—	—	—	—	—	—	—	—	—	—
8.	Anglo Russian Grumant Co., Ltd.	—	—	—	—	—	—	—	—	—	—
	Total	130	120	82	128	184	150	275	300	200	260

Table IV. *Exports*

No.	Company	1907	1908	1909	1910	1911	1912	1913	1914
1.	Bjørnøen A.S.	—	—	—	—	—	—	—	—
2.	Arctic Coal Co., 1907–1915	1500	2000	4000	4600	22000	23520	32800	38440
2 a.	Store Norske Spitsbergen Kulkompani Aktieselskap, 1916–1924	—	—	—	—	—	—	—	—
3.	Kings Bay Kul Comp. A/S	—	—	—	—	—	—	—	—
4.	The Spitsbergen Coal and Trading Co., Ltd., 1907–1915	—	4000	—	—	—	—	—	—
4 a.	A/S De Norske Kulfelter Spitsbergen, 1916–1924	—	—	—	—	—	—	—	—
5.	A/S Isefjord Kulkompani	—	—	—	—	—	—	—	—
6.	Svenska Stenkolsaktiebolaget Spetsbergen	—	—	—	—	—	—	—	—
7.	Russiske Kulfelter i Green Harbour Spitsbergen, 1915–1924	—	—	—	—	—	—	—	—
7 a.	N.V.NederlandscheSpitsbergen Compagnie, 1920–1924	—	—	—	—	—	—	—	—
8.	Anglo Russian Grument Co, Ltd.	—	—	—	—	—	—	—	—
	Total	1500	6000	4000	4600	22000	23520	32800	38440

of Men employed.

1917	1917 –18	1918	1918 –19	1919	1919 –20	1920	1920 –21	1921	1921 –22	1922	1922 23	1923	1923 –24	1924	1924 –25	No.
37	21	50	80	120	65	200	180	188	104	31	28	260	82	102	123	1.
—	—	—	—	—	—	—	—		—	—	—	—	—			2
250	220	320	300	320	289	400	217	420	282	355	343	425	361	490	433	2 a.
143	62	300	150	250	169	250	214	298	164	182	167	298	213	308	249	3.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.
70	62	82	60	47	40	70	82	3	3	20	3	3	7	11	14	4 a.
—	—	—		—	—	90	15	—	—	—	—	—	—	—		5.
	49	79	105	148	125	206	182	179	138	223	165	221	202	240	216	6.
—	—	—	—	—	22	180	107		—	—	—	—	—	—	—	7.
—	—	—	—	—		—		265	211	315	187	295	304	500	398	7 a.
	—	—	—	—	5	21	38	45	22	40	20	20	25	90	66	8.
500	414	831	695	885	715	1417	1035	1398	924	1166	913	1522	1194	1741	1499	

(tons of 1000 kg.).

1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	Total	No.
—	—	—	—	2000	20000	20000	9000	13000	20827	84827	1.
17830	—	—	—	—	—	—	—	—	—	146690	2.
—	19245	24060	39391	46458	9921	14707	119337	125000	149186	547305	2 a.
—	—	800	15000	15489	35162	74479	73026	91596	88944	394496	3.
—	—	—	—	—	—	—	—	—	—	4000	4.
—	—	—	838	4500	9797	—	7000	—	7245	29380	4 a.
—	—	—	—	—	2000	—		—	—	2000	5.
—	—	—	4000	19860	38514	38184	73678	86146	102798	363180	6.
—	—	—	3500	11000	13400	—	—	—	—	27900	7.
—	—	—	—	—		18000	36000	25200	65000	144200	7 a.
—	—	—	—	—	2000	7000	8000	—	16000	33000	8.
17830	19245	24860	62729	99307	130794	172370	326041	340942	450000	1776978	

List of Plates.

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Errata.

Page 40, line 20 from below, for 1918, read 1908.
Page 58, line 10 from below, for 1269, read 1,269.
In the analysis of Mine sample, Mine No. 2, first column, page 69, below, for:
Average of 6 analyses made in 1922, read: Average of 5 analyses made in 1922.
Calorific value 7790, read: 7970.
B.T.U. 14022, read: 14346.

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