SOVIET GEOLOGICAL RESEARCH IN SVALBARD 1962-1992

EXTENDED ABSTRACTS OF UNBUPLISHED REPORTS

EDITOR: A. A. KRASIL'ŠČIKOV

MEDDELELSER NR. 139
OSLO 1996

MEDDELELSER NR. 139

Soviet Geological Research in Svalbard 1962-1992

Extended abstracts
of unpublished reports

Edited by: A.A.Krasil'ščikov
Polar Marine Geological Research Expedition

NORSK POLARINSTITUTT
OSLO 1996

Sponsored by:

Russian-Norwegian Joint Venture "SEVOTEAM", St.Petersburg
IASC Secretariat, Oslo

Compilation: A.A.Krasil'ščikov, M.Ju.Miloslavskij, A.V.Pavlov, T.M.Pčelina, D.V.Semevskij, A.N.Sirotkin, A.M.Teben'kov and E.P.Škatov: Poljarnaja morskaja geologorazvedočnaja ėkspedicija, Lomonosov - St-Peterburg (Polar Marine Geological Research Expedition, Lomonosov - St.Petersburg) 189510, g. Lomonosov, ul. Pobedy, 24, RUSSIA
Figures drawn by: N.G.Krasnova and L.S.Semenova
Translated from Russian by: R.V.Fursenko
Editor of English text: L.E.Craig
Layout: W.K.Dallmann
Printed February 1996
Cover photo: A.M.Teben'kov: Field camp in Møllerfjorden, northwestern Spitsbergen, summer 1991.
ISBN 82-7666-102-5

CONTENTS

INTRODUCTORY REMARKS

Winfried K. Dallmann, Norwegian Polar Institute

Although scientific cooperation between Russian and western geologists in Svalbard has increased significantly during the last 6-7 years, there is still a remarkable lack of knowledge of Russian data among western geologists, particularly concerning the quality and amount of data, filed in the archives of the Spitsbergen Party of PMGRÈ (Polar Marine Geological Research Expedition, Lomonosov - St.Petersburg). The reasons for this are not only political and linguistical in nature, but are derived from the different scientific schools in the east and west, and in policies about publishing original data. As a result of the latter, Russian geologists have easier access to western scientific results than vice versa.

In this context, the Norwegian Polar Institute greatly welcomes the initiative of Dr. Aleksandr A. Krasil'ščikov, the leader of the Spitsbergen Party (former "Spitsbergern Expedition"), to publish extended abstracts in English of selected reports of Soviet geological research in Svalbard during the past three decades. Readers may find reports relevant to their interest in Svalbard geology; these reports may be fully or partly translated by request.

Remarks on transliteration of Russian names and references

Russian names and references in publications of the Norwegian Polar Institute correspond to the ISO (International Standard Organization) transliteration, which - with a very minor deviation - is also used in the International Bibliographic System. The advantage of this transliteration compared with national transcriptions, such as the English transcription, is its reversibility. Russian names transcribed in English or other languages cannot unequivocally be transcribed back into the Cyrillic alphabet; this may cause problems when inquiring for authors, or when looking for place names on Russian maps. Unfortunately, various electronic databases and international journals have adopted the English transcription. For this reason, a conversion table is added below. Be aware that conversion is only valid from Cyrillic or ISO to English, but not vice versa.

Cyrillic	ISO	English	Cyrillic	ISO	English	Cyrillic	ISO	English
а	a	a	к	k	k	х	h [3]	kh
б	b	b	л	l	l	ц	c	ts
в	v	v	м	m	m	ч	č	ch
г	g	g	н	n	n	ш	š	sh
д	d	d	о	o	o	щ	šč	shch
е	e	e, ye [1]	п	p	p	ъ	''	*(left out)*
ё	ë	e, yo [1]	р	r	r	ы	y	y
з	z	z	с	s	s	ь	'	*(left out)*
ж	ž	zh	т	t	t	э	ė	e
и	i	i	у	u	u	ю	ju	yu
й	j	y [2]	ф	f	f	я	ja	ya

[1] if first letter in a word [2] ий transcribes "y" in English [3] in bibliographic transliteration, "ch" is often used

PREFACE

Aleksandr A. Krasil'ščikov, Polar Marine Geological Research Expedition

The volume contains comprehensive summaries of 67 reports, embracing a three decade period (1962-1992) of Russian geological research in Svalbard. These predominantly regional studies were initiated in 1962 on behalf of the Ministry of Geology of the USSR by the Spitsbergen Expedition, which was organized by the Institute of Arctic Geology (NIIGA, Leningrad) and subsequently incorporated into the Polar Marine Geological Research Expedition (PMGRE, Lomonosov).

Results of the studies were partly published in Russian as monographs and articles. However, much valuable original data contained in unpublished reports have remained unknown to western geologists. It is hoped that publication in English will help to fill this information gap. Studies by the Spitsbergen Expedition covered a wide range of geological problems but followed two main lines of activity which resulted in two large groups of reports: a) regional geological mapping and b) thematic projects.

The book begins with a general review of the geology of Svalbard (*Krasil'ščikov et al. 1986*), which is, essentially an explanatory note to a series of geological maps of the archipelago and its separate areas. Reports are commonly grouped by subjects (folded basement, Devonian molasse complex, sedimentary cover, magmatism, mineral occurrences). Reports on geological fieldwork in the West-Spitsbergen Trough and Bjørnøya form separate subsections in the chapter on the sedimentary cover. Each extended abstract is preceded by the full title of its respective report[1]. A list of published references is provided at the end of the text. All illustrations are taken from original reports and in several cases are somewhat generalized or rearranged, but not modified in principle.

The authors wish to gratefully acknowledge Tore Gjelsvik, Honorary Director of the Norsk Polarinstitutt, who was one of the initiators of Russian-Norwegian cooperation in the study of the geology of Spitsbergen and has over many years exerted every effort to make this cooperation diversified and productive. It is hoped that the present publication will further assist in the choice of direction of future joint activities.

The book is dedicated to the memory of our friends who worked on Spitsbergen over many years, and, first of all, to the authors of the reports used here, namely, Ju.P.Burov, L.G.Murašov, A.I.Panov, V.M.Petrenko, V.N.Vasil'ev and V.N.Sokolov, the first head of the Spitsbergen Expedition.

[1] All the original reports are housed in the Central Geological Archives of Russia (Moscow) and in the Archives of the Research Institute for Geology and Mineral Resources of the World Ocean (St.Petersburg) and of the Polar Marine Geological Research Expedition (Lomonosov).

1. MAIN FEATURES OF THE GEOLOGY OF SVALBARD

KRASIL'ŠČIKOV, A.A., ABAKUMOV, S.A., LIVŠIC, JU.JA, MOKIN, JU.I., PČELINA, T.M., GOVORUHA, N.L., PANOV, A.I., SEMEVSKIJ, D.V., SIROTKIN, A.N., STARICYN, V.F. & TEBEN'KOV, A.M. 1986:

Explanatory note to a series of geological maps of Spitsbergen
[Ob'jasnitel'naja zapiska k komplektu geologičeskih kart arhipelaga Špicbergen]
Report on the thematic project, 1984-1986
272 pages, 10 appendices, 11 illustrations, 7 tables, 3 text supplements, 185 references

The report is an explanatory note to a set of geological maps of Svalbard. The set includes: maps, scale 1:1,000,000, such as geological, geomorphological, structural-tectonic sketch maps, maps showing coal and bitumen occurrences; and geological maps for separate areas of the archipelago, scale 1:200,000 - 1:300,000 (Ny Friesland, northwestern Spitsbergen, west coast of Spitsbergen, Andrée Land, southern Spitsbergen, Edgeøya). The text contains four sections: Topography and Glaciation, Geological Structure (Folded basement, Devonian molasse complex, Platform cover), Tectonics, and Mineral Occurrences.

While writing the report, a Stratigraphical Dictionary for Svalbard (Gramberg et al. 1990) and a database for igneous rocks were compiled (Supplements 1 and 3); new data on the biostratigraphy and paleomagnetism of Triassic deposits of western areas of Spitsbergen (Supplement 2) were also given.

Topography and Glaciation

A geomorphological map, scale 1:1,000,000, was compiled for mountainous regions, and the main features of erosional and accretional relief were drawn. The master map was supplemented with small scale insets, showing the main types of landforms and different-aged erosional surfaces. The 'block' character of the modern structural grain of the archipelago is believed to be reflected in its topography, and the tectonics have had a strong influence on the main morphological landforms (fjords, dividing crests, trough valleys). A boundary between the alpine relief of western Spitsbergen and smooth and slightly broken ground with mountain ice caps in the eastern part of the archipelago was drawn by the authors along the line Wijdefjorden - Agardhbukta.

The inset map shows eight groups of erosion surfaces, namely, Holocene, late Neogene, post-Paleogene, Late Cretaceous and Pleistocene, Late Cretaceous - early Paleogene, Cretaceous and Pleistocene, Jurassic-Cretaceous and Pleistocene, and pre-Carboniferous. Considering accretional features, different-level marine terraces are of great interest for paleoreconstructions of Quaternary history. Following Korjakin (1975), three groups of glaciers: alpine glaciers, mountain ice caps, and ice sheets were recognized and briefly described.

In the authors' view, the formation of modern landforms started in Pleistocene time. The Pleistocene / Holocene boundary was marked by a distinctive elevation of most of the archipelago and was accompanied by volcanicity, reduction of ice sheets, shaping of modern fjords, and formation of strandflats.

Geological Structure

All the geological maps were compiled as of July 1, 1986. Their legends were tied to the single stratigraphic scale adopted by that time in the USSR; local subdivisions were retained for the Precambrian only. The geological structure of the archipelago was considered separately for three main structural-stratigraphical complexes (stages), typical of young mobile platforms and epi-platform orogenic regions. The lower stage represents the platform folded basement, subjected to Caledonian tectonics; the middle or intermediate stage was made up of the thick orogenic complex of superimposed Devonian basins; the upper stage represents a heterogeneous sedimentary cover of the young platform; the cover section is crowned by a loose complex of different-facies Quaternary sediments.

Folded Basement

The description of folded basement is illustrated by three geological maps, scale 1:200,000, for Ny Friesland, northwestern Spitsbergen, and its west coast. A lithostratigraphic correlation chart of the four main types of basement section is proposed (Fig. 1).

The gneiss-granitic complex of Nordaustlandet and the Richardvatnet Group of northwestern Spitsbergen, both tentatively placed in the Archean-Lower Proterozoic, were considered to be the oldest bodies. The Lower Proterozoic, encompassing relatively high-grade formations on Spitsbergen, was divided into two complexes, differing in lithology, metamorphic grade, and structural style. Angular unconformity, blurred by later tectonic and thermal processes, is believed to be present between the complexes.

The Atomfjella Group of Ny Friesland and the Smeerenburgfjorden Group of northwestern Spitsbergen were assigned to the lower complex. They are dominated by mica- and garnet-mica plagiogneisses; marble and quartzite, allowing the sequences to be divided into formations, are subordinate. The presence of many bodies of orthoamphibolites, as well as migmatites and granitized rocks, most of which were formed as late as Caledonian time, is a special feature of the Lower Proterozoic rocks.

The upper complex includes the Mossel Group of Ny Friesland, the Krossfjorden and the Kongsfjorden groups of northwestern Spitsbergen, and the Isbjørnhamna Group on its southwestern coast. The bulk of the groups are made up of mica- and garnet-mica schists; quartzites are common; as a rule, marble units are of considerable importance in the middle part. The Mossel and Krossfjorden groups display a distinct down-section increase in metamorphic grade from greenschist to epidote-amphibolite facies.

The Upper Proterozoic is mainly represented by sedimentary rocks, occurring between the Lower Proterozoic high-grade rocks and Cambrian fossiliferous beds. Both lithofacies and biostratigraphic (stromatolites, microphytolites) criteria were used in subdivision of the Upper Proterozoic rocks. This allowed the recognition of the lower Riphean(?), middle-upper Riphean, and Vendian complexes. A considerable change is believed to take place in the tectonic setting of Late Proterozoic basins in pre-Vendian time.

The upper part of the Caledonian folded basement of Svalbard is mainly composed of Cambrian and Ordovician carbonate sequences. The upper age limit of the sedimentary complex within the folded basement is given by a radiometric date of the initial stages of Caledonian metamorphism (440 Ma); it roughly conforms to the age of the Ordovician/Silurian boundary.

Sections of the report concerning separate regions (Ny Friesland, northwestern Spitsbergen, west coast of Spitsbergen), present the description of formations of local lithostratigraphic schemes of the basement and give the characteristics of the most important rock groups and their distribution patterns in section and over the area. The wide development of the processes of migmatization, granitization and anatexis was noted in all the sections of Ny Friesland and, particularly, northwestern Spitsbergen. Intrusive bodies of the basement include: Early Proterozoic basic-ultrabasic complex and a complex of rheomorphic granites; Late Proterozoic effusive-intrusive metabasic complex of the west coast; Middle Paleozoic (Caledonian proper) complex of postorogenic granitoids, accompanied by a dyke series.

Devonian Orogenic (Molasse) Complex

The molasse complex, represented by three Devonian series, is exposed in the Andrée Land graben; separate Lower-Middle Devonian outcrops were also studied in the Hornsund area. The report presents a correlation chart for the areas, based on lithological differences and identifications of fossil fish remains. The known stratigraphic schemes, proposed by Friend (1961), Gee & Moody-Stuart (1966), Murašov & Mokin (1976), were used for subdivision and correlation.

The Gedinnian, Siegenian and Emsian stages were recognized in the Lower Devonian rocks. The Gedinnian Stage incorporates the Siktefjellet Group (up to 400 m) and the Red Bay Group (1700-2500

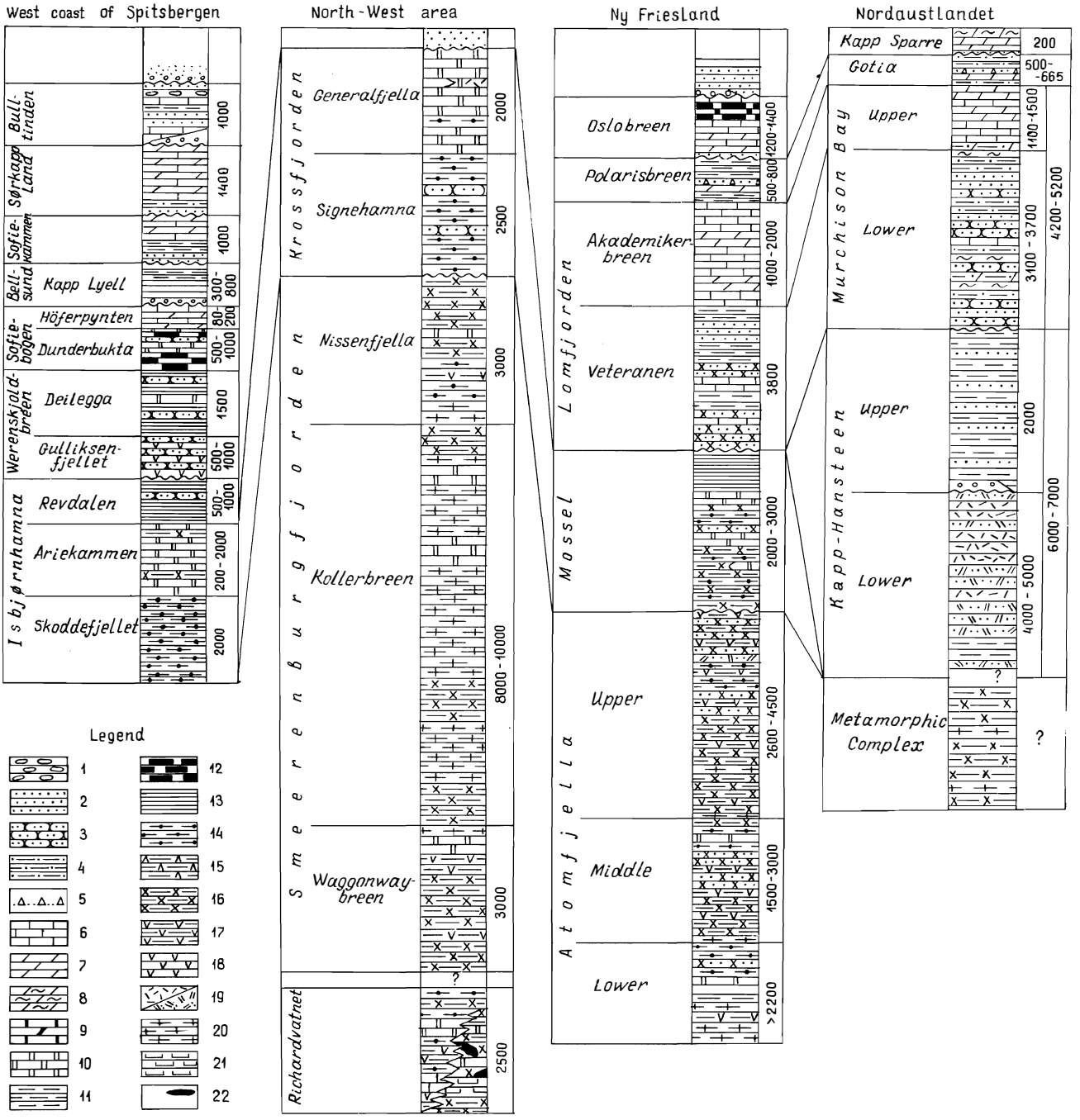


Fig. 1: Correlation of composite sections of folded basement of Svalbard.
1 conglomerate; **2** sandstone; **3** quartzite; **4** siltstone; **5** tilloid rock; **6** limestone; **7** dolomite; **8** clay dolomite; **9** limestone containing bitumen and dolomite; **10** marble and calciphyre; **11** shale; **12** carbon-rich and graphitic shale; **13** chlorite and sericite slate; **14** mica schist; **15** actinolite schist; **16** gneiss and plagiogneiss; **17** amphibolite; **18** basic effusives; **19** acid and intermed. effusives (a), their tuffs (b); **20** nebulite granites and migmatites; **21** amphibole-pyroxene-garnet rocks ("eclogite"); **22** metabasic rocks

m), though the former had been previously placed in the Silurian System (Gee & Moody-Stuart 1966). The Wood Bay Group (about 3000 m) corresponds as a whole to the Siegenian and Emsian stages. The Middle Devonian Series consists of the Eifelian Stage, represented by the Grey Hoek Group (1100-1200 m), and the Givetian Stage, subdivided into two formations reaching over 700 m in composite thickness. The Frasnian and Fammenian (Upper Devonian) deposits were found in Dickson Land only where they make up much of the Mimerdalen Group (up to 800 m).

The entire Devonian section displays different-order cyclic structure with the thickness of cycles and the size of clastics decreasing up-section; the grey offshore facies increases in thickness in the same direction.

For a more detailed description of the Devonian rocks of Spitsbergen see Chapter 3 of this book.

Platform Cover

The main stages of formation of the platform cover, that is the Upper Paleozoic (starting with the Lower Carboniferous), Mesozoic, Lower Cenozoic, and Upper Cenozoic, coincide with the main sedimentary cycles; the stages are separated by periods of general uplift. The West-Spitsbergen trough and the East-Spitsbergen uplift are the major features of the sedimentary cover, formed by these lithostratigraphic sequences. The structure of these major features is illustrated by geological maps, scale 1:300,000, which accompany the report; the stages of their formation are shown in lithofacies profiles at the latitude of Isfjorden, and in paleotectonic sketch maps.

Following Cutbill & Challinor (1965), the Upper Paleozoic complex is divided into three groups: Billefjorden (Lower Carboniferous), Gipsdalen (Middle Carboniferous - Lower Permian), and Tempelfjorden (Upper Permian) groups. The internal structure of the groups and their facies changes are shown in a correlation chart for separate areas of Svalbard (Fig. 2). The chart gives a clear idea of an intricate paleotectonic setting, existing at early stages of accumulation of the platform cover. The authors note evidence of particularly intense block movements in Bashkirian time when the entire archipelago represented a combination of graben-like troughs and horst-like uplifts. The central Nordfjorden uplift and the associated narrow troughs of St.Jonsfjorden and Billefjorden were the major features on Spitsbergen.

The Mesozoic complex was described using the subdivisons of the single stratigraphic scale previously recorded by Pčelina (*1983*). The report presents a lithostratigraphic correlation chart of the four main section types typical of the main structural-facies zones, such as the central part of the West-Spitsbergen trough, its west and east slopes, and the East-Spitsbergen uplift. It was noted that the basal horizons of the Mesozoic section (Induan, Lower Triassic) accumulated on the essentially level surface of underlying rocks. The Mesozoic sedimentation as a whole took place in relatively shallow sea basins, undergoing episodic uplift; greatest uplift continued throughout Late Cretaceous time.

The Lower Cenozoic complex includes Paleogene deposits, occurring in the most downwarped part of the West-Spitsbergen trough and in the narrow graben-like troughs along the west coast of Spitsbergen (Kongsfjorden, Forlandsundet, Renardodden, Øyrlandet areas). In describing the complex the authors used the stratigraphic scheme proposed by Livšic (1973, 1974). He recognized seven formations in the central basin; they form two cycles which, in the author's opinion, show two stages of formation of the Paleogene basin, the late Paleocene - early Eocene and the late Eocene - Oligocene. Interchange of coal-bearing and coal-free sequences in the section forms the basis for subdivision into formations and recognition of cycles. Fault control of the Paleogene basins was responsible for the high rate and pulsating nature of sedimentation. This section of the report is illustrated by a correlation chart for different areas of the archipelago and thickness sketch maps for different formations in the central basin.

The still incomplete Late Cenozoic complex, composed of different-facies upper Quaternary and Holocene sediments, is described in greater detail in the Chapter entitled "Quaternary Deposits and Geomorphology".

Basic igneous rocks, formed during three main periods, were described very briefly as part of the platform cover. The first period (Jurassic - Late Cretaceous) witnessed the intrusion of dolerite sills and dykes. K-Ar dating of dolerites (Burov et al. 1976) indicate that the main phase of magmatic activity was Middle Cretaceous in age (about 100 Ma). In the extreme east of the archipelago (Kong Karls Land), basalt sheets, overlying Valanginian deposits, erupted at that time. The second period (Oligocene?) was marked by eruptions of olivine basalts in Andrée Land. The third period of magmatism (Holocene) is represented by the volcanoes Sverrefjellet, Sigurdfjellet, and Halvdanpiggen. They are built up of amygdaloidal alkali basalts and agglomerate tuffs and are associated with the faults forming the western boundary of the Devonian graben.

Tectonics

Features of the folded basement, orogenic complex, and sedimentary cover of the epi-Caledonian platform were treated separately in the report.

Basement Structure

Two structural-formational complexes, the pre-Upper Proterozoic crystalline basement and the main geosynclinal complex (Upper Proterozoic - Ordovician) are thought to take part in the formation of Caledonian terranes of Svalbard. Primary relations between complexes were obscured by extensive metamorphism and rheomorphism, which resulted in the formation of a new Caledonian infrastructure. The main geosynclinal complex formed in different tectonic settings. The western and eastern zones of the Caledonides are separated on Spitsbergen by a system of central grabens. Rheomorphosed basement "inliers" form cores of anticlinoria in both zones.

In the authors' view, the eastern zone of the Caledonides (Hinlopen synclinorium) represented an extensive miogeosynclinal trough, the development of which is recorded in three lithostratigraphic subcomplexes, corresponding to classic stages of the European tectonic scale: Gotian (early Riphean), Baikalian (middle-late Riphean), and Caledonian proper (Vendian - Early Paleozoic). The western zone was probably noted for a more complex tectonic regime as suggested, for example, by wide occurrences of Late Proterozoic eugeosynclinal-type magmatism. However, paleotectonic reconstructions in the western zone are hampered by intense alpine thrusting along the west coast of Spitsbergen.

Six major structures were recognized in the tectonic section within the archipelago (Fig. 3); they are as follows: northeastern crystalline basement inlier, Nordenskiöldbukta anticlinorium, Hinlopen synclinorium, western Ny Friesland anticlinorium, northwestern basement inlier, and horst-anticlinorium of the west coast of Spitsbergen. As a rule, the structures are tectonically attached to each other and are complicated by higher-order folds. The western zone of the Caledonides displays the most varied structural elements, widely developed thrusts and, correspondingly, overturning of folds.

Structure of the Molasse Complex

Caledonian tectonics culminated in the formation of superposed troughs, which were infilled with Devonian orogenic molasse deposits. The formation of the Devonian graben structure in the north of Spitsbergen is usually related to the Late Devonian phase of Caledonian movement ("Svalbardian folding" in the sense of Vogt, 1938).

The Devonian graben is bounded by faults, steeply dipping to the east. A similar fault along the line Breibogen-Ekmanfjorden divides the graben into the "internal horst" on the west and the "Andrée Land monocline". According to Burov & Semevskij (1976), the latter represents a wide asymmetric anticline, which is conjugate with the syncline on the west. Numerous faults and strike-slip faults, differing in strike direction, determine a distinct internal block structure of the Devonian graben.

Structure of the Platform Cover

The following major features: horst-like uplift of the west coast of Spitsbergen, West-Spitsbergen trough with its West and East boundary fracture zones, Sassendalen monocline, East-Spitsbergen horst-like uplift, and the Olgastretet trough were recognized in the cover of the Caledonian platform. Each of the features was described in detail after Livšic (1973, 1974).

This section of the report is illustrated by: a sketch map of platform structures; a structural map of the West-Spitsbergen trough along the Paleogene base; and a graph and table, presenting rates of the formation of the sedimentary cover in various areas of Svalbard.

Livšic drew attention to substantial differences in platform structures on either side of the East boundary fracture zone. High mobility of the western part of the archipelago is present throughout the

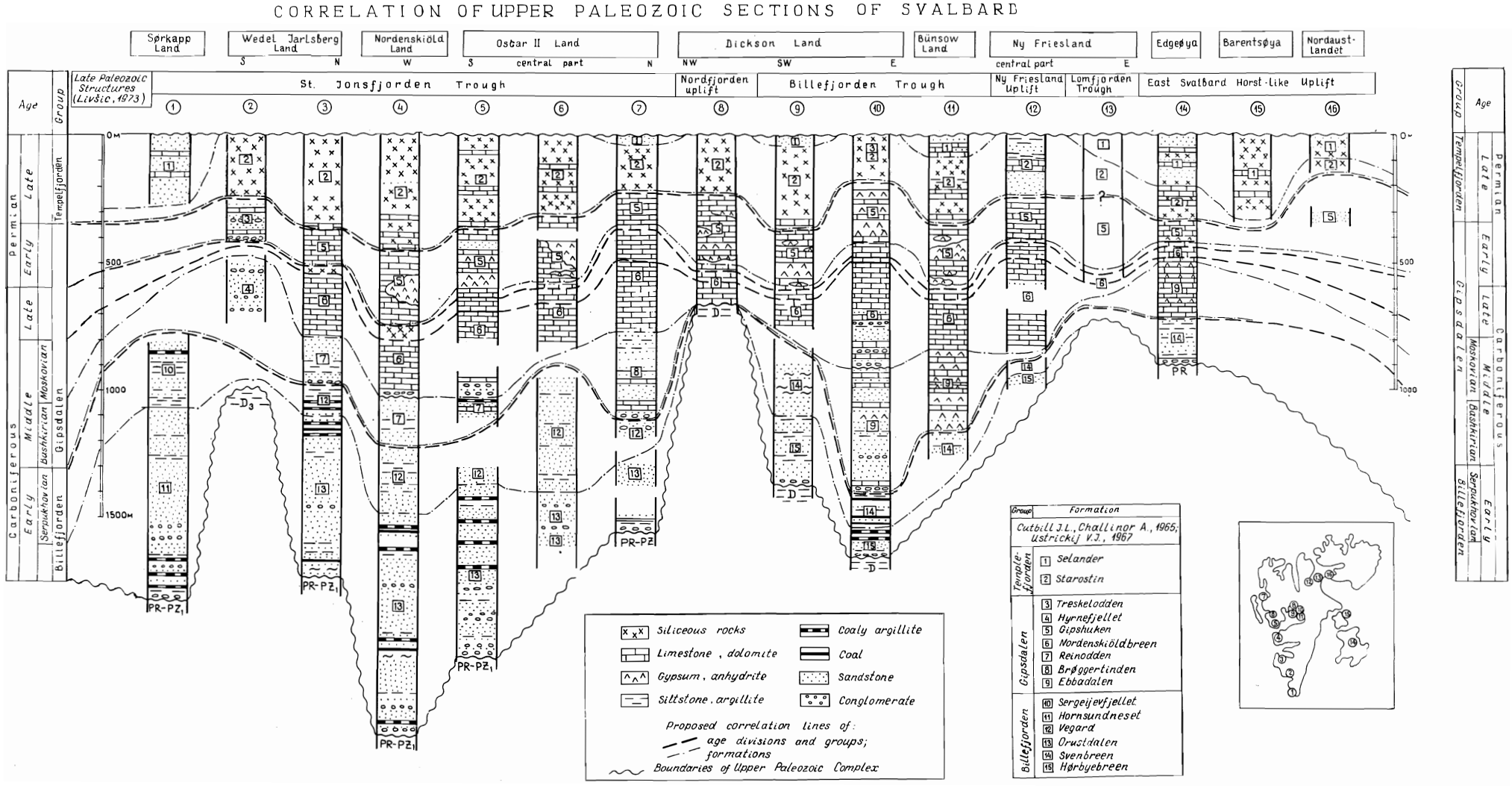
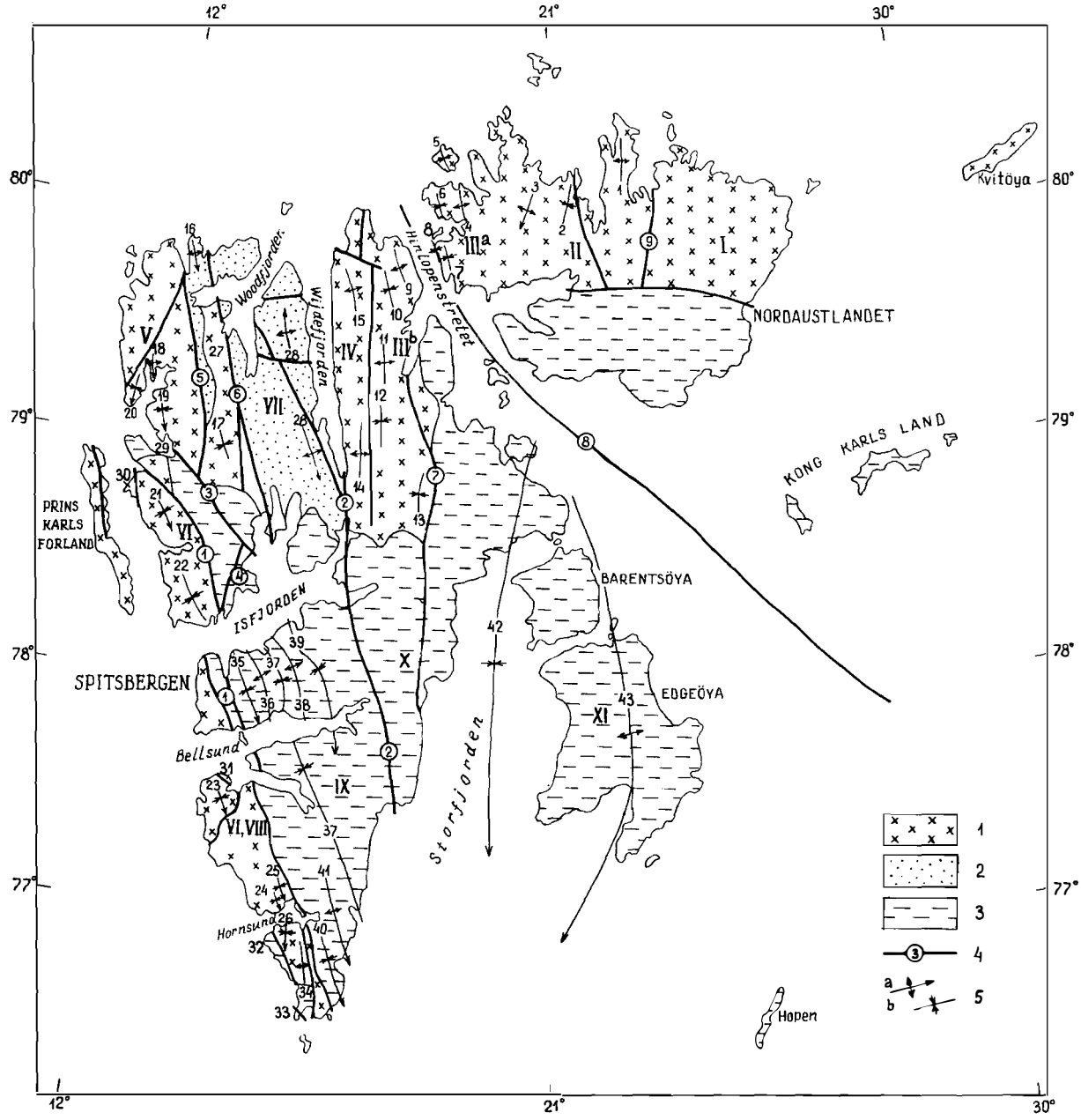


Fig. 2: Correlation of Upper Paleozoic sections of Svalbard.



history of the platform. In Late Paleozoic and Mesozoic time the movement may have been related tobasement structural features; in Early and, particularly, Late Cenozoic time the mobility may have been dictated by the activity in the Mid-Atlantic ridge.

Mineral Occurrences

This section of the report is a succinct explanatory note to a new map of coal- and bitumen occurrences, scale 1:1,000,000, and its inset map, showing localities of ore mineralization and gemstone raw materials.

The section gives information on all the coal deposits belonging to the Russian Trust "Arktikugol" and western companies; and also localities allotted to "Arktikugol". Estimated coal reserves from different-age beds for five areas of the archipelago (west coast, central basin, East Spitsbergen, eastern islands, Bjørnøya) were summarized in the table, taken from Pavlov & Evdokimova (*1981*).

Fig. 3 (opposite page): Sketch map of the tectonic structures of Svalbard.
1 folded basement; **2** Devonian molasse complex; **3** platform cover; **4** major fault zones; **5** axes of anticlines (a) and synclines (b). Explanation of numbers on map:

Major structures of basement:

I North-East uplift
II Nordenskiöldbukta anticlinorium:
1 Prins Oscars Land horst-anticline
2 Lovén syncline
3 Nordkapp anticline
III Hinlopenstretet synclinorium
IIIa Eastern limb
IIIb Western limb
4 Floraberget anticline
5 Lågøya syncline
6 Kinnvika syncline
7 Sveanor syncline
8 Sparreneset syncline
9 Heclahuken anticline
10 Kluftadalen syncline
11 Gullfaksebreen anticline
12 Veteranen syncline
13 Kvitbreen syncline
IV Western Ny Friesland anticlinorium:
14 Atomfjella anticline
15 Bangenhuken anticline
V North-West uplift:
16 Richardvatnet anticline
17 Snøfjella syncline
18 Krossfjorden anticline
19 Blomstrandhalvøya graben-syncline
20 Mitrahalvøya syncline
VI West coast horst-anticlinorium:
21-26 minor synclines:
21 Bulltinden
22 Alkhornet
23 Kapp Lyell
24 Sofiekammen
25 Luciakammen
26 Hornsundtind

Major structures of Devonian complex and platform cover:

VII Devonian graben of Andrée Land:
27 inner horst
28 Andrée Land anticline
VIII West coast horst-like uplift:
29-33 superimposed graben-troughs:
29 Kongsfjorden
30 Forlandsundet
31 Renardodden
32 Hornsundneset
33 Øyrlandet
34 Olsokbreen swell
IX West-Spitsbergen graben-like trough:
35 Iradalen depression
36 Holmsenfjellet swell
37 Skiferdalen depression
38 Reindalen swell
39 Tverrdalen depression
40 Bettybukta depression
41 Isbukta swell
X Sassendalen monocline
XI East-Svalbard horst-like uplift:
42 East-Spitsbergen depression
43 Barentsøya-Edgeøya swell

Major fault zones:

1-4 fault zones:
1 Western marginal zone
2 Eastern marginal zone
3 Pretender zone
4 Erdmannflya-Bohemanflya zone
5-9 faults:
5 Raudfjorden-Kronebreen
6 Bockfjorden-Ekmanfjorden
7 Lomfjorden-Agardhbukta
8 Hinlopenstretet
9 Duvefjorden

New analyses of areal and stratigraphic distribution of gas, oil and bitumen occurrences were made; their generalized geological and chemical characteristics were given. It was noted that gas shows were discovered as springs in natural outcrops of Mesozoic and Paleogene rocks, as well as in coal mines and in coal-prospecting and deep boreholes. Liquid oil shows were recorded only in the lower Paleocene rocks in the area of the Barentsburg coal deposit. As for bitumen occurrences, they are typical in practically all of the sedimentary cover of Svalbard; they were discovered even in folded basement rocks. The Lower-Middle Triassic sequence is considered a prospective oil-source. In the authors' opinion, the most promising areas are southeastern Spitsbergen and the adjacent shelf, where sufficiently high thicknesses of sedimentary cover are combined with a relatively low degree of catagenic transformations and where structures, prospective in a hydrocarbon context, were found.

An inset sketch map, scale 1:2,500,000, shows the main occurrences of ore minerals giving a general idea of the metallogeny of Spitsbergen.

Occurrences of iron (Daudmannsøyra, Recherchefjorden), titano-magnetite ores (northern Wedel Jarlsberg Land), copper-nickel ores (Bockfjorden, Sarsøyra and other areas), ores of non-ferrous and precious metals (western Oscar II Land), complex ores (western Nordenskiöld Land, Petermannfjellet and other areas), as well as rare-earth mineralization in granites and coal measures were described briefly.

Other minerals which the authors consider may be of practical interest, are phosphorites, common in Mesozoic deposits, occurrences of quartz crystal and barite in central Spitsbergen, jasper in western Oscar II Land, and gypsum in the Billefjorden area.

Recommendations for use of the compiled maps and other findings of the studies which were undertaken are given in the brief "Conclusion".

2. THE FOLDED BASEMENT

Most investigators believe that the folded basement of Svalbard was formed as the result of Caledonian tectonics in pre-Devonian time. An early reconnaissance survey (1962-1964) of folded basement was carried out by geologists of the Spitsbergen Expedition in the north of the archipelago. The results were summarized in a report by Krasil'ščikov et al. (*1967*) and later published in a monograph (Krasil'ščikov 1973).

More detailed studies have been undertaken in the north-west of Spitsbergen and along its west coast since 1969. Particular attention has been given to petrochemical and petrophysical examination of crystalline rocks of the northwestern area. The results were presented in an extensive report by Abakumov & Čajka (*1979*). For a variety of reasons, data on weakly metamorphosed Precambrian - Lower Paleozoic sequences of the west coast obtained in this period (up to the late 1970s), were not completely processed.

In the 1980s, mapping continued along the west coast and in Ny Friesland. A report on the geology of Ny Friesland was compiled in 1989 (*Abakumov et al. 1989*). Reports by Mil'štejn et al. (*1984, 1986*) were concerned with biostratigraphic subdivision of the Upper Proterozoic rocks of Spitsbergen.

KRASIL'ŠČIKOV, A.A. & LOPATIN, B.G. 1963:

Preliminary results of the study of Caledonian granitoids and Hecla Hoek gneisses in northern Svalbard

[Predvaritel'nye resul'taty izučenija kaledonskih granitoidov i gnejsov Gekla Huk v severnoj časti arkhipelaga Špicbergen]
Report on fieldwork in 1962
178 pages, 5 appendices, 70 illustrations, 16 tables, 36 references

The report presents results of a one year survey of folded basement, conducted by Soviet geologists in the north of Spitsbergen. In 1962 the geologists visited three localities in the north-west of Spitsbergen (south coast of Smeerenburgfjorden, Danskøya, west coast of Bockfjorden) and two localities on Nordaustlandet (east coasts of Rijpfjorden and Brennevinsfjorden). Geological sketch maps, scale 1:50,000, were compiled for all the localities. A detailed review of earlier work on the problem was concluded with a summary of the publications by Klitin (1960) and Harland (1961).

Crystalline rocks, assigned after Harland to the Proterozoic Finnlandveggen Group, were described on the south coast of Smeerenburgfjorden. The rocks are biotite- and biotite-amphibole gneiss and plagiogneiss, migmatized and granitized to a variable degree. They contain lenses of high-alumina crystalline schists; and marbles and diverse "skarn" (scapolite-pyroxene-, pyroxene-garnet-, amphibole) rocks on the coast of Smeerenburgfjorden. The Finnlandveggen Group rocks are cut through by an intrusion of biotite-granite porphyry (Smeerenburgfjorden) and by dykes of granodiorite - quartz-diorite and leucocratic granite. The wide distribution of the dyke complex on Danskøya was noted. A Caledonian (Silurian) age is inferred for the intrusions.

In the Bockfjorden area, biotite-gneiss, basic and high-alumina crystalline schists, marbles and pyroxene-amphibole rocks (skarns?) were described in the Finnlandveggen Group. In addition, the authors described small isolated outcrops of biotite-muscovite granites, which they consider may have been formed through granitization of the Finnlandveggen Group rocks. The report presents data suggesting that the Lower Devonian siltstone-sandstone sequence with conglomerates rests with unconformity on basement; and new data on the composition of tufa (travertine) and water from the Joutunkjeldane spring.

The west coast of Rijpforden is mainly composed of biotite-muscovite granites which cut the sequence of mica-quartz schists, assigned, after Sandford (1956), to the Kapp Hansteen Formation. An intrusive contact with indication of greisening was described in the north of Vindbukta. Farther north the schists are overlain by quartzitic sandstone of the Murchison Bay Group, but structural relations remain

uncertain. The authors suggested the existence of a regional fault zone along Rijpfjorden and a relatively flat anticline east of the zone.

Two types of granite, gneissoid rapakivi-like granite and equi-fine-grained granite, were described on the east coast of Brennevinsfjorden (Zeipelbukta area). As a rule, the equi-fine-grained granite has sharp contacts, although gradational contacts can also be observed in places. No contacts of the granites with the country rocks have been observed.

Pyrrhotine-chalcopyrite mineralization of disseminated-vein type was discovered together with the scarn rocks in the Smeerenburgfjorden and Bockfjorden areas. Drop-like, spherical, flattened "magnetic globules", 0.1-0.2 mm in size, were found in panning of the beach and alluvium in Zeipelbukta (Nordaustlandet). Spectral analysis showed the presence of Fe (10%), Al, Ca, Si (0.5% each), and Cu, Ni, Mn (0.1% each). The genesis of the magnetic globules remains uncertain, and a suggestion of meteoritic origin was made.

KRASIL'ŠČIKOV, A.A. & ABAKUMOV, S.A. 1964:

Preliminary results of the study of the sedimentary-metamorphic Hecla Hoek Complex and Paleozoic granitoids in central Spitsbergen and northern Nordaustlandet

[Predvaritel'nye resul'taty izučenija osadočno-metamorfičeskogo kompleksa Gekla-Huk i paleozoiskih granitoidov v central'noj časti Zapadnogo Špicbergena i na severe Severo-Vostočnoj Zemli]

Report on fieldwork in 1963

149 pages, 7 appendices, 35 illustrations, 7 tables, 32 references

The report presents results of field studies carried out in 1963 in southern Ny Friesland (Terrierfjellet, Oslobreen) and on Nordaustlandet (Oxfordhalvøya, east coast of Rijpfjorden, and north-west coast of Murchisonfjorden). Geological sketch maps, scale 1:50,000, were compiled for all the localities. For the stratigraphic subdivision of the sedimentary-metamorphic sequence of folded basement (Hecla Hoek Complex), the authors used schemes proposed by Harland & Wilson (1956) for Ny Friesland, and Kulling (1934) for Nordaustlandet.

Quartz-mica- and garnet-biotite-schists, assigned to the Proterozoic Planetfjella Group, and quartzites, assigned to the overlying Lower Veteranen Group, were described in the Terrierfjellet area. No direct contact has been observed between them. In the eastern part of Terrierfjellet and at Ekkoknausane both sequences are cut by biotite- and biotite-amphibole granosyenites (3 analyses for oxides were taken), and are tentatively placed into the Paleozoic. Steeply dipping WNW, schists and quartzites which are cut by granosyenites, are unconformably overlain by subhorizontal Lower Carboniferous deposits.

The boundary strata of the Polarisbreen Group (Upper Precambrian) and the Oslobreen Group (Cambrian-Ordovician) were described in the Oslobreen area. The "Upper Shale Sequence" of the Polarisbreen Group (190-200 m) is made up of variegated clayey siltstone with thin layers of dolomite. The sequence is overlain with no apparent unconformity by the "Oslobreen quartzitic Sandstone" (30-35 m), markedly rich in glauconite in the lower part. Above this is the "Oslobreen Dolomite" (165-175 m) with thin layers of oncolitic structures. The top of the section under study is formed by the "Oslobreen Lower Limestone", the lower part of which (about 60 m) was described on the southern slope of Komarovfjellet. No new fossils have been collected there.

In the Oslobreen area, all the rocks of the Hecla Hoek Complex dip due E at 30-70° and are unconformably overlain by flat-lying Carboniferous deposits. The Lower Carboniferous sequence (20-25 m), composed of quartzose sandstone with rare seams of coaly mudstone, was described at Diglovtoppen; a horizon of silico-argillaceous ferruginous rocks, with breccia and current structures, lies at the base of the sequence.

A monotonous sequence (1700 m) of sericitic shale, assigned to the Kapp Hansteen Group, and non-metamorphic rocks, assigned to the Flora Formation of the Murchison Bay Group, occur on Oxfordhalvøya. The formation is subdivided into three members, namely, the lower sandstone-dolomite (700-750 m), the middle dolomite-siltstone (325-400 m), and the upper quartzite (825-850 m). The

dolomite of the middle member yielded the oncolite *Osagia* Twenh., resembling Middle Riphean oncolites of Tajmyr. Sections of four Holocene marine terraces were first described at the top of Wahlenbergfjorden; the upper terrace is 50-55 m high.

Scree deposits of biotite-muscovite granites were found north-east of Oxfordhalvøya; an E-W dyke of kersantite, up to 5 m thick, cutting through the Flora Formation, was observed north of Oxfordhalvøya. A Caledonian age is inferred for the intrusive rocks. A difference in the character of tectonic structures was noted on Oxfordhalvøya (Flora Formation) and to the north of it (Kapp Hansteen Group). The Kapp Hansteen schists show a monoclinal(?) dip WNW at 25-30°. The rocks of the Flora Formation show a more diversified attitude in the form of conjugate anticlines and synclines. The difference in structural character is believed to be caused by a major E-W fault along the north coast of Wahlenbergfjorden. Another major fault is probably associated with a N-S valley, separating the outcrops of schists and granites.

Three upper formations of the Murchison Bay Group were described briefly in the north-west of Murchisonfjorden. Riphean microphytolites and the upper Riphean stromatolites *Gymnosolen* were first found in carbonate rocks and in dolomites of the Ryssø Formation, respectively. The rocks are folded into open N-S folds.

The east coast of Rijpfjorden (south of Vindbukta) is made up of rocks of the granitic series, including biotite and biotite-muscovite granites, granodiorites, granosyenites, and alaskites (10 analyses for oxides). Large xenoliths of biotite-muscovite and biotite-garnet-gneisses were found in the southern part of the granitoid intrusion. Vein rocks are represented by veins of pegmatites and younger approx. E-W dykes of kersantite, varying from a few centimetres to 4-5 m in thickness. A K-Ar age of 355-395 Ma was determined for five samples of granites from a collection made in 1962 (for details see Krasil'ščikov et al., 1964). Spectral analysis of samples and panning did not show significant concentrations of mineral components. Data on bitumen content in Riphean (Murchisonfjorden) and Lower Paleozoic (Oslobreen) carbonate rocks were obtained for the first time. All the samples analyzed (18) showed the presence of bitumen "A", 0.01 to 0.04 %.

To conclude the report, the authors dealt with the general problems concerning the structure and development of northern Spitsbergen.

ABAKUMOV, S.A. 1965:

Metamorphic rocks of the Lower Hecla Hoek Group on Ny Friesland, western Spitsbergen
[Metamorfičeskie porody nižnej gruppy kompleksa Gekla Huk na poluostrove Nju Frisland, Zapadnyj Špicbergen]
Report on fieldwork in 1964
165 pages, 2 appendices, 51 illustrations, 10 tables, 16 references

The report is compiled from data of geological-petrographical studies on Ny Friesland in 1964. Study of the stratigraphy and composition of metamorphic sequences was carried out at two localities, namely, the east coast of Austfjorden and a locality south of Mosselbukta. Geological maps, scale 1:100,000, were compiled for both localities. During fieldwork, the author used and refined a stratigraphic scheme proposed by Harland & Wilson (1956) as a basis for subdivision of the metamorphic sequences, which are tentatively placed in the Proterozoic.

The Austfjorden Group (over 1000 m), subdivided into two formations, namely, Austfjorden (mica-garnet plagiogneiss and schist, marble, garnet-amphibolite) and Smutsdalen (quartzite with lenses of amphibolite), was recognized by the author as a lower member of the entire metamorphic sequence of Ny Friesland.

The Austfjorden Group occurs only at the south locality along the west coast of Ny Friesland , where it is characterized by a very steep westward dip, but younging eastward; in the author's view, the structure of the area is determined by a conjugate syncline and anticline, 1 km and 5 km wide, respectively.

Following Harland & Wilson (1956), the metamorphic sequence, overlying the Austfjorden Group, is divided into three groups, Finnlandveggen (1400 m), Harkerbreen (1700-1800 m), and Planetfjella. However, the internal subdivision of the first two groups differs from that proposed by Harland. The Malmgrenfjellet Formation (migmatized and granitized quartzite-gneiss and biotite-gneiss, amphibolite) and the Stormerfjellet (garnet-biotite-gneiss and schist, marble beds) Formation were recognized in the Finnlandveggen Group. The Harkerbreen Group is subdivided into three formations with the lower, Camryggen Formation, first recognized as a formation. The bulk of the group is composed of quartzite-gneiss, biotite-gneiss, and amphibolite. Migmatites are very common in the Camryggen Formation. The middle Bleikfjellet Formation is distinguished by the appearance of epidote-mica-gneiss rock types. Muscovite-quartzite plays a significant part in the upper, Tordenryggen Formation. The author suggested that the Harkerbreen Group of the southern locality is equivalent to the Sørbreen Formation (in the sense of Harland) of the northern locality. The report gives a detailed stratigraphic description of parts of the formations recognized.

The Planetfjella Group, enclosed in a narrow tectonic block, and younger deposits, associated with the block on the east, are only outlined in the report. Nevertheless, the author noted that the Planetfjella Group is more complex in structure at the northern locality as compared to the southern site and that on further study it can be subdivided into formations. The author considers that the stratigraphic scheme proposed by Harland, is not completely appropriate for northern Ny Friesland.

A special section of the report deals with the results of petrographic studies of 11 rock groups (using 630 thin-sections) and with the study of rock-forming and accessory minerals.

Igneous rocks of the localities under consideration are Caledonian granites and granosyenites of the Chydeniusfjella intrusion (in the south) and single dykes of Mesozoic dolerites (in the north).

Occurrences of talc, phlogopite, iron, copper, and zinc were found at the localities; they are of mineralogical interest only.

KRASIL'ŠČIKOV, A.A. 1965:

Upper Proterozoic - Lower Paleozoic deposits in the Murchisonfjorden and Sorgfjorden areas
[Verhneproterozojskie - nižnepaleozojskie otloženija rajonov Merčison-fiorda i Sorg-fiorda, Severo-Vostočnaja Zemlja]
Report on fieldwork in 1964
73 pages, 3 appendices, 9 illustrations, 19 references

The report presents results of the study of folded basement in the Murchisonfjorden (Nordaustlandet) and the Sorgfjorden (northern Ny Friesland) areas.

In the Murchisonfjorden area, the Upper Proterozoic clastic-carbonate basement rocks are represented by the Murchison Bay Group (2250-2600 m), subdivided, after Kulling (1934), into six formations: Flora, Norvik, Raudstup, Sälodd, Hunnberg, Ryssø formations. In the middle of the group, clastic rocks give way to carbonate rocks. Upper Proterozoic stromatolites, oncolites and catagraphites were first described in the carbonate section (Hunnberg and Ryssø formations). The conformably overlying Sveanor Formation (50-120 m) is an assemblage of sandstone with scattered pebbles of rocks of variable composition. A glaciomarine (tillite) origin is traditionally assumed for the Sveanor Formation; by analogy with tillites elsewhere in Svalbard, the formation is dated to be of Late Precambrian age. The basement section of Nordaustlandet is completed by the Kapp Sparre Formation (600-650 m), subdivided into the argillaceous-carbonate, sandstone-dolomite, and dolomite members. The dolomites of the upper member contain imprints of Early Paleozoic inarticulate brachiopods.

Krasil'ščikov considers that the Murchisonfjorden area is located in the junction zone of the region of maximum downwarping of the Caledonian geosyncline and the geanticline of Nordaustlandet. Most folds in the area are approx. N-S in trend and asymmetric in structure; dip angles at their limbs vary from 20-40° to 70-80°. Approx. N-S and approx. E-W faults and minor thrusts associated with folding, and the youngest approx. E-W wrench faults were also described.

In the Sorgfjorden area, reconnaissance observations indicated the fundamental resemblance to the Upper Proterozoic sections on Nordaustlandet and in Ny Friesland. The oldest rocks of the area (quartz-biotite-muscovite and garnet-biotite-schists with units of marble and quartzite) form the Planetfjella Group, tentatively assigned to the Middle Proterozoic. The relationship between the Planetfjellet Group and the overlying quartzites of the Flora Formation remain unclear. Limestone and dolomite, recognized as the Kluftdalen Formation, comparable with the Hunnberg and the Ryssø formations of Nordaustlandet, were described in the valley continuing inland from Sorgfjorden; Riphean oncolites were also found in the dolomites of the middle part of the formation. The upper horizons of the Sorgfjorden area are composed of tillites of the Polarisbreen Formation; they form a trough of the central structure, the Kluftdalen syncline. A sill of Mesozoic gabbro-dolerites (35-40 m) was described east of Sorgfjorden, at Heclahuken.

KRASIL'ŠČIKOV, A.A., KUNO, V.G. & ŠIRŠOVA, T.E. 1967:

The geology of basement to the epi-Caledonian platform of Svalbard
[Geologija fundamenta ėpikaledonskoj platformy Špicbergena]
Report on the thematic project, 1962-1964
372 pages, 17 appendices, 51 illustrations, 32 tables, 47 references

The report is based on data obtained through fieldwork in 1962-1964 on northern Spitsbergen, with use of information published in foreign sources, especially data concerning southern and western Spitsbergen.

Introductory geological notes are accompanied by a literature review of the evolving notions of the geology of the folded basement of Spitsbergen as of 1967. The introduction is followed by Sections dealing with the stratigraphy of Precambrian complexes, the petrography of metamorphic rocks, intrusive bodies, tectonics and mineral occurrences, related to the basement.

Precambrian-Lower Paleozoic sections (Hecla Hoek Complex) of Nordaustlandet, Ny Friesland, northwestern Spitsbergen, the west coast of Spitsbergen and Prins Karls Forland, southwestern and southern Spitsbergen were described in the Section entitled "Stratigraphy". A study of lithology, biostratigraphy and analysis of the geological history allowed a correlation chart for the basement of these areas to be constructed and four large complexes, namely, the Lower Paleozoic, Vendian, Riphean, and Middle Proterozoic(?) to be recognized.

On Nordaustlandet, the highest-grade rocks (garnet-biotite- and biotite-muscovite gneisses and crystalline schists) form small isolated outcrops, as well as skialiths and xenoliths in extensive granitoid intrusions. They were viewed by the authors as a relic of the substrata and were formally recognized as a presumably pre-Riphean independent metamorphic complex.

On Nordaustlandet, stratified bodies are traditionally placed in the Hecla Hoek Complex and divided into three Precambrian groups (Kapp Hansteen, Murchison Bay, and Gotia) and the Cambrian Kapp Sparre Formation. The Kapp Hansteen volcanic-sedimentary group (750-1700 m) is tentatively assigned to the uppermost Middle Proterozoic. The overlying Murchison Bay Group (about 4000 m) is subdivided into six formations. Rare middle Riphean microphytolites were found in the lower part of the group. The upper carbonate part of the group contains representative assemblages of upper Riphean stromatolites and microphytolites. Clastic deposits, presumably Vendian in age, were first recognized as the Gotia Group (500-650 m) and subdivided into three formations; the middle, Sveanor Formation is composed of tilloid rocks. On Nordaustlandet, the folded basement section is completed with the Kapp Sparre Formation (about 200 m), an assemblage of sandstone and dolomite, yielding brachiopods of presumed Cambrian age.

The most complete basement section was described by British geologists on Ny Friesland. The lithostratigraphic chart, proposed by Harland et al. (1966) and somewhat modified by the present authors, was taken as a basis for subdivision. Krasil'ščikov et al. recognized four supergroups, namely, Stubendorffbreen (Middle Proterozoic?), Lomfjorden (Riphean), Polarisbreen (Vendian), and Oslobreen

(Cambrian-Ordovician). A more detailed subdivision into formations is also correlated with Harland's scheme.

The lower and upper groups, differing in lithology and metamorphic grade, were recognized in the Stubendorffbreen Supergroup. The report gave a revision of primary data, obtained in 1964 from the supergroup sections at the northern and southern localities of the north coast of Ny Friesland (*Abakumov 1965*). The overlying section was described in the report mainly from Harland's et al. (1966) data.

Correlation of schemes, proposed earlier for northwestern Spitsbergen by different geologists, and observations, made by the present authors in the south of Smeerenburgfjorden, on Danskøya, and at Bockfjorden, were presented in the report. Five formations were recognized. Three lower formations (Nissenfjella, Signehamna, Generalfjella) are equivalent to three formations of the same names, proposed by Gee & Hjelle (1966) in the Krossfjorden area. It is the opinion of the authors that the upper formations (Biskayerhuken and Montblanc), recognized by Harland et al. (1966) on the peninsula east of Raudfjorden, formed the Krossfjorden section. They also noted that establishing a stratigraphy of the metamorphic complex of northwestern Spitsbergen is a 'matter of convention' because of very intensive areal distribution of the processes of migmatization and granitization.

All the sections of the west coast of Spitsbergen, from Kongsfjorden to Sørkapp Land, including Prins Karls Forland, were described from data of non-Russian geologists. In the correlation chart compiled by the authors, almost all the sections were tied, to a greater or lesser degree of reliability, to the southern Spitsbergen section, which had received the most study (Major & Winsnes 1955; Birkenmajer 1960, among others). The two upper formations (Sofiekammen and Sørkapp Land) were dated by Cambrian and Ordovician faunal remains, respectively. The middle section is viewed as Upper Proterozoic, whereas three lower formations (Isbjørnhamna, Eimfjellet, and Deilegga) are considered equivalent to the Middle Proterozoic(?) Stubendorffbreen Supergroup of Ny Friesland.

Detailed petrographical description of the metamorphic rocks of Ny Friesland and Nordaustlandet was given in the Section entitled "Petrography". Data on mineral and chemical composition of the rocks, and optical properties of rock-forming minerals, were provided.

The geological, petrographical and petrochemical (34 analyses) details of Precambrian and Middle Paleozoic intrusive complexes were presented in the Section entitled "Intrusive Rocks".

Metagabbroids, forming small intrusions on eastern Nordaustlandet, were classified with the Precambrian complex. K-Ar ages were given for metagabbro from Storøya (677 Ma) and secondary Fe-phlogopite from metapyroxenite at Kapp Laura (442 Ma). Another type of intrusive and probably associated effusive rocks included carbonatized dolerites and amygdaloidal basalts, occurring in pebbles of Vendian tilloids on Nordaustlandet and in Ny Friesland. However, the authors noted that the oldest occurrences of Precambrian magmatism were represented by pre-Riphean(?) basic and intermediate effusive rocks, altered into amphibolites in sections of north-west Spitsbergen and Ny Friesland.

The Middle Paleozoic complex is made up of intrusions of acid and subalkali rocks, studied on Nordaustlandet (biotite- and biotite-muscovite granites-granodiorites of Prins Oscars Land and Sjuøyane, porphyroblastic granites of Laponiahalvøya) and on northern Spitsbergen (granosyenite intrusions of Ny Friesland, biotite-granites of the Hornemantoppen intrusion of the north-west area). Veins of pegmatites and aplites, a dyke series of granodiorite-quartz-diorites on Danskøya, and dykes of kersantite on Nordaustlandet are associated with the same complex. Detailed examination of accessory minerals from rocks of the Middle Paleozoic intrusive complex allowed the association of certain mineral assemblages with different types of intrusions in various areas of Spitsbergen to be ascertained.

The Section entitled "Tectonics" presents a description of the main basement structures at the present erosional surface, the nature of structural-formational complexes and the geological evolution of Spitsbergen in Precambrian and Early Paleozoic time. Five major structures were: horst-like uplift on eastern Nordaustlandet, anticlinorium in central Nordaustlandet, synclinorium in Hinlopenstretet, anticlinorium in western Ny Friesland, and anticlinorium on the west coast.

The authors proposed a two-level basement structure with further subdivision of each level into structural stages. The lower level (structural-formational complex) was formed in Early-Middle Proterozoic time. The crystalline basement as a whole had been formed by middle(?) Middle

Proterozoic time; by the end of the Middle Proterozoic (1700-1600 Ma) it had been followed by phyllite formations of the upper structural complex.

The upper basement level is represented by practically unmetamorphosed, and for the most part sedimentary, Upper Proterozoic (Riphean-Vendian) formations. Tectonic changes and a change in the structural setting of sedimentary basins in Vendian time reflected tectonic instability at the Precambrian/Paleozoic boundary; this reorganization was not accompanied by any substantial metamorphism.

The formation of the Caledonian folded basement was concluded in Silurian time with general inversion of geosynclinal troughs, folding, metamorphism and granite formation. In summary, the authors arrived at the conclusion that tectonic zoning of the Proterozoic-Early Paleozoic megabasin, non-uniform development of the structural-formational zones, and the effects of older tectonic and magmatic cycles were responsible for the heterogeneous structure of the Caledonian folded region of Spitsbergen.

ABAKUMOV, S.A. & KRASIL'ŠČIKOV, A.A. 1971:

Precambrian rocks of the Krossfjorden and Hornsund areas
[Dokembrijskie obrazovanija rajonov Kross-fiorda i Hornsunna]
Report on fieldwork from 1969-1970
156 pages, 4 appendices, 49 illustrations, 7 tables, 42 references

The report consists of two separate parts. The first part (by S.A.Abakumov) represents a geological report on the Krossfjorden area. The second part concerns the stratigraphy and tectonic structure of the Precambrian sedimentary strata of the Hornsund area. Both parts are accompanied by geological maps, scale 1:100,000, sections and stratigraphic columns.

1. The Krossfjorden area is built up of a Proterozoic metamorphic complex, divided into three formations: Kollerbreen (first recognized), Signehamna, and Generalfjella (Gee & Hjelle 1966). The geographically separate Kollerbreen Formation differs from the overlying formations in having a higher metamorphic grade, and in lithology of primary sedimentary strata. The Kollerbreen Formation is tentatively assigned to the Lower-Middle Proterozoic, and the two overlying formations to the Upper Proterozoic.

The Kollerbreen Formation is distinguished by alternating biotite-garnet (containing sillimanite in places) gneisses and plagiogneisses, and the wide distribution of the effects of ultrametamorphism and granitization.

The Signehamna Formation (5500 m) is made up of garnet-mica schists and quartzite-schists, intercalated with quartzite in the lower part; and massive marbles and calciphyres in the upper part. Garnet varieties of schists disappear in eastern sections. No direct contact with the underlying Kollerbreen Formation has been observed, but the presence of a "transitional zone", 150-200 m thick, is inferred between them.

The Generalfjella Formation (2500 m) rests conformably on the Signehamna marbles. A uniform unit of dark mica schists, showing characteristic lamellar jointing and containing rare layers of quartzites, changes up-section into a unit of strongly folded and differently-coloured marbles (or marmorized limestones), showing no signs of silicate mineralization.

Separate chapters deal with the petrography and chemistry of metamorphic and ultrametamorphic rocks. The author recognized two stages of endogenic thermal activity. The early stage was characterized by regional metamorphism ranging from greenschist to amphibolite facies; it was accompanied by the zonal effects of plagiogranitization and ultrametamorphism. The late stage is indicated by the zonal processes of potassic metasomatism and granitization.

Three groups of intrusive bodies were described in detail: a small body of post-tectonic (Silurian?) biotite granodiorites, anatectic biotite granites of uncertain age, and dykes and veins of aplites and migmatites.

2. A section of Precambrian and Lower Paleozoic deposits was studied in the Hornsund area. Stratigraphic subdivision was based on the scheme proposed by Birkenmajer (1958), but alternative interpretation of the section was discussed separately.

The Precambrian deposits consist of six formations, forming two complexes with tectonic contacts between them.

The lower complex (Isbjørnhamna and Eimfjellet formations) is distinguished by: a high metamorphic grade (epidote-amphibolite facies); the presence of volcanic rock; and a peculiar stratified "zone of granitization" after "amphibolites" in the Eimfjellet Formation. An Early-Middle Proterozoic (pre-Riphean) age was tentatively assumed for the complex.

The upper complex starts with the Lower Riphean(?) Deilegga phyllite formation, containing conglomerates at the base. On the north coast of Hornsund (at Sofiebogen Bay), the overlying section forms an almost continuous succession of rocks, dipping monoclinally westward at 30-50°.

The following units were described in detail from west to east: the Slyngfjellet conglomerate formation (400 m); the Höferpynten limestone-dolomite formation (160-350 m), and the Gåshamna Formation, an assemblage of phyllite-like schists and quartzitic sandstone (1200 m). On both the north and south coasts of Hornsund, the Höferpynten dolomites yielded abundant but monotonous microphytolites of the *Osagia* and *Vesicularites* groups, suggesting, according to V.E.Zabrodin and V.E.Mil'štejn, a middle Riphean age for the deposits. However, similar forms of microphytolites were also found in dolomite layers from the lower (?) part of the Gåshamna Formation.

The tectonic structure of the Hornsund area was treated in the report as being associated with a system of upthrusts from WSW. For instance, the metamorphic basement, complicated by asymmetric north-west-trending folds and internal thrusts, is thrust over the Upper Precambrian sedimentary complex. As stated above, the latter forms the Sofiebogen monocline, which in turn is upthrust onto the Cambrian carbonate strata of Sofiekammen from the west. A large fault, separating the Deilegga phyllites from the Slyngfjellet conglomerates, is inferred along the western margin of the monocline beneath Hansbreen.

The final chapter presents a discussion concerning the peculiar Precambrian section of southwestern Spitsbergen and, as a consequence, possible revision of the earlier (Krasil'ščikov 1970) correlation chart for subdivision of the Precambrian-Lower Paleozoic rocks in Svalbard.

ABAKUMOV, S.A. & ČAJKA, L.A. 1979:

Geology and petrophysical properties of the rocks of northwestern Spitsbergen
[Geologija i petrofizičeskie svoistva gornyh porod severo-zapadnogo Špicbergena]
Report on the project, based on the data obtained by fieldwork from 1960-1972 and in 1977; in 2 volumes
398 pages, 4 appendices, 118 illustrations, 14 tables, 121 references

The report presents results of fieldwork, carried out on northwestern Spitsbergen from 1969-1972 and in 1977. Their main aim was to tackle the problem concerning the existence of the pre-Caledonian crystalline basement with the aid of geological observations and detailed petrographical, petrochemical and petrophysical examination of the rocks. With this aim in mind:

- 1400 thin-sections were described;
- 170 determinations of optical constants were made;
- 190 and 44 analyses of rocks and rock-forming minerals were made, respectively;
- 11 mineralogical analyses of heavy minerals of granitoids were performed;
- 20 hydrochloric extracts from carbonate rocks were made;
- 7 X-ray crystal analyses of feldspars were made;
- 123 petrophysical studies of standard specimens were made.

The report contains three large sections: 1) geological structure of the area; 2) methods of the petrophysical studies; 3) petrophysical classification and character of recognized groups of metamorphic and intrusive rocks. In addition to 79 drawings and photos, contained in the report, the authors appended a separate volume of photomicrographs and drawings (39), illustrating detailed petrophysical studies.

The Section entitled "Geological Structure" deals with: the tectonic structure of northwestern Spitsbergen; the stratigraphy of Precambrian complexes; the geology of different-aged intrusive bodies; the section also presents a petrographic description of metamorphic and intrusive rocks, and a description of the distinguishing processes of metamorphism and ultrametamorphism.

The authors consider that two different-aged structural stages, namely, the pre-Riphean crystalline basement and the Riphean-Early Paleozoic complex of the Caledonides, are the main geological feature of the area. Processes of Caledonian granitization, affecting the lower horizons of the Riphean geosynclinal complex and leading to the formation of a new, Caledonian infrastructure, are common in the area. Metamorphic zoning, superposed on crystalline basement rocks in Caledonian time and progressive through deposits of the geosynclinal complex, crosses stratigraphic boundaries. These phenomena, together with multistage deformations, have obscured the surface of structural unconformity between the ancient basement rocks and the deposits of the geosynclinal complex.

The rocks, belonging to the basement, form the Smeerenburgfjorden Group; above comes the Krossfjorden Group, forming the lower part of the Riphean complex. The existence of an unstratified tectonic zone (up to 3 km wide), mainly made up of mafic rocks forming an eclogite formation, which is presumably the oldest in the northwestern region, is inferred on Biskayerhuken Peninsula.

The Biskayerhuken eclogite formation (first recognized in this report) is composed of eclogites, amphibolites, ultrabasic rocks, various gneisses, granitoids, pegmatites and garnet-mica schists.

The Smeerenburgfjorden Group includes the highest-grade rocks of the area. No base of the section has been found; contacts with the overlying Krossfjorden Group are tectonic. The rocks exhibit amphibolite facies metamorphism with relics of granulite facies. The bulk of the group is built up of: diverse gneisses and plagiogneisses, which encompass marble horizons; and different types of migmatites and rheomorphic granitoids. The group is divided into two formations based on composition. The lower, Waggonwaybreen Formation, essentially magnesian in character, contains lenses of amphibolites. The upper, Kollerbreen Formation is dominated by high-alumina varieties of gneisses and plagiogneisses.

The Krossfjorden Group contains relatively weakly metamorphosed rocks, the metamorphic grade of which increases down-section from greenschist to epidote-amphibolite facies. The group is divided into three formations: Nissenfjella, Signehamna, Generalfjella. The Nissenfjella Formation is restricted to the type section area; it is distinguished by the predominance of biotite-plagiogneisses, and the presence of amphibolites and migmatites. The Signehamna Formation is a uniform assemblage of mica- and garnet-mica schists, containing quartzite units. The upper part of the group (Generalfjella Formation), usually lying in synclinal troughs, is mainly carbonate in composition.

Intrusive bodies include the pre-Riphean mafic complex (ultrabasic rocks, gabbroids, metabasic rocks, amphibolites, eclogites) and the Caledonian complex of granitoids. The latter includes syn-orogenic intrusions of normal granites and a post-orogenic intrusion of "monzonites" (granodiorites), with a dyke series of mainly the same composition.

The Section entitled "Some Methodology Problems of Petrophysical Studies" (written by L.A.Čajka) not only gives a comprehensive description of techniques and apparatus used in studying rocks, but also presents a substantially original concept of the methodology of petrophysical studies as a whole.

Preliminary large-scale measurements of density and magnetic susceptibility of the whole collection of metamorphic and intrusive rocks of northwestern Spitsbergen (1308 specimens) were made. A correlation chart from these measurements was used as a basis for selecting 123 specimens for thorough petrophysical study. All further studies were made on two-dimensional objects - cut bars, 0.2-0.3 cm thick. The studies included determination of parametres of: water absorption and electrical conductivity; porosity and permeability, and some other physical properties.

The final results obtained from processing of the data were the determination of the coefficients of density decrease and rock uniformity. Values of the ratio between the coefficients served as a basic criteria for classification of all the material studied. Thus the authors recognized and described some groups and subgroups, forming four large complexes, each with distinguishing petrophysical features. They are as follows:

- Smeerenburgfjorden gneisses and granites;
- Krossfjorden metamorphic schists;
- crystalline schists and tectonites of the Biskayerhuken area;
- "monzonites" (granodiorites) of the Hornemantoppen intrusion.

The studies conducted by the authors led them to some important theoretical and applied conclusions. It is believed, in particular, that the structure of pore space can be used for classification of metamorphic rocks with linear texture thus allowing prediction of the degree, and the nature of, tectonic processes on them. The authors consider that the petrophysical differences between the granite-gneiss complex and the stratified carbonate-quartzite-schist sequence suggest it is unlikely that the former is due to granitization of the Riphean geosynclinal deposits.

ABAKUMOV, S.A., SIROTKIN, A.N. & TEBEN'KOV, A.M. 1989:

Metamorphic and magmatic complexes of Ny Friesland and their petrochemical and geochemical character

[Metamorfičeskie i magmatičeskie kompleksy Nju Frislanda i ih petro- i geohimičeskaja harakteristika]
Report on fieldwork in 1986-1987
370 pages, 17 appendices, 117 illustrations, 77 tables, 46 references

This fundamental work summarized data obtained on the geology of Ny Friesland over the period 1962-1988. The existing stratigraphic scheme was revised in order that it be applied to the whole of Ny Friesland. A geological map, scale 1:100,000 was compiled. Lithostratigraphical, petrographical and petrochemical characteristics of metamorphic and igneous rocks of Ny Friesland were given. Metamorphic facies were described; geochemical characteristics of metamorphic complexes were given. Mineral occurrences were described. During the study, 2856 thin sections were described; the following analyses were made: 195 mineralogical, 150 chemical, 134 microprobe, and some other analyses.

A Chapter entitled "Lithostratigraphy" describes the Precambrian Atomfjella, Mossel and Veteranen groups, including their structural features and the nature of the contacts with each other.

The Lower Proterozoic Atomfjella Group is divided into seven formations, namely Eskolabreen (gneisses, migmatites, ghost granites, amphibolites, quartzites, 1500 m), Smutsbreen (garnet-biotitic plagiogneisses and schists, marbles, quartzites, 1000-1200 m), Polhem (quartzites, plagiogneisses, amphibolites, 600 m), Rittervatnet (mica-garnet schists, marbles, quartzites, plagiogneisses, amphibolites, 950-1000 m), Bangenhuken (biotite- and amphibole-biotite gneisses, amphibolites, 2000 m), Vassfaret (quartzites, plagiogneisses, biotite-muscovite and garnet-mica schists, amphibolites, 600 m), and Sørbreen (quartzites, amphibolites, metavolcanic rocks, 450-500 m).

Unconformably(?) overlying is the Mossel Group, consisting of three formations, namely Flåen (plagiogneisses, crystalline schists, quartzites, marbles, 1000-1100 m), Mosseldalen (first recognized; an assemblage of marbles, mica-garnet schists, quartzites, 1100-1200 m), Rosenfjella (chlorite-mica- and chlorite-sericite-schists, 1500 m). An Early Proterozoic age was tentatively assumed for the group; the group has a tectonic contact with the overlying rocks of the Upper Proterozoic Lomfjorden Supergroup. The report describes the lower, Veteranen Group, composed of four formations, namely, Kortbreen (siltstones, sandstones, limestones, quartzites, 300-1200 m), Kingbreen (siltstones, mudstones, quartzites, limestones, 200-600 m), Glasgowbreen (quartzites, siltstones, mudstones, 600-800 m), and Oxfordbreen (siltstones, sandstones, limestones, 500-800 m).

The Chapter entitled "Characteristics of the Rock Composition" gives petrographic and petrochemical characteristics of rocks of the metamorphic complexes, and analysis of their mineral assemblages. Eight petrographic groups are characteristic of the Atomfjella Group. They are as follows: 1) quartzites, quartzite-gneisses; 2) biotite- and biotite-epidote plagiogneisses; 3) biotite-amphibolite gneisses and plagiogneisses; 4) granitoids; 5) garnet-mica schists and plagiogneisses; 6) scapolite-bearing rocks; 7) marbles and calciphyres; 8) metavolcanic rocks. The Mossel Group rocks contain six petrographic groups: 1) biotite-muscovite gneisses and plagiogneisses; 2) garnet-biotite-muscovite schists; 3) chlorite-mica, chlorite-sericite schists; 4) marbles; 5) quartzites and quartzite-sandstones; 6) biotitic microgneisses.

Mineral assemblages of the metamorphic rocks were studied together with the chemistry of the rocks and individual rock-forming minerals. The studies allowed the recognition of mineral assemblages, which distinguished the conditions of metamorphism. The data obtained were confirmed by results from mineralogical geothermometers. For instance, the Atomfjella Group rocks have been metamorphosed in the whole range of amphibolite facies; locally the rocks have been retrogressively metamorphosed to epidote-amphibolite and green-schist facies. The Mossel Group rocks have been metamorphosed in epidote-amphibolite and greenschist facies; metamorphic isograde s are subparallel to stratigraphic boundaries.

A separate chapter deals with the problem of Atomfjella Group amphibolites, considering their geological and petrographical, petrochemical and geochemical characteristics. An attempt to distinguish para- and orthoamphibolites was made and the criteria given. A spatial association of the para-amphibolites with the carbonate-schist strata of the Rittervatnet and Smutsbreen formations; and the orthoamphibolites with gneisses and quartzites of the rest of the formations in the group was revealed.

The examination of 1720 samples, which had been subjected to special semiquantitative analysis, allowed the geochemical characteristics of the metamorphic rocks to be obtained. A special chapter deals with the techniques of sampling and mathematical processing of the results of analysis. The chapter also presents data on the average content of some trace elements both in separate types of metamorphic rocks and over different stratigraphic units. The geochemical background of western Ny Friesland is believed to have been formed due to metamorphic processes. Later processes of trace element redistribution have had no profound effect on the structure of the geochemical field.

The following different-aged complexes were recognized and described in detail in the Chapter entitled "Igneous Rocks":

- Early Proterozoic: gabbro-diabase and hyperbasic complexes on Mosselhalvøya and the Flåtan granitic intrusion;
- Late Proterozoic: metabasic complex of central Ny Friesland, granite-granodiorite complex of northern Ny Friesland, granite-granosyenite complex of the Chydeniusbreen intrusion; and Mesozoic dolerite and Neogene plateau basalt complexes.

A point worth mentioning here is that a Late Proterozoic (but not Caledonian) age for the granite-granosyenite complex has not been supported by recent geochronological studies (Teben'kov et al.1995).

The chapter describes the geological structure of individual intrusions and lava sheets and presents petrographical, petrochemical and geochemical characteristics of the igneous rocks; their position in the above complexes and their association with various tectonic-magmatic cycles are substantiated.

The last chapter concerns the mineral resources of Ny Friesland. Here attention is given to rock crystal occurrences in the north of the peninsula. The chapter gives their geological characteristics; describes in detail rock crystal-bearing bodies, quartz reefs and their country rocks; an association of the rock crystal-bearing zones with certain structural features of the metamorphic complex is established; stages of formation of the quartz reefs are determined; and rock crystal potential is given for the whole of Ny Friesland.

Of other mineral resources, occurrences of serpentine-asbestos, talc, iron, copper are briefly mentioned.

MIL'ŠTEJN, V.E. & GOLOVANOV, N.P. 1984:

Upper Precambrian biostratigraphy of Spitsbergen
[Biostratigrafija verhnego dokembrija Špicbergena]
Report on the thematic project, 1981-1984; in two volumes
315 pages, 23 appendices, 78 illustrations, 17 tables, 156 references

The report presents for the first time a detailed biostratigraphic description of Riphean and Vendian strata on Bjørnøya (1980), south coast of Hornsund, north coast of Bellsund (1981), and the west coast of Lomfjorden (1982). At the localities under study, Upper Proterozoic deposits were described in detailed sections in accordance with the existing stratigraphic schemes (Krasil'ščikov & Livšic 1974; Krasil'ščikov & Kovaleva 1976; Harland et al. 1966). Analysis of vertical distribution of microphytolites, stromatolites, and inorganic microfossils allowed the recognition of four biostratigraphic units, Middle-Upper Riphean, Upper Riphean, Upper Riphean-Vendian, and Vendian. Each of them contains local microphytolite assemblages, used by the authors for correlation of individual strata at different localities.

The report contains four large chapters: (1) Description of sections, (2) Microphytolites, (3) Stromatolites, (4) Correlation chart.

On Bjørnøya, the Russehamna dolomite formation yielded Upper Riphean stromatolites and some microphytolite assemblages, assigned to the Upper Riphean and Upper Riphean-Vendian units. The mudstones of the Sørhamna Formation yielded Vendian microfossils.

A section of the Höferpynten and Gåshamna formations was described on the south coast of Hornsund. In the Vendian Gåshamna Formation, microphytolites were found in pebbles of the underlying dolomites only. In the underlying Höferpynten Formation, abundant but rather monotonous microphytolites are present in three upper members, whereas two lower members and the lower part of the third member yielded stromatolites and microfossils. The upper member was assigned by the authors to the Late Riphean-Vendian, and the rest of the members to the Middle-Late Riphean.

On the north coast of Bellsund (in the Kapp Martin area), the Upper Proterozoic section was divided into five lithological sequences: the upper conglomerate-dolomite sequence was placed into the Vendian, and four lower sequences into the Middle-Late Riphean. Microphytolites and microfossils are present throughout the section, whereas stromatolites were found in the dolomites of the middle sequence only.

On the west coast of Lomfjorden, a section of the Upper Proterozoic, Lower Veteranen and Akademikerbreen groups was described; the groups are traditionally divided into formations following the scheme proposed by Harland et al. (1966). The Akademikerbreen carbonate group yields abundant stromatolites and microphytolites (five local microphytolite assemblages were recognized). Microfossils were found in the uppermost part of the group (Backlundtoppen Formation) and over the entire section of the Lower Veteranen Group only. The latter is mainly composed of sandstone, siltstone and mudstone, but stromatolites and microphytolites were also found in carbonate units of the Oxfordbreen, Bogen, Galoistoppen, and Kingbreen formations. In spite of abundant microphytolite remains, the authors succeeded in recognizing only two assemblages, Late Riphean and Late Riphean-Vendian in age. The boundary between them was drawn within the Akademikerbreen Group, at the base of the Draken Formation using stromatolites, and between the lower and upper members of the Grusdievbreen Formation using microphytolites.

The Section entitled "Microphytolites" considers at length the history and techniques of the study of microphytolites in Russia, dwells on the problems of their origin and systematics, as well as the environments of enclosing deposits. New forms of the *Osagia* and *Vesicularites* groups were described and illustrated by 24 plates.

The Section entitled "Stromatolites" mainly outlines different-aged stromatolite assemblages.

The last Section confirms the recognition of the Middle-Upper Riphean, Upper Riphean, Upper Riphean-Vendian and Vendian units and gives a chart of their possible correlation (Fig. 4 is a modified version).

MIL'ŠTEJN, V.E., GOLOVANOV, N.P. & IL'ČENKO, L.N. 1986:

Upper Precambrian biostratigraphy of the west coast of Spitsbergen
[Biostratigrafija verhnego dokembrija zapadnogo poberežja ostrova Zapadnyj Špicbergen]
Report on the thematic project in 1985-1986
189 pages, 16 appendices, 60 illustrations, 11 tables, 8 references)

The report continues the description of the biostratigraphy of Upper Proterozoic deposits of Spitsbergen. The technique, described in the previous report (*Mil'štejn & Golovanov 1984*), was applied in this study. Four localities were investigated on the north coast of St.Jonsfjorden, Isfjorden, Bellsund and Hornsund. Microphytolites and microfossils (including filamentous algae), collected in stratigraphic sections, were described; the sections yielded no stromatolites.

A tectonic contact was observed between the Vendian and Riphean deposits in most sections; erosion is inferred to take place at the base of the Vendian in the north of St.Jonsfjorden only. All the Riphean and Vendian sequences, recognized lithologically, yielded microfossils. Microphytolites are generally present in essentially carbonate Riphean sequences.

Subdivision into middle Riphean, middle-upper Riphean and Vendian units was adopted in the correlation chart. However, microfossils and filamentous algae allow subdivision of the middle Riphean and the upper Riphean units (Fig. 4).

It should be noted that of 146 specimens collected, 97 yielded microfossils; the first time such an abundance of microfossils was examined on Spitsbergen. The report is supplemented by plates of microphytolites (18) and microfossils (15).

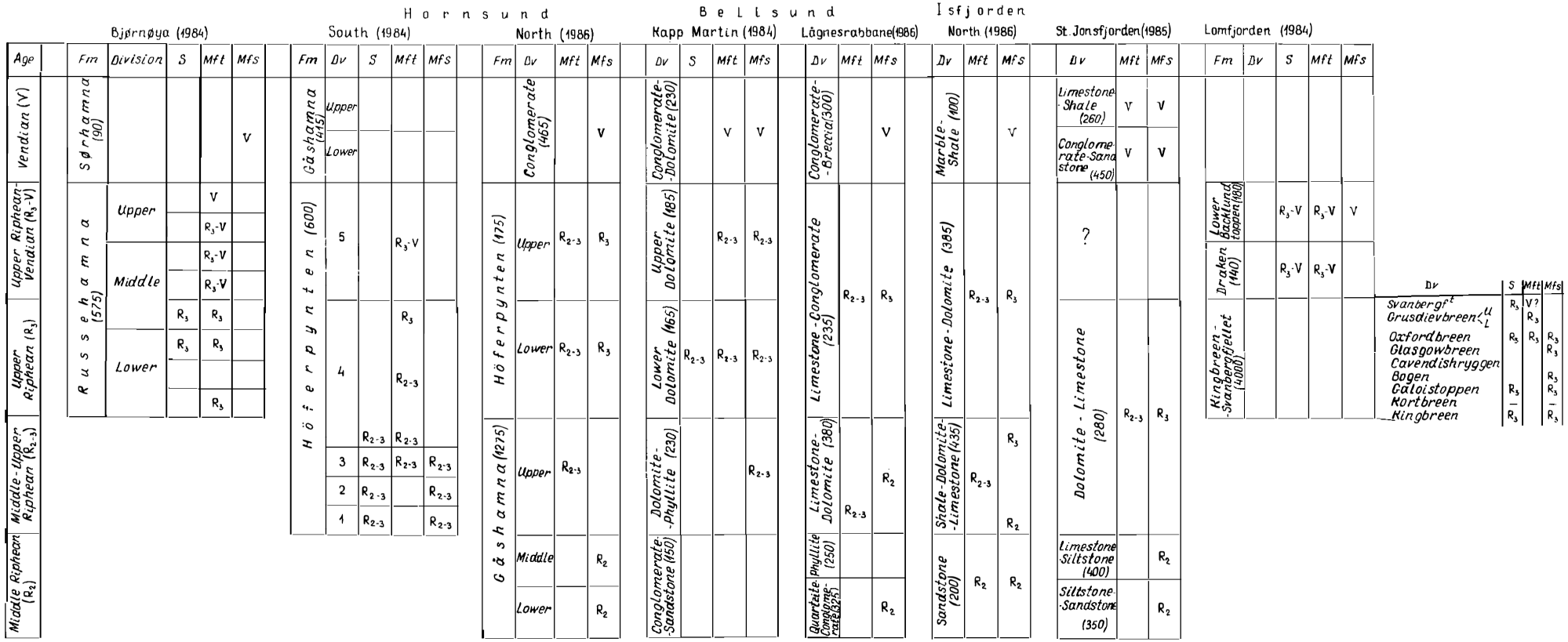


Fig. 4: Biostratigraphical correlation of the Upper Proterozoic of Svalbard.

3. THE DEVONIAN MOLASSE COMPLEX

The Devonian rocks have been investigated by the Spitsbergen Expedition since 1964 (*Burov & Murašov 1965*) following two related activities (Fig. 5): firstly, geological mapping, scale 1:100,000 - 1:200,000, of Dickson Land, Andrée Land, and the Liefdefjorden area, and secondly, specialized lithostratigraphical investigations.

Geological mapping was carried out on topographic base maps, scale 1:100,000 (published by Norsk Polarinstitutt, 1960). Each report is essentially an explanatory note to a geological map, accompanied by generalized stratigraphic columns for areas, geological profiles, lithostratigraphical sections and, in the later reports, by tectonic maps. In addition to the detailed lithostratigraphy of a section, most reports give a comprehensive petrographical description of all the rock types encountered, as well as data on mineralogy of heavy fractions, information on bitumen content and reservoir features (Table 1).

Fieldwork primarily concerned with the second activity resulted in compilation of the report on the stratigraphy and lithology of the Devonian of Spitsbergen (*Murašov 1979*). Murašov considered earlier work on the stratigraphy of the Devonian rocks and then largely adopted a stratigraphic subdivision scheme, proposed and modified by Friend (Friend 1961; Friend et al. 1966) and improved by Gee & Moody-Stuart (1966). The age of new lithological units, like that of earlier recognized units, was confirmed by numerous collections of fossil fauna and flora.

Fossils were identified by V.N.Talimaa (Lithuanian Geological Institute, Vilnius), and L.V.Obručev and L.I.Novickaja (Paleontological Institute, USSR Academy of Sciences): fish; V.S.Kulikova (VSEGEI) and O.N.Lobanova (NIIGA): pelecypoda; A.F.Abušik (VSEGEI): ostracoda; N.M.Petrosjan (VSEGEI): flora; A.F.Dibner (NIIGA) and G.K.Vaitekuene (Lithuanian Geological Institute, Vilnius): spores.

Figures 6 and 7 present correlation charts of composite columns from the reports of Andrée Land and Dickson Land, respectively. Using them as a basis, this book will consider data available on separate areas and then give the general characteristics of the Devonian of Spitsbergen after Murašov (*1979*).

3.1. Liefdefjorden - Raudfjorden area

BUROV, JU.P. & MURAŠOV, L.G. 1965:

Geological studies in the Liefdefjorden, Bockfjorden and Woodfjorden areas
[Geologičeskie issledovanija v rajonah Lifde-fiorda, Bok-fiorda i Vud-fiorda]
Report on fieldwork in 1964
146 pages, 12 appendices, 16 illustrations, 8 tables, 46 references

Two localities, the north coast of Liefdefjorden and the east coast of Bockfjorden, were investigated.

The Precambrian basement, unconformably overlain by Devonian rocks, is composed of marble and crystalline schists. A direct contact was observed on Wulffberget, on the north-eastern slope of Pteraspistoppen, on the north offshoot of Siktefjellet, and on the north coast of Liefdefjorden in front of the Erikbreen snout.

The Devonian section, 1350 m thick, was described by stratigraphic profiles in the north of Liefdefjorden (Pteraspistoppen). The upper section (about 1000 m) was also present in Bockfjorden and in the Sigurdfjellet area.

Following Friend (1961), five sequences, equivalent to formations, were recognized in the Devonian section. All of them, except the upper (Kapp Kjeldsen Formation), were assigned to the Red Bay Group. Basal (?) conglomerates, differing in composition and colour, were joined into a formation of the same name (150-600 m), the Red Bay Formation. The Andréebreen Formation, mainly composed of sandstone (450 m), is believed to rest on the eroded surface of the Red Bay Formation; the sandstone

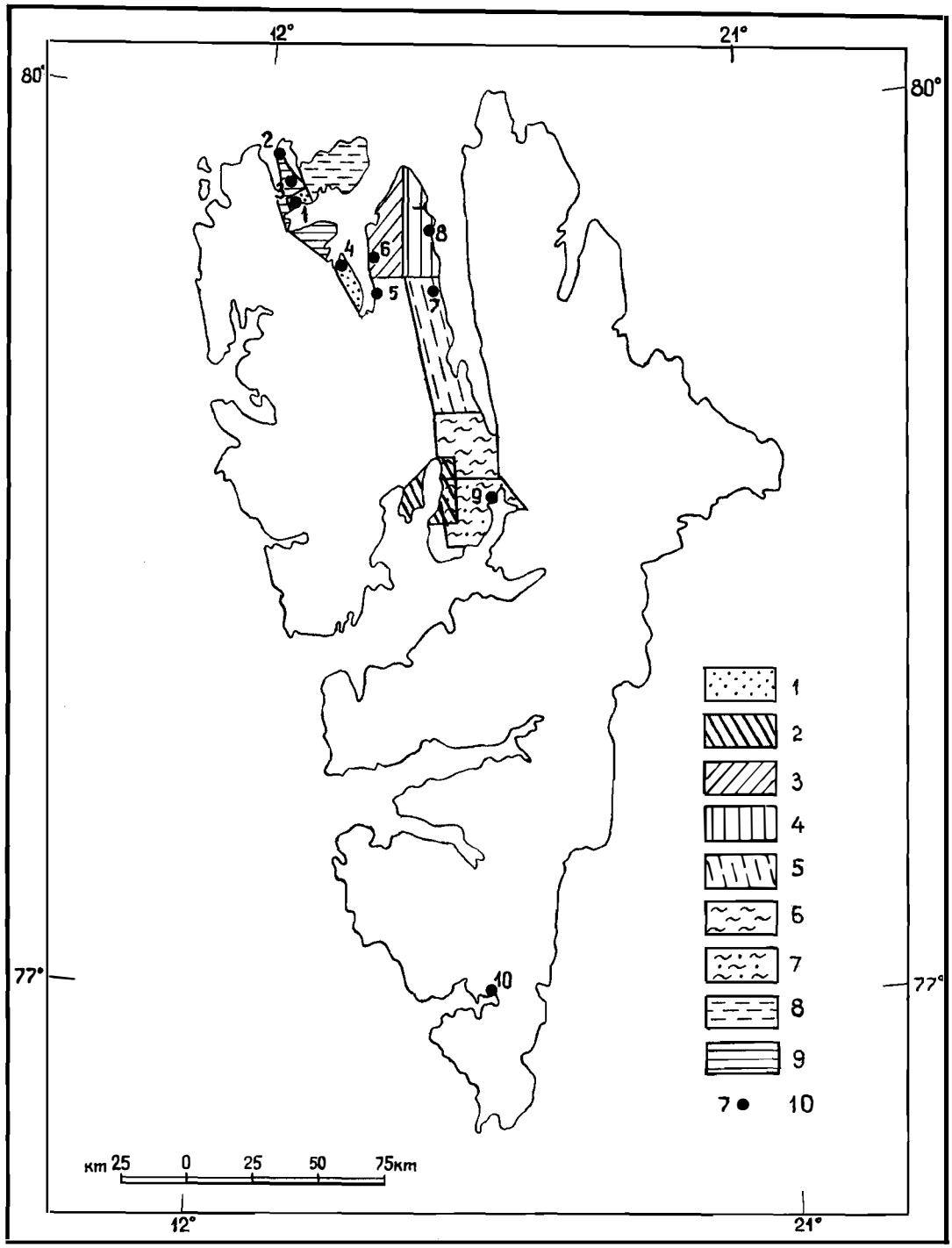


Fig. 5: Study areas and localities in the Devonian deposits of Spitsbergen:
1 Burov & Murašov *1965*; **2** Burov *1968*; **3** Mokin et al. *1972*; **4** Burov et al. *1973*; **5** Burov et al. *1974*; **6** Panov et al. *1975*; **7** Panov et al. *1976*; **8** Mokin *1977*; **9** Mokin & Kolesnik *1978*; **10** localities of main stratigraphical sections (*Murašov 1971, 1973, 1979*)

contains some horizons yielding poorly preserved flora. Traditionally, both lower formations were placed into the Upper Silurian (Downtonian).

Conformably overlying are the Frænkelryggen Formation (750 m) and the Ben Nevis Formation (900 m) with abundant Gedinnian fish remains, including the species *Pteraspis* previously unknown on Spitsbergen. Both formations are assemblages of siltstone, mudstone, and sandstone; the lower variegated formation is dominated by siltstone and mudstone, and the upper grey formation by sandstone.

The upper section described in the south, in Bockfjorden, is represented by the Kapp Kjeldsen Formation of variegated sandy-siltstone (1170 m). The formation yielded abundant fragments of previously unknown ostracoda and fish scales; the lower strata made up of four horizons, yielded flora which included new forms. The authors assign the formation to the Eifelian Stage based on the floral assemblage (before identification of the fauna collected). Bitumen analysis of 134 samples indicated very low bitumen content of the Devonian (Downtonian) rocks in the area; determinations of porosity (238 samples) and permeability (20 samples) also gave negative results.

A recent volcano, Sverrefjellet, was also described in the report, but it will be considered in the Section dealing with the magmatism of Spitsbergen.

MOKIN, JU.I. & KOLESNIK, V.G. 1978:

Outline of the geology of the Raudfjorden and Liefdefjorden area
[Geologičeskoe stroenie rajonov Raud-fiorda i Lifde-fiorda]
Report on fieldwork in 1977
56 pages, 2 appendices, 16 illustrations, 19 references

The area investigated covers the east coast of Raudfjorden (including Buchananhalvøya), the northwest coast of Liefdefjorden, and a peninsula between Liefdefjorden and Bockfjorden.

A subdivision of the Lower Devonian deposits, adopted by the authors, does not differ in principle from earlier schemes. Following Murašov (Murašov & Mokin 1976), all the deposits, which are older than the Kapp Kjeldsen Formation (Siegenian), are assigned to the Gedinnian stage, although no new fauna and flora were collected.

Particular attention is given to the lower essentially conglomeratic part of the section. Investigation of specific outcrops led the authors to the conclusion that the Lilljeborgfjellet, the Wulffberget, and the Princesse Alicefjellet conglomerate sequences, recognized by Murašov & Mokin (1976) as separate formations, have very variable thickness and limited areal extent, i.e. they may be facies varieties within a single formation which, to avoid confusion, was named the Rivieratoppen Formation (60-400 m). Additionally, the authors suggested a lithostratigraphic analogy with the Siktefjellet and the Rabotdalen sandstone beds, which were also included in the new formation.

MOKIN, JU.I. 1977:

Outline of the geology of Reinsdyrflya, Spitsbergen
[Geologičeskoe stroenie poluostrova Rejnsdjurfljua, Zapadnyj Špicbergen]
Report on fieldwork in 1976
59 pages, 2 appendices, 6 illustrations, 1 table, 29 references

A preliminary survey provided a rough idea of the geology of Reinsdyrflya, an area of about 350 sq.km.

The peninsula is mainly composed of Lower Devonian (Siegenian and Emsian) rocks, subdivided into the Kapp Kjeldsen (in excess of 1000 m), the Keltiefjellet (830 m), and the Stjørdalen (420 m) formations. The latter is conformably overlain by the Gjelsvikfjellet Formation (120 m), assigned to the Eifelian (Middle Devonian). The section is dominated by red siltstone and mudstone, with layers of greenish-grey sandstone, rare gravelstone, and, in the Middle Devonian, marlstone.

The Devonian rocks of the peninsula form an east-north-easterly dipping monocline, which is step-faulted with throws ranging between 100-300 m. The monocline is also complicated by two gentle folds, namely, an anticline and a syncline in the north-east and the south-west, respectively; the folds vary from 2-3 to 8 km in width; dip angles of the limbs do not exceed 10-20°.

3.2. Andrée Land

MOKIN, JU.I., MURAŠOV, L.G., BUROV, JU.P. & KOLESNIK, V.G. 1972:

Outline of the geology of northwestern Andrée Land
[Geologičeskoe stroenie severo-zapadnoj časti Zemli Andre]
Report on fieldwork in 1971
132 pages, 11 appendices, 30 illustrations, 6 tables, 68 references

The report contains a description of the geological structure of the northwestern part of Andrée Land (north of Stjørdalen) and the results of specialized lithostratigraphical study of the Grey Hoek and the Wood Bay groups, in the map area. In addition to a composite stratigraphic column for the Lower Devonian, accompanying the geological map of the area, the report provides correlation charts of the Wood Bay and the Grey Hoek sections for northern Andrée Land and for all the Devonian sections of Spitsbergen (scale 1:20,000), mapped by Russian geologists.

The boundary between the groups is drawn where red siltstone of the Verdalen Member, known from the literature, is replaced by grey siltstone of the lower bed of the Grey Hoek Group. However, because of the small thickness of the member and a colour similar to that of the underlying rocks of the Stjørdalen Formation, the authors of the report mapped them as a single lithostratigraphic unit, the Lower to Middle Devonian Wood Bay Group.

The Stjørdalen Formation (315-415 m) is subdivided into four horizons of siltstone with variable amounts of sandstone layers and marl nodules; fish remains collected there support a late Emsian age.

The Verdalen Member (40-85 m) is made up of: (1) grey silty limestone and dolomite with interbeds of silt in the lower part; and (2) red siltstone intercalations of sandstone, gravelstone, and marl nodules in the upper part. No new fossils were found in the rocks of this member. Identification of fish fauna from the Verdalen Member, made by non-Russian scientists (Örvig 1969), allowed assignment of an Eifelian, Middle Devonian, age.

The Grey Hoek Group was described from data obtained at the type section on the north-east coast of Andrée Land (Skamdalen area). Four sequences, 1100 m thick, recognized in the type section are believed to occur in other outcrops of the Grey Hoek Group. Two lower finer-grained units are dominated by mudstone, and by lime-rich siltstone in the lower horizons. The upper sequences are mainly siltstone with layers of sandstone, increasing in amount up-section. Carbonate concretions, in many places with pelecypoda, are characteristic of the upper strata.

New fauna and flora (in the upper sequence) were collected throughout the section. Their identification allowed the entire Grey Hoek Group to be assigned to the Eifelian, although pelecypoda are divided into two assemblages of different age: the lower assemblage, from early Coblenzian to early Middle Devonian; and the upper assemblage, Middle Devonian in age.

The major (7-11 km wide), approximately N-S trending Junkerdalen syncline, gently plunging southward, was first recognized in the Devonian terrain. The synclinal trough is complicated by a V-shaped graben, composed of narrow to overturned folds, evidently related to a fault deformation zone. On the east, the Junkerdalen syncline is conjugate with the Andrée Land anticline the axis of which lies outside the area to be mapped. In addition to these major folds, the authors mapped many approx. E-W faults, steeply dipping northward and having a 120-300 m (up to 1300 m?) throw. Displacement of the Junkerdalen graben by approx. N-S faults suggests they are younger in age.

The report gives a comprehensive description of a sequence of young (Late Cretaceous to Paleocene) basalt, which form the mountain summits east of Woodfjorden (for details see Section entitled "Magmatism"). The hypsometric position of the basalt sequence enables the rise of Andrée Land from Late Cretaceous-Paleocene time up to the present to be estimated at 800 m in the north to 1300 m in the south.

Fluorimetric capillary analysis of 222 samples from the grey rocks of the Wood Bay and the Grey Hoek groups indicated a very low bitumen content for the section: up to 0.0006% (rarely 0.001 to 0.005%) with organic carbon ranging between 0.1 to 1.0%. As a rule, bitumen content increases up to

0.01-0.02% in carbonate concretions only. Hot and cold extraction of bitumen from the concretions showed the presence of light petroleum and 'airblown' bitumen in them. Determinations of porosity and permeability indicate that the section contains no horizons with good reservoir properties.

BUROV, JU.P., MOKIN, JU.I. & KOLESNIK V.G. 1973:

Outline of the geology of northern Andrée Land
[Geologičeskoe stroenie severnoj časti Zemli Andre]
Report on fieldwork in 1972
119 pages, 3 appendices, 10 illustrations, 1 table, 71 references

The report generalizes data from geological mapping of the northern part of Andrée Land in 1971/1972. A description of the entire section of the Lower to Middle Devonian rocks, 3200 to 3400 m thick, was mainly based on the results of simultaneous lithostratigraphical studies, made by L.G.Murašov (*Murašov 1973*).

A detailed description of the tectonic structure of the north of Andrée Land is accompanied by a tectonic sketch map, scale 1:100,000. The anticline and the syncline of Andrée Land are recognized as major structures. The syncline was previously referred to as Junkerdalen by the same authors *(Mokin et al. 1972)*. Both structures trend north-northwest with the axis gently (up to 2°) plunging in the same direction. The width of the anticline reaches 20 km in the south and that of the syncline varies from 7 to 11 km. The amplitude of anticline crest measures 1300 m with average dip angles being 5 to 7° and 10 to 12° in the west and the east, respectively. In the synclinal trough, the amount of downwarping reaches 1000 m with dip angles being 8-10° and 12-15° in the west and the east, respectively. Both structures are complicated by minor and major folds with angles varying between 10 and 40°.

The northern part of the Andrée Land syncline is cross-cut by a N-S zone of narrow folds, thinning-out southward. The authors regard the zone, up to 5 km wide, as a graben (Prinsetoppen), continuing the near-axial part of the syncline. Steep zones of the folds were traced along the coasts of Woodfjorden and Wijdefjorden. Besides the zones and subparallel fractures, the youngest system of approx. E-W faults with throws ranging from 150 to 200 m, was mapped.

Data on bitumen content and reservoir features of the Devonian rocks were taken from the reports of Burov & Murašov (*1965*), Mokin et al. (*1972*), and Murašov (*1973*).

MURAŠOV, L.G. 1973:

Lower-Middle Devonian stratigraphy of northern Andrée Land
[Stratigrafija nižne-srednedevonskih otloženij severnoj časti Zemli Andre]
Report on fieldwork in 1971-1972
166 pages, 12 appendices, 42 illustrations, 71 references

The report presents results of a lithostratigraphic study of the Lower to Middle Devonian of the northern part of Andrée Land, carried out by the author in 1971/1972. Detailed description of seven specific sections, ranging from 210 to 780 m in thickness, allowed their correlation and compilation of a composite lithostratigraphic section, totalling 2200 m in thickness. The author proposed to abandon the recognition of groups and proved the viability of subdividing the section into stages and formations. This principle was used as a basis for the correlation chart for all the Devonian deposits of different areas of Spitsbergen.

In the north of Andrée Land, the Lower to Middle Devonian strata are intercalated siltstone and mudstone with thin layers of sandstone, gravelstone, and limestone; the layers of sandstone markedly increase in number and thickness up-section.

The composite section is made up of five formations, in descending order the Stjørdalen siltstone (420 m), Gjelsvikfjellet Formation of variable composition (215-230 m), Tavlefjellet mudstone (300 m), Forkdalen siltstone (630 m), and Wijde Bay sand-silty formation (600 m). Remains of fish, pelecypoda and flora determined ages to stage level. Three middle formations, first recognized in this report, were given an Eifelian, Middle Devonian age. An Early Devonian (late Emsian) age for the Stjørdalen Formation was supported and a Givetian age was tentatively assumed for the Wijde Bay Formation. The report presents detailed results of the identification of fossil remains, accompanied by a table showing the distribution of individual species throughout the section.

The composition of the rocks, including their heavy mineral fraction (0.03-0.65 mm) was studied thoroughly. In particular, a stable mineral association, leucoxene + tourmaline + garnet, was found. The Tavlefjellet and the Forkdalen formations contain a lot of carbonate concretions, with pelecypoda and fish scales in many places.

The boundary between the red and grey deposits is drawn within the Gjelsvikfjellet Formation, dividing it into two members: the (red) Verdalen and the (grey) Skamdalen member. The author considers that along the boundary the oxidising subcontinental depositional environments give way to reducing coastal-marine environments. It is believed that, as early as in late Eifelian time, the coastal-marine basin shoals and becomes fresh in Givetian (?) time.

Analysis of bitumen content and reservoir properties of the Devonian grey rocks showed that they are unprospective in this context (total bitumen content up to 0.0003%, open porosity 1-3.6%). Of some interest are carbonate concretions of the Forkdalen Formation; hot extraction yielded 0.01-0.02% bitumen "A", and sophisticated treatment of bitumens showed the presence of light petroleum bitumen presumably of epigenetic nature.

BUROV, JU.P., SEMEVSKIJ, D.V., PANOV, A.I., MOKIN, JU.I. & KOLESNIK, V.G. 1974:

Outline of the geology of southeastern Andrée Land
[Geologičeskoe stroenie jugo-vostočnoj časti Zemli Andre]
Report on fieldwork in 1973
215 pages, 5 appendices, 54 illustrations, 24 tables, 87 references

The report, based on the results of geological mapping of the southeastern part of Andrée Land, is an explanatory note to the geological map, scale 1:100,000; it includes a description of the tectonics and geomorphology of the area mapped. The area is built up of Lower to Middle Devonian rocks and unconsolidated Quaternary deposits, as well as sheets of Cretaceous-Paleocene basalt and dykes of Late Paleozoic monchiquites at separate localities (see Section entitled "Magmatism").

According to Murašov & Mokin (1976), the Devonian section includes the following formations: Kapp Kjeldsen (Siegenian, 900-1000 m), Keltiefjellet (Siegenian to Emsian, 850-900 m), Stjørdalen (Emsian, 250-300 m), as well as Gjelsvikfjellet (190-200 m), Tavlefjellet (250-300 m), and Forkdalen (in excess of 500 m), assigned to the Eifelian Stage. The lithology of the formations and composition of the rocks were described in detail, although it was noted that the sections slightly differ from the type sections.

For instance, the Kapp Kjeldsen Formation is less fossiliferous. When compared to the type section, the Keltiefjellet Formation shows a greater amount of sandstone layers; new fauna and flora collections confirm a Siegenian-Emsian age. The rhythmically deposited red Stjørdalen Formation, yielding abundant fish remains, differs from the type section by a greater thickness. The Gjelsvikfjellet Formation has an insignificant areal extent (a peninsula between Vestfjorden and Austfjorden) and, by analogy with the type section, is divided into the Verdalen and the Skamdalen members; new collections of fish remains in both members lend credence to an Eifelian age for them. The upper formations (Tavlefjellet and Forkdalen) differ from their equivalents in the north of Andrée Land by having a much lesser areal extent; they also yielded remains of fish, pelecypoda (generally from carbonate concretions) and flora, suggesting an Eifelian age for the deposits.

The basalt sequence of tentative Cretaceous-Paleocene age has remained in the north-west of the area only (Paleontologryggen), where it reaches 22 m in apparent thickness.

Quaternary deposits, generally having no wide areal extent, incorporate upper Pleistocene proluvial sediments (0.6 m) and Holocene sediments of raised beaches, totalling 20 m in thickness; the latter are described in some detail.

The Andrée Land anticline whose axis shows a change in orientation from approx. N-*S (Burov et al. 1973*) to north-westerly is considered a major tectonic structure of the area. Most minor folds, including the prominent Westfjorden syncline, are approx. N-S, whereas the axes of even more minor folds are subparallel to the axis of the Andrée Land anticline.

The tectonic sketch map, scale 1:100,000, shows a complex pattern of faults, grouped into four systems, which trend north-east, roughly north-south, roughly east-west, and north-west. All of them are classed as steeply dipping faults (60-80°) with usual throws varying from 100 to 350 m. Of particular interest are faults, forming "the eastern boundary zone of faults" (Livšic 1973); total displacement along the zone is estimated here at 3-4 km. Within the zone, the authors recognize a subzone of "main strike-slip faults" (on the east) and a subzone of "shears and linear folds". The boundary between the subzones is marked by the narrow (2-2.5 km) Gråkammen graben. Its eastern margin encompasses a vertical zone of breccia (30-70 m wide), cemented with bull quartz and calcite. The authors relate the appearance of monchiquite dykes (described in the Section entitled "Magmatism") to the faults within the western subzone.

As in other areas of Andrée Land, bitumen content and reservoir properties of the Devonian rocks are low and of no practical significance. Spectral analysis revealed low copper and gold in quartz veins.

3.3. Dickson Land and Hornsund area

BUROV, JU.P. 1968:

Lower Devonian deposits and trappean occurrences in Dickson Land
[Nižnedevonskie otloženija i projavlenija trappovogo vulkanizma v rajone Zemli Diksona]
Report on fieldwork in 1967
104 pages, 5 appendices, 30 illustrations, 7 tables, 40 references

The report contains the results of investigation of two Lower Devonian sections by layers. One section (151 layers attaining 640 m in thickness) is situated on the east coast of Dicksonfjorden (at the mountain Lykta), the other (44 layers totalling 180 m in thickness) is located on the east coast of Ekmanfjorden (at the mountain Kapitol). In addition, the report presents data on dolerite intrusions which are beyond the scope of the present study.

All the Lower Devonian deposits are placed into the 'Dicksonfjorden Sandstone' Formation, recognized earlier by Friend (1961) and dated as Coblenzian in age. New collections of ostracoda and flora, and the occurrence of charophytes suggest an early Middle Devonian age for the rocks. However, the author assigns the formation to the Coblenzian, Lower Devonian, and tentatively correlates it with the Keltiefjellet Formation of Andrée Land for as long as abundant fish remains, collected throughout the section, remain unidentified.

A distinctly variable sequence structure within the formation is first recognized by this work. Five sequences were found in its most representative section, on Lykta; the Kapitol section, correlated with the upper part of the above-mentioned section, contains two sequences. The sequences are mainly siltstone (80%) and sandstone (20%) with thin layers of mudstone. The sequences are subdivided into horizons, 30 to 60 m thick.

Study of the sequence structures and mineral composition, as well as analysis of assemblages of fossil fauna and flora, suggest a shallow slightly brackish- (or fresh-) water depositional basin; deposits,

formed through breakdown of acid rocks at the beginning of Devonian time, probably served as provenance.

PANOV, A.I., SEMEVSKIJ, D.V., MOKIN, JU.I. & ZELENKO, A.S. 1975:

Outline of the geology of northern Dickson Land
[Geologičeskoe stroenie severnoj časti Zemli Diksona]
Report on fieldwork in 1974
145 pages, 4 appendices, 26 illustrations, 7 tables, 76 references

This is a report on geological mapping of the northern part of Dickson Land between Austfjorden and Dicksonfjorden. The report is accompanied by geological and geomorphological maps, scale 1:100,000, and a tectonic sketch map; in the north, they link up with the above-mentioned maps of Andrée Land (*Burov et al. 1974*).

The Devonian rocks rest unconformably on the Proterozoic crystalline basement, forming a narrow horst south of Austfjorden. Part of the section (138 m), composed of intercalated quartzite, amphibole and mica schists, locally migmatized, was described in a sea cliff. The whole complex of crystalline rocks is correlated with the Atomfjella Group of Ny Friesland.

The Devonian section, totalling 2-2.2 km in thickness, starts with Siegenian rocks and is subdivided following the scheme, adopted for Andrée Land (*Murašov 1973*). The Lower Devonian is made up of the following formations: Kapp Kjeldsen (850-950 m), Keltiefjellet (850-900 m), and Stjørdalen (200 m). The latter is overlain by the upper member of the Gjelsvikfjellet Formation (155 m) with a stratigraphical unconformity, and assigned to an Eifelian, Middle Devonian age.

The Kapp Kjeldsen Formation, previously referred to as the Reuterskiöldfjellet sandstone (Friend et al. 1966), differs from its type section in Andrée Land with a marked predominance of more coarse-grained rocks (sandstone with layers of gravelstone) and a mainly greenish color. A 200 m thick unit of variegated sandstone and siltstone, known as the "Pale Beds" in literature, is recognized in the upper part of the formation only.

The Keltiefjellet Formation, most developed in the area, is a rhythmic alternation of grey-green sandstone and siltstone with layers of brown mudstone. As a whole, the formation is more arenaceous than that in the Woodfjorden area. Flora imprints and fish scales collected there suggest a middle Siegenian to early Emsian age range.

The Stjørdalen Formation has a limited areal extent and a considerably reduced thickness, as compared to the type section. A rhythmic intercalation of crimson-red siltstone and mudstone is present with minor beds of sandstone in the lower section. Fish remains support an Emsian age for the formation.

The Gjelsvikfjellet Formation, forming the top of the Devonian section in the north of Dickson Land, is represented by the upper member (Skamdalen) only, thus suggesting a stratigraphical unconformity. This is mainly a red siltstone sequence with minor mudstone and sandstone. Flora and pelecypoda found here provide no accurate age determination, but the sequence is correlated with the Skamdalen member and assigned to the Eifelian by fish remains.

The unconformably overlying Carboniferous rocks are represented by all three series with total thickness between 650-700 m. The stratigraphy and the lithology of the sequences support the recognition of the western and the eastern structural-facies zones; the boundary between them is fixed by a horst-like uplift of the Lower Devonian west of the Proterozoic horst. The western boundary fault of the horst is associated with discrete relict outcrops of the Lower Carboniferous coal measures (up to 75 m), containing basal conglomerates and resting upon the Lower Devonian Kapp Kjeldsen Formation. The (lower) gypsum-bearing sequence and the (upper) conglomerate sequence of Bashkirian (Middle Carboniferous) age, 425 m in total thickness, occur east of the horst in the subsiding tectonic block.

In the eastern zone, the Carboniferous rocks lie on younger Devonian formations. The most complete section was described at the mountain Citadellet. The Lower Carboniferous sequence (145 m), also

containing conglomerates at the base, incorporates no coal seams of any importance. This is overlain without evident unconformity by undifferentiated Middle (Moscovian) to Upper Carboniferous mainly carbonate deposits, 110 m in total thickness. New identifications of miospores (Early Carboniferous in age) and foraminifera (Middle to Late Carboniferous in age) are discussed.

The tectonic sketch map shows the Dicksondalen monocline and two subzones within the Central Spitsbergen Fault Zone[2]. An approx. N-S fault about 5 km from Dicksonfjorden serves as an eastern boundary of the monocline. The authors point out a regional south-westerly dip of the monocline at an angle up to 10°, however, southerly dip angles, possibly reflecting overall subsidence, are predominant within the monocline (as well as in the more easterly subzone of linear folds).

The subzone of linear folds (11-12 km) is bounded by approx. N-S faults with throws varying from 200 m (on the east) to 700-800 m (on the west). Approx. N-S folds display limbs of 200-300 m, dip angles vary from 8-10° to 25-30°; hinges plunge gently south. The subzone of "main strike-slip faults" stretches along the coast of Austfjorden and farther north, into the Mimerbukta area. The inner part of the subzone is cut by a series of differently oriented and different-order faults into blocks, of which the most significant is a narrow (up to 1.5 km) horst of the Proterozoic basement. Most faults are considered by the authors as post-Middle Devonian in age and grouped into two systems: approx. N-S and younger approx. E-W systems.

A geomorphological map is constructed on the principle of genetically uniform surfaces; six surfaces of erosion and eight surfaces of accumulation are recognized. As in other areas under study, bitumen content and reservoir features of the Devonian rocks are low.

PANOV, A.I., SEMEVSKIJ, D.V., MOKIN, JU.I., ZELENKO, A.S. & KORČINSKAJA, M.V. 1976:

Outline of the geology of central Dickson Land

[Geologičeskoe stroenie central'noj časti Zemli Diksona]
Report on fieldwork in 1975
161 pages, 4 appendices, 24 illustrations, 5 tables, 27 references

The report presents the results of geological mapping of the central part of Dickson Land, south of the area mapped by Panov et al. (*1975*).

The crystalline basement outcrops within a 2-3 km wide horst and on the slopes of Ragnarbreen, Ebbabreen, and Nordenskiöldbreen. The basement is made up of biotite and amphibole-biotite schists and amphibolites, assigned to the Proterozoic Atomfjella Group. Total apparent thickness of the section within the horst is about 1000 m. In mid-section, a unit of crystalline schists (300 m) is injected with parallel layers of granitic material; as the contact is approached, the schists show effects of prograde metamorphism such as formation of hornfels, muscovite and microcline. The basement rocks, are unconformably overlain by the Lower Carboniferous coal measures with conglomerates (up to 5 m) at the base. Nontectonic contacts between the crystalline basement and the Devonian rocks have not been recognized here or elsewhere.

The Devonian outcrops, about 2400 m in thickness, are represented by all three series and are further subdivided into formations, following Murašov (*1971, 1973*). The Lower Devonian is subdivided into the Kapp Kjeldsen Formation (650 m) and the Keltiefjellet Formation (710 m), correlated with the Reuterskiöldfjellet "Formation" and the Mimerbukta "Formation", respectively (*Murašov 1971*)[3]. Both formations show a variable alternation of greenish-grey sandstone and reddish siltstone and mudstone.

[2] commonly referred to as the Billefjorden Fault Zone [Norsk Polarinstitutt]

[3] correct names: Reuterskiöldfjellet Sandstone, Mimerbukta Sandstone (Gramberg et al., eds. 1990) [Norsk Polarinstitutt]

The whole Middle Devonian section is composed of grey siltstone and mudstone with minor fine-grained sandstone at the base of the formations. The Middle Devonian succession consists of: the upper (Skamdalen) member of the Gjelsvikfjellet Formation (250 m, Eifelian) and the Estheriahaugen Formation (120 m, Givetian). Subdivision into stages is permitted by abundant collections of fish remains (Skamdalen), pelecypoda, fossil flora and miospores. The Skamdalen Member is bounded by stratigraphical unconformities; the Estheriahaugen Formation is conformably overlain by the Upper Devonian.

The Upper Devonian deposits are subdivided into the following formations: Fiskekløfta (145 m), Planteryggen (180-200 m), and Plantekløfta (100-400 m). A description of the sections is taken from Murašov (*1971*), who carried out specialized lithostratigraphical studies in Dickson Land.

The Carboniferous rocks resting unconformably on the Devonian rocks are represented by three types of sections. The east type (including the Lower Carboniferous coal measures, 150-200 m thick, east of the Pyramiden fault) incorporates Bashkirian and Moscovian (Middle Carboniferous) gypsum-bearing and conglomerate sequences (1000 m), and the Upper Carboniferous limestone sequence (65-80 m), described on the east coast of Wijdefjorden.

The west, or to be more accurate, central type of section is entirely composed of an undifferentiated Middle to Upper Carboniferous carbonate sequence, the *Cyathophyllum* limestone, unconformably overlying various Devonian formations. Lastly, on the north-west (the mountains Citadellet and Triungen), Lower Carboniferous coal measures (150 m), containing commercial coal seams and yielding a spore-pollen assemblage, typical of the late Tournaisian-Visean, occur between the *Cyatho-phyllum* limestone and the Lower Devonian variegated Keltiefjellet Formation.

The south-west of the area is covered by Lower and Upper Permian rocks (about 600 m). The boundary between the Upper Carboniferous limestone and the Lower Permian limestone is drawn on the basis of a change of foraminiferal assemblages. Up-section, the limestones are intercalated with dolomite, and gypsum bands appear; the Upper Permian section is characterized by the predominance of siliceous rocks, containing layers of sandstone and limestone.

Upper Pleistocene clays, making up a 60 m raised beach at the head of Petuniabukta, are recognized in different types of Quaternary deposits.

As in other areas of Dickson Land, the tectonic picture is characterized by approx. N-S zoning. The tectonic map presents (from west to east): the Dickson south-westerly dipping monocline; the western zone of linear folds, on the east margin of which the conjugate Odindalen anticline and the Munindalen syncline are the most pronounced features; the Central Spitsbergen Fault Zone[2], encompassing the basement horst; the east zone of linear folds with the Billefjorden syncline representing the major structure; the Petuniabukta monocline, gently dipping to the south-west, on the east margin of the area.

Analysis of a few samples for bitumen content and reservoir properties did not provide positive results. The report gives brief descriptions of Lower Carboniferous coals. Problems of coal content are discussed at length in other reports.

MURAŠOV, L.G. 1971:

Devonian deposits in the Mimerdalen area, Dickson Land, and the Hornsund area, Torell Land
[Devonskie otloženija Zemli Diksona, rajon Mimerdalen, i Zemli Torelja, rajon Hornsunna]
Report on fieldwork in 1970
151 pages, 11 appendices, 47 illustrations, 43 references

The report contains results of a detailed lithostratigraphic description of the Devonian in Dickson Land (Mimerdalen area) and on the north coast of Hornsund.

Mimerdalen area

Murašov considers that all three Devonian series are present in the area under study; this is confirmed by new identifications of fossil fauna and flora. A stratigraphic scheme proposed by earlier research (Friend 1961; Friend et al. 1966) was used, but the terminology was modified.

The Reuterskiöldfjellet "Formation" and the Mimerbukta "Formation"[3] are recognized within the Lower Devonian. They are correlated with the Kapp Kjeldsen Formation and the Keltiefjellet Formation of Andrée Land, respectively.

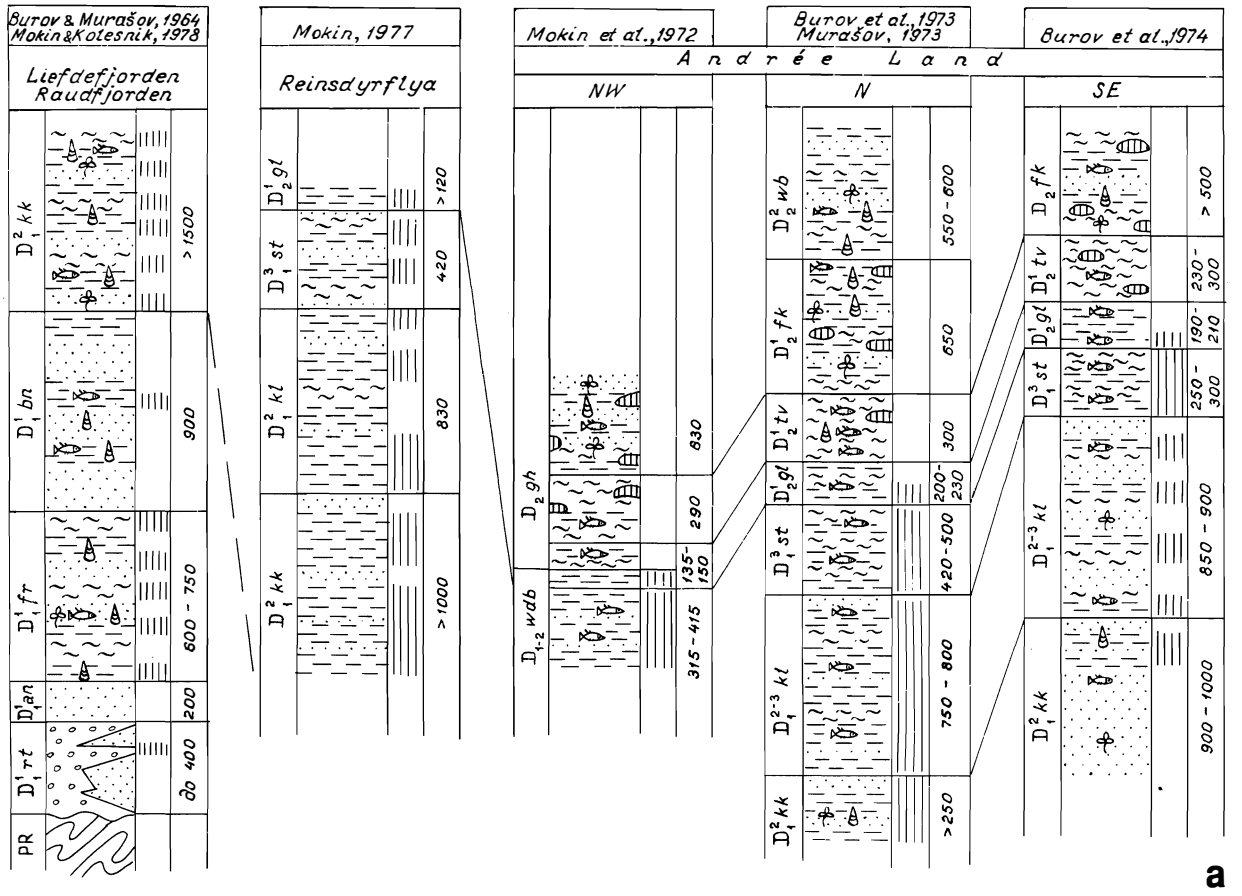
The Reuterskiöldfjellet Formation lies in a tectonically defined block and is divided into the lower red sandstone-siltstone sequence (280 m) and the upper grey sandstone sequence (350 m). Fish remains, collected in the lower sequence, are characteristic of a Siegenian (Early Devonian) age.

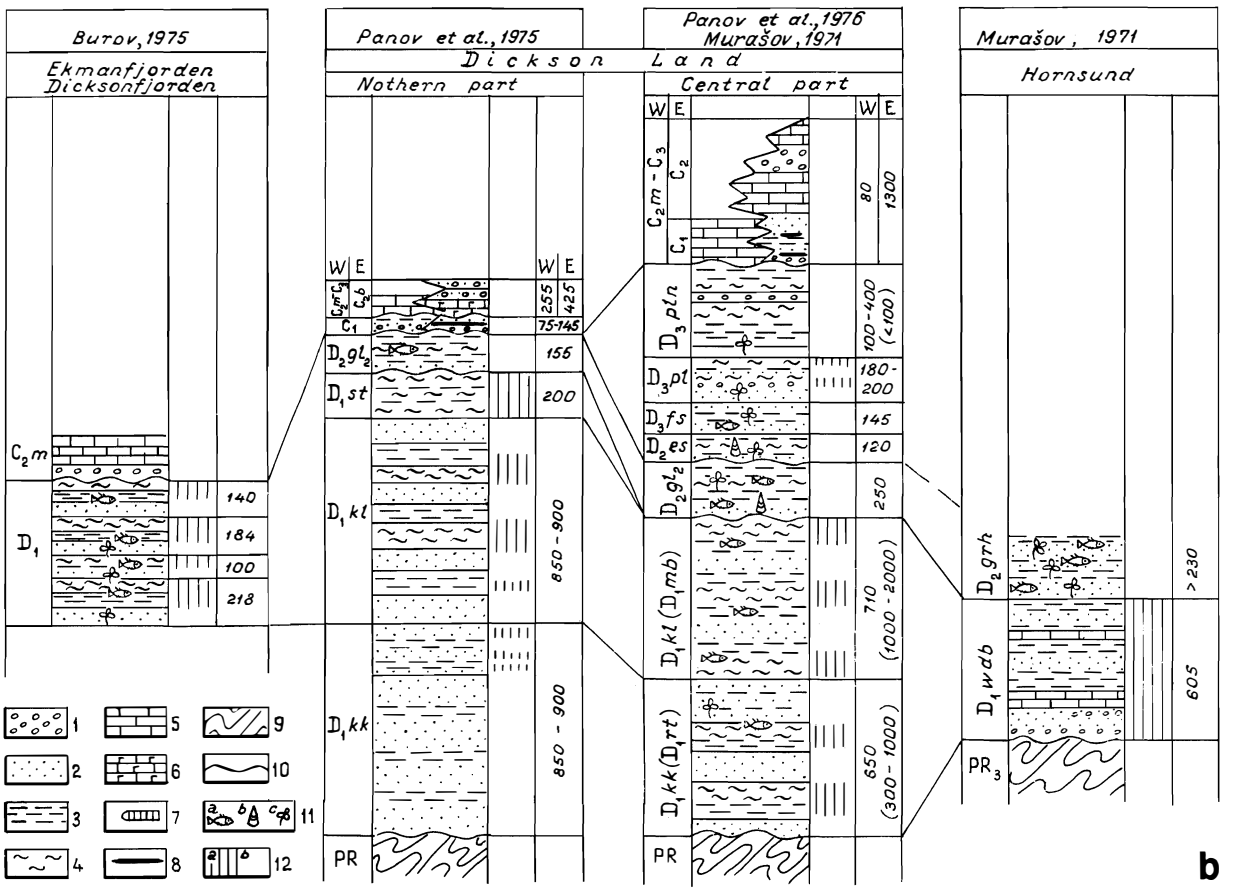
The Mimerbukta Formation forms the eastern part of the area and has a faulted contact with the Reuterskiöldfjellet Formation. A detailed section was not drawn because of poor exposure; the thickness is estimated at 2000 m. The main rock varieties are: red, green and grey sandstone and quartzitic sandstone with lenses and layers of conglomerates; violet, brown and black siltstone and mudstone. Fish and plant remains are poorly preserved, but suggest an age younger than Emsian.

The Middle to Upper Devonian deposits, forming the Mimerdalen Group, are subdivided into four formations, with only the lower (Estheriahaugen) Formation traditionally dated as late Givetian, Middle Devonian in age. New identifications of fish, flora and miospores places the three overlying formations (Fiskekløfta, Planteryggen, and Plantekløfta) into the Frasnian and Fammenian, Late Devonian. Local occurrences of Upper Devonian deposits (including the Estheriahaugen Formation) in the Mimerdalen area are overlain by Lower Carboniferous coal measures without evident unconformity.

The Estheriahaugen Formation (up to 110 m) is made up of grey siltstone and sandstone and, less commonly, mudstone, with a thin (0.1 m) coal seam in mid-section. The siltstones of the lower part of the formation yielded rich spore assemblages; remains of flora, pelecypoda, and gastropoda were collected in the upper horizons. Using paleontological evidence, the author stresses that the Estheriahaugen Formation is only tentatively assigned to the Givetian and that a Late Devonian age cannot be ruled out.

Fig. 6 (opposite page): Correlation of composite stratigraphic sections presented in various reports: **a**: Andrée Land and Liefdefjorden area; **b**: Dickson Land and Hornsund area.
1 conglomerate; **2** sandstone; **3** siltstone; **4** mudstone; **5** limestone and dolomite; **6** gypsum and anhydrite; **7** carbonate nodules; **8** coal; **9** folded basement; **10** various types of unconformities; **11** fossils: (a) fish, (b) pelecypoda and ostracoda, (c) flora; **12** red (a) and grey (b) successions
Symbols of stratigraphic divisions:
Groups (series): **skt** Siktefjellet; **rdb** Red Bay; **wdb** Wood Bay; **gh** Grey Hoek; **wb** Wijde Bay; **mm** Mimerdalen; **mt** Marietoppen
Formations: **rv** Rivieratoppen; **ll** Lilljeborgfjellet; **sk** Siktefjellet; **wl** Wulffberget; **rb** Rabotdalen; **pa** Princesse Alicefjellet; **an** Andréebreen; **fr** Frænkelryggen; **bn** Ben Nevis; **kk** Kapp Kjeldsen; **kl** Keltiefjellet; **st** Stjørdalen; **gl** Gjelsvikfjellet; **tv** Tavlefjellet; **fk** Forkdalen; **tn** Tage Nilsson; **es** Estheriahaugen; **fs** Fiskekløfta; **pl** Planteryggen; **pln** Plantekløfta; **mb** Mimerbukta; **rtr** Reuterskiöldfjellet


Burov & Murašov, 1964
Mokin & Kolesnik, 1978
Liefdefjorden
Raudfjorden
Mokin, 1977
Reinsdyrflya
Mokin et al., 1972
Burov et al., 1973
Murašov, 1973
Burov et al., 1974
A n d r é e L a n d
NW
N
SE
a


Burov, 1975
Ekmanfjorden
Dicksonfjorden
Panov et al., 1975
D i c k s o n L a n d
Nothern part
Panov et al., 1976
Murašov, 1971
Central part
Murašov, 1971
Hornsund
b

The Fiskekløfta Formation (145 m) rests conformably on Middle(?) Devonian sandstone. On the basis of the ratio of mudstone to siltstone and sandstone, five lithological horizons are recognized in the section. Fish remains were collected throughout; charred trunks and plant leaves were found in the upper horizon; abundant spores were extracted from the siltstone forming the middle horizon. All the paleontological evidence suggests a Frasnian, Late Devonian, age although some forms of plants are already typical of the Early Carboniferous.

The Planteryggen Formation (180-400 m) is divided into eight horizons, varying in thickness from 4-8 to 44 m. The formation is dominated by grey quartzose sandstone with minor dark grey siltstone and mudstone. Bands of red sandstone and mudstone appear approximately 60 m from the base of the formation. Thin layers of small-pebble conglomerates are observed up-section. The author gives a Late Devonian age based on identification of flora, although most foreign researchers assign the Planteryggen Formation to the Givetian, Middle Devonian.

The Plantekløfta Formation (up to 100 m) rests with angular(?) unconformity and with basal conglomerates on different horizons of the Planteryggen Formation, but no direct contact was observed by the author. The lithology is typically intercalated small-pebble conglomerates, sandstone, siltstone, and mudstone. Seven horizons, differing in thickness (2.5-4 to 45 m), were recognized based on the relative thickness of each rock type.

Bitumen content of the Lower to Middle Devonian of the Mimerdalen area is low, under 0.005%. Sandstone, mudstone and ferrocarbonate nodules, in which bitumen "A" varies from 0.16 to 0.31%, were found in the Middle Devonian Estheriahaugen Formation only; elementary analysis indicated a petroleum origin for the bitumen. Reservoir properties of the whole section are low.

Hornsund area

The Devonian type section was described along the north coast of Hornsund east of Burgerbukta. All the Devonian deposits of the area, previously forming the "Marietoppen Formation" (Friend 1961; Birkenmajer 1964); are subdivided into conformable Wood Bay Group (Lower Devonian) and Grey Hoek Group (Middle Devonian).

The Wood Bay Group (605 m) is mainly made up of red siltstone, sandstone, and conglomerates with bands of grey coloured equivalents and carbonate rocks. The group forms a tectonic contact with the folded basement. Eight horizons, varying from 22 to 122.5 m in thickness, are recognized. Poorly preserved fauna was found in thin-sections only.

The Grey Hoek Group starts with coarse-grained sandstone with thin layers of red siltstone, in which flora was discovered; remains of fish and ostracoda were found in the overlying sandstone. This fossil assemblage is encountered throughout the group and supports the assignment to an Eifelian to Givetian (Middle Devonian) age. Five horizons of grey siltstone and sandstone, totalling 230 m in thickness, are recognized in the lower part of the group; the overlying part is deformed into tight folds, is poorly exposed and its thickness is uncertain.

Bitumen content of the Lower to Middle Devonian rocks of the Hornsund area is low, however, bitumen "A" is as high as 0.01-0.02% in seven of 80 samples analyzed.

FRIEND, 1961; GEE & MOODY-STUART, 1966			
Age (Stage)		Group, Series	Formation, Division
Late	Famennian	Mimerdalen	Plantekløfta
	Frasnian		Planteryggen
Middle	Givetian		Fiskekløfta
			Estheriahaugen
			Wijde Bay
	Eifelian	Grey Hoek	
Early	Siegenian-Emsian	Wood Bay	Stjørdalen
			Keltiefjellet Kapp Kjeldsen
	Gedinnian	Red Bay	Ben Nevis Frænkelryggen Andréebreen
			Red Bay conglomerate
		Siktefjellet	Siktefjellet Lilljeborgfjellet

MURAŠOV, 1979			
Formation, Subformation (Svita, Podsvita)	Group (Serija)	Age (Stage)	
Plantekløfta		Culm (?)	Early Carboniferous
Planteryggen	Mimerdalen	Famennian	Late
Fiskekløfta		Frasnian	
Estheriahaugen		Givetian	Middle
Tage Nilsson	Grey Hoek		
Forkdalen Tavlefjellet Skamdalen Gjelsvikfjellet Verdalen		Eifelian	
Stjørdalen	Wood Bay	Siegenian-Emsian	Early
Keltiefjellet Kapp Kjeldsen			
Ben Nevis Frænkelryggen Andréebreen	Red Bay	Gedinnian	
Princesse Alicefjellet Rabotdalen Wulffberget			
Siktefjellet Lilljeborgfjellet	Siktefjellet		

Fig. 7: Correlation of stratigraphic nomenclature of the Devonian of Spitsbergen.

3.4. Spitsbergen (as a whole)

MURAŠOV, L.G. 1979:

Stratigraphy and composition of Devonian deposits on Spitsbergen (in type sections)
[Stratigrafija i veščestvennyi sostav devonskih otloženij Špicbergena (po stratotipičeskim razrezam)]
Report on the thematic project, based on the data obtained in fieldwork in 1964, 1970-1973, 1974
235 pages, 10 appendices, 32 illustrations, 18 tables, 71 references

The report presents a comprehensive description of the lithostratigraphy and lithology of the Devonian rocks of Spitsbergen. Most observations were obtained by the author in the course of detailed research on type sections (Fig. 5). One of the main aims of the work was adaptation of the local stratigraphic scheme to be suitable for geological mapping. The proposed scheme (Figs. 5 and 7) includes traditional units, chosen on the strength of critical analysis of earlier work (Friend 1961; Friend et al. 1966; Gee & Moody-Stuart 1966), and new formations, recognized by the author; in some cases, age boundaries of the recognized formations and groups were revised.

According to Murašov, the Devonian of Spitsbergen reaches 8000-9000 m in thickness. The Lower Devonian (5600-6100 m) consists of the Siktefjellet, the Red Bay, and the Wood Bay groups (the upper part belongs to the Middle Devonian). The Middle Devonian (about 2000 m) is made up of the Grey Hoek and the Wijde Bay groups. The Upper Devonian (225-545 m) is represented by the Mimerdalen Group with the lower (Estheriahaugen) and the upper (Plantekløfta) formations tentatively dated as Givetian and Culm in age, respectively.

Appendices to the report are: a composite section of the Devonian of Spitsbergen, scale 1:10,000; detailed stratigraphic sections of each group, scale 1:2000; and tables, showing fish fauna distribution within them.

The following is a brief description of the groups and formations, on a stage-by-stage basis.

The Gedinnian (Early Devonian) Stage incorporates the Siktefjellet and the Red Bay groups. However, the lower Gedinnian, which includes part of the Red Bay Group, is formed by intercalated conglomerate (differing in appearance) and sandstone formations, roughly equal in thickness.

The type section of the Siktefjellet Group is described on the north coast of Liefdefjorden. The group combines all the oldest Devonian deposits, resting with structural unconformity on the Precambrian crystalline basement. It is subdivided into the Lilljeborgfjellet and the Siktefjellet formations by a presumed stratigraphical unconformity.

The Lilljeborgfjellet Formation (110-400 m), is formed by grey polymictic conglomerates.

The Siktefjellet Formation (340-400 m), is formed by grey quartzose and polymictic sandstones with lenses and bands of siltstone and mudstone; quartz gravelstones lie at the base of the formation. For the first time the rocks of the formation yielded (Gedinnian?) flora, only previously known in the overlying strata.

The Red Bay Group is subdivided by Murašov into six intercalated red and grey formations, most of them being recognized as formations for the first time.

The Wulffberget Formation (35-200 m), of breccia-conglomerates, is formed by blocks (at the bottom) and rounded pebbles (at the top) of grey marbles, cemented with coarse-grained sandstone. The author suggests an angular unconformity at the base of the formation.

The Rabotdalen Formation (200 m), is grey sandstone with thin layers of siltstone in the lower part of the unit. Well preserved fossil flora was collected throughout; ostracoda are less common; the upper unit yielded fossil fish; all the fossils suggest an Early Devonian age for the formation.

The Princesse Alicefjellet Formation (300-350 m), is red small-pebble quartzite conglomerates with lenticular intercalations of sandstone and gravelstone of the same composition. The conglomerates are believed to rest with a non-angular unconformity, on the Rabotdalen sandstone.

The Andréebreen Formation (200 m), is grey sandstone with thin layers of siltstone in the upper part; no fossils were found.

The Frænkelryggen Formation (600-750 m), is red siltstone and sandstone with minor gravelstone and mudstone, with bands of similar rocks in grey.

The Ben Nevis Formation (900 m), is grey cross-bedded sandstone; the upper part is dominated by siltstone; thin layers of mudstone and lime-rich gravelstone occur throughout the section.

Both upper formations contain abundant well preserved fossil fish. The fossils were thoroughly examined by non-Russian scientists; in particular, about 20 fossiliferous horizons were recognized in the Ben Nevis Formation. New collections and analysis of earlier data allowed Talimaa (1978) to determine six biostratigraphic horizons in each formation. According to Talimaa, correlation of the horizons with the classic Devonian scheme allows the assignment of the Frænkelryggen Formation to the lower Gedinnian, the lower part of the Ben Nevis Formation (50 m) to the upper Gedinnian, and the rest of the formation to the Siegenian. Nevertheless, both formations are considered as Gedinnian in age in the report.

The undifferentiated Siegenian and Emsian mainly correspond to the Wood Bay red sand-siltstone group. The group, traditionally divided into three formations, Kapp Kjeldsen, Keltiefjellet, and Stjørdalen formations, rests conformably on the underlying grey rocks of the Ben Nevis Formation.

The Kapp Kjeldsen Formation (1100-1500 m), is composed of red siltstone (90%) with bands of mudstone, sandstone, gravelstone, and ferruginous silty limestone. On the basis of the proportion of each rock type and the amount of grey (greenish-grey) bands, the formation is subdivided into four sequences. The upper sequence (160 m) was previously referred to as the "Pale Beds" (Føyn & Heintz 1943). The beds are composed of variegated (red and grey-green) siltstone, containing Siegenian fish remains. Some underlying horizons also yielded fish and flora remains, typical of a Siegenian-Emsian age.

The Keltiefjellet Formation (600-900 m), is composed of mainly red siltstone and sandstone, intercalated with greenish-grey varieties; gravelstone beds are notably minor in occurrence. Fossils are rare.

The Stjørdalen Formation (400 m) differs from the underlying rocks in having a more fine-grained composition and a permanent red colour to the rocks. Siltstones are intercalated with the fine-grained sandstone; pelitomorphic limestone nodules are observed. Fish remains from the upper part of the formation are characteristic of a late Emsian age.

The red rocks of the lower sequence (605 m) of the Marietoppen Group[4] in the Hornsund area, which overlie the Caledonian folded basement with structural unconformity, are also assigned to the Wood Bay Group (*Murašov 1971*).

The Middle Devonian grey deposits are represented by the Eifelian and the Givetian, corresponding to the Grey Hoek and the Wijde Bay groups, respectively. Both groups are structurally conformable with the under- and overlying sequences.

The Grey Hoek Group is subdivided into three formations (*Murašov 1973*): the Gjelsvikfjellet, Tavlefjellet, and Forkdalen formations; their type sections are located in the east of Andrée Land.

The Gjelsvikfjellet Formation (250 m) includes two members. The lower (Verdalen) member was previously recognized as a separate red sequence, capping the top of the section of the Stjørdalen Formation and, the whole of the Wood Bay Group. However, the common occurrence of limestones and the assemblage of fish fauna, typical of the early Eifelian, led to the assignment of the sequence to the Middle Devonian Grey Hoek Group. The upper (Skamdalen) member is made up of grey siltstones with bands of mudstone, limestone and fine-grained sandstone. Fish remains suggest an Eifelian age for the member.

The Tavlefjellet Formation (300 m) is essentially dark mudstone with minor layers of siltstone and silty limestone. The latter form nodules with Eifelian pelecypoda and fish remains.

The Forkdalen Formation (630 m) is subdivided into three sequences. The lower and the upper sequences are intercalated siltstone and mudstone; the upper sequence is dominated by sandstone with thin layers of siltstone, and abundant jointly carbonate nodules with bitumen-bearing calcite. The entire section contains organic detritus and large remains of flora, pelecypoda, and fish, characteristic of the Eifelian Stage.

In the south of Spitsbergen, the upper grey sequence (over 230 m) of the Marietoppen Group is regarded as equivalent to the Eifelian Grey Hoek Group (*Murašov 1971*), though a Givetian age is given by Murašov for the uppermost part of the group, which is intensely folded and, hence, inadequately studied.

In the north of Spitsbergen, the Givetian is represented by the Wijde Bay Group in the east of Andrée Land and the Estheriahaugen Formation in the center of Dickson Land.

The Wijde Bay Group, established by Holtedahl as early as 1914, was recognized as a formation by Murašov (*1973*). It is here named the Tage Nilsson Formation after the mountain Tage Nilssonfjellet on the west coast of Wijdefjorden.

The Tage Nilsson Formation (600 m) is composed of quartzitic sandstone and sandstone, complexly intercalated with dark grey siltstone and mudstone. On the basis of flora, fish and pelecypoda collections, most investigators assign the formation (Wijde Bay Group) to the Givetian or late Eifelian-Givetian age.

The Estheriahaugen Formation (over 110 m) was previously referred to as the lower grey formation of the Mimerdalen Group (Friend 1961). Characteristic spore and pollen assemblages and flora give an uppermost Givetian or, possibly, early Frasnian age. Murašov accepts a tectonic contact with the underlying Devonian sequence, though some investigators (Vogt 1938) proposed an angular unconformity.

On the northern side of Mimerdalen, the type section of the formation (108 m) is described in detail. The section is made up of intercalated siltstone, fine-grained sandstone, and mudstone. A lens of coal was found 50 m above the exposed basement. Mudstones, comprising the middle part of the formation, show increased bitumen content to the rest of the formation.

There is no question that the Fiskekløfta and Planteryggen formations of the Mimerdalen Group are Late Devonian in age; as mentioned above, the uppermost (Plantekløfta) formation is Early Carboniferous in age.

The Fiskekløfta Formation (145 m) starts with a marker bed of dark grey mudstone, containing carbonate-ferruginous nodules. Above are intercalated grey siltstone, mudstone and sandstone; nodules

[4] correct name: Marietoppen Formation (Gramberg et al., eds. 1990) [Norsk Polarinstitutt]

occur throughout the section. Even the lower bed yielded fish remains characteristic of the Frasnian Stage; this age is supported by most miospore forms extracted from the rocks of the formation.

The Planteryggen Formation (180-400 m) is made up of grey rocks in the lower part with light-coloured quartzose sandstone intercalated with the dark grey mudstone. Bands of red sandstone and siltstone appear in the middle part; small-pebble conglomerates, 4-6 m thick, occur in the upper section. Only the lower 180 m of the section is described in detail. The lower part of the formation yielded Upper Devonian flora.

The Plantekløfta Formation (150-200 m) occurs in the type section area only on the eastern slope of Munindalen. The formations are intercalated small-pebble conglomerates and siltstones. The Plantekløfta and the Planteryggen formations are believed to be separated by angular unconformity. Most investigators place the Plantekløfta Formation into the Mimerdalen Group and assume a Late Devonian age for the formation. Identification of new collections of flora, as well as the above-mentioned unconformity with conglomerates at the base, allow Murašov to tentatively assign the formation to the lowermost Carboniferous (Culm), considering it as basal Carboniferous beds.

The report gives characteristics of the composition, including mineralogy of the heavy fraction, of all rock types from each formation and their internal structure. This data, combined with analysis of fauna and flora, as well as paleoreconstructions of previous researchers, led the author to some conclusions regarding depositional environments in a changing Devonian basin. The following are the main conclusions:

1. All the Devonian deposits of Spitsbergen accumulated in water, in a variety of depositional basins, namely, fresh-water (including river), brackish-water, lagoonal, and coastal-marine basins.
2. Conglomerates of the Siktefjellet and the Red Bay groups were formed by fast shallow water streams flowing across highly uplifted terrain. Sandstones of the groups were deposited by swift currents flowing across relatively subdued relief.
3. Evidence of essentially fresh-water lake basins, which may have been submerged from time to time, appears in the upper part of the Red Bay Group (Frænkelryggen Formation).
4. Middle to Upper Devonian deposits of the Grey Hoek, the Wijde Bay, and the Mimerdalen (except for the Plantekløfta Formation) groups accumulated mostly in coastal-marine environments.
5. As for Lower Devonian conglomerates, those of the Plantekløfta Formation at the base of the Carboniferous may also have been formed by swift currents flowing across broken ground.

Types of analyses	Burov & Murašov 1965	Burov 1968	Murašov 1971	Mokin et al. 1972	Murašov 1973	Burov et al. 1974	Panov et al. 1975	Panov et al. 1976	Murašov 1979
Quantitative characteristic of lithology	-	-	-	-	31	22	5	-	32
Mineralogical analysis of heavy fraction	24	4	10	26	11	40	17	-	60
Flourimetric capillary analysis	134	51	248	222	152	96	128	31	360
Extraction of bitumen "A"	-	-	1	22	41	5	-	-	108
Sophisticated treatment of bitumens	-	-	1	3	15	10	-	-	31
Determination of porosity (numerator) and permeability (denominator)	238/20	-	44/32	45/27	-	31/16	47/46	32/20	-

Table 1: Type and number of analyses of Devonian deposits of Spitsbergen.

The author agrees with Burov & Semevskij (1976) that the Devonian trough continues southward toward Edgeøya and Barentsøya.

The report summarizes and analyzes all the data concerning bitumen content and reservoir features of the Devonian rocks of Spitsbergen. The generalization is based on the results of 680 fluorimetric capillary and 58 detailed bitumen analyses, as well as 317 new determinations of porosity of the rocks throughout the section.

By and large, all the results provided evidence for an extremely low bitumen "A" content (less than 0.001%) throughout the Devonian section. Of some interest are carbonate nodules and rare bands of mudstone in which, as suggested by hot extraction data, bitumen "A" accounts for 0.01-0.02%. The mudstone and the sandstone bands of the Estheriahaugen Formation show obviously increased bitumen content (0.16-0.31%); a petroleum nature of bitumen and its epigenetic character are postulated. Reservoir (granular) properties of the whole of the Devonian section are extremely low.

4. THE PLATFORM COVER

The sedimentary platform cover started forming on the Caledonian basement in Carboniferous time. A number of angular and other unconformities divide the cover rocks into lithostratigraphical complexes, namely, Upper Paleozoic (including Lower Carboniferous), Mesozoic, Paleogene, and unconsolidated Quaternary complexes.

Since the Spitsbergen Expedition in Svalbard carried out a combination of general geological surveys and detailed lithostratigraphical studies, the reports forming this chapter were written on both stratigraphical and regional (West-Spitsbergen trough, Bjørnøya) principles. The Paleogene sequences, which were described at length in the reports of the West-Spitsbergen trough and in a monograph by Livšic (1973, 1974), are not dealt with here.

4.1. The Upper Paleozoic

The Upper Paleozoic rocks were studied by the Spitsbergen Expedition mainly to determine their petroleum and coal potential. Gypsum-bearing deposits also received some attention. Lithostratigraphical studies and geological mapping were carried out.

Lithostratigraphical study of the Upper Paleozoic rocks commenced in 1962, when key sections were compiled on the south coast of Isfjorden and Sassenfjorden (*Pavlov et al. 1963*). Studies of a similar nature have continued, with short breaks, to the present day and have covered almost all the Permo-Carboniferous terrains on Spitsbergen. Over 30 sections, some incomplete, were compiled. Subsequently, Karnoušenko (*Krasil'ščikov et al. 1986*) has drawn up composite sections of the Late Paleozoic rocks for the main structural-facies zones and proposed a correlation chart (Fig. 2). Detailed stratigraphic sections, collection of flora and fauna, sampling for petrographical, mineralogical, chemical, X-ray crystal, spectral, fluorescence, coal petrography and other examinations were made. Each stage of the work concluded with a report, providing an account of the geological structure and detailed lithostratigraphical description of the area under study, using all identified fossils and analytical data. The study culminated with a summary of coal, oil, gas and other mineral resource potential of the area. Since Gavrilov (*1978*) compiled a report summarizing all the data on the Upper Paleozoic rocks obtained over 15 years, no summary papers have been made. Upper Paleozoic rocks were also studied in the following stratigraphic wells: Grumant-I (*Škola et al. 1977*), Raddedalen-I (*Bro & Švarc 1983*), and Vassdalen-II and -III (*Bro et al. 1990*)[5].

Fossils were identified at NIIGA by V.I.Ustrickij (brachiopods), O.V.Lobanova (pelecypods), Ju.G. Ragozov (corals), L.E.Skoropisceva (crinoids), A.F.Dibner (spores and pollen), and at VSEGEI by O.F.Lazutkina (bryozoan) and G.P.Radčenko (flora).

Geological mapping was carried out in almost all the areas where key sections were studied since this permitted the most complete and better exposed sections to be chosen. As a result, reports were generally accompanied by geological sketch maps, scale 1:50,000 and 1:100,000. Geological fieldwork at scales of 1:200,000 and 1:100,000 was performed in the Billefjorden area which is thought to hold the greatest potential for coal and, possibly, gas production (*Panov et al. 1975, 1976; Miloslavskij et al. 1993; Makar'ev et al. 1991*).

[5] Well logs are not reviewed here.

GAVRILOV, B.P., PAVLOV, A.V. & FEDINA, I.P. 1964:

Geological studies in the Billefjorden and Hornsund areas
[Geologičeskie issledovanija v rajonah Bille-fiorda i Hornsunna, Zapadnyj Špicbergen]
Report on fieldwork in 1963
196 pages, 10 appendices, 28 illustrations, 13 tables, 35 references

The report presents results of lithostratigraphical studies of the Middle to Upper Paleozoic rocks on the west and east coast of Billefjorden and at two localities in the Bellsund area.

On the west coast of Billefjorden, the section starts with a sequence (800 m) of variegated sandstone, siltstone, mudstone and conglomerate, given, after Harland (1961), an Early Devonian age. It is unconformably overlain by a coal-bearing, essentially sandstone sequence (up to 220 m), yielding Lower Carboniferous flora and spore and pollen assemblages. The Middle-Upper Carboniferous and Permian deposits are most completely described on the east coast of Billefjorden. The Middle and Upper Carboniferous rocks are represented here by a gypsiferous sequence (380 m) and a limestone sequence (130 m), respectively. The Permian section (320 m) is composed of intercalated dolomite and limestone with the middle part rich in gypsum. Fauna, collected throughout the section, suggests an Early Permian age for the deposits; only the top 5 metres contain Upper Permian brachiopods.

Lower Carboniferous (about 1000 m) and Upper Carboniferous deposits are described on the north coast of Bellsund. The Lower Carboniferous sequence is dominated by sandstone with subordinate conglomerate, siltstone, and mudstone. A thin layer of sandstone with pebbles lies at the base of the Upper Carboniferous carbonate strata.

A complete Permian section, divided into two formations, namely, the carbonate Lower Permian Bravaisberget Formation[6] (430 m) and the carbonate-siliceous Upper Permian Starostin Formation[7] (380 m), was compiled on the east coast of Bellsund, south of Midterhuken.

The lithology of the section is defined on the basis of petrographical study, phase carbonate and trace element analyses. Identifications of new collections of brachiopods, pelecypods, crinoids, and foraminifera are given.

All the samples under study show low bitumen (chloroform bitumen "A" accounts for thousands, less commonly, hundreds of a percent, in rare cases reaching 0.3%) and low organic carbon (about 0.06-0.8%, in some cases up to 3.13%). The exception is a fusuline limestone horizon, 8.8 m in apparent thickness, sampled in the Upper Carboniferous section of Billefjorden. Here the bitumen "A" content is in excess of 1% and $C_{org.}$ varies within 1.65-2.48%.

The presence of the horizon containing bitumen in the Upper Paleozoic section led the authors to propose a search for oil and gas not only in the Paleogene and Cretaceous terrains but also in the Jurassic, Triassic, and even Upper Permian terrains.

[6] Not to be confused with the synonymous Middle Triassic formation (Mørk et al. 1982) [Norsk Polarinstitutt]

[7] Formation name according to Burov et al. (1965); corresponds to lower members of the Kapp Starostin Formation (Cutbill & Challinor 1965) [Norsk Polarinstitutt]

GAVRILOV, B.P. 1965:

Middle and Upper Paleozoic deposits of the west coast of Spitsbergen (Brøggerhalvøya, St.Jonsfjorden, Hornsund)

[Sredne- i verhnepaleozojskie otloženija zapadnogo poberež'ja ostrova Zapadnyj Špicbergen (poluostrov Bregger, Sent-Džons-fiord, Hornsunn]

Report on fieldwork in 1964

148 pages, 8 appendices, 14 illustrations, 7 tables, 14 references

The Middle to Upper Paleozoic deposits were investigated on Brøggerhalvøya, at the top of St.Jonsfjorden, and on Treskelen in Hornsund. The report presents lithostratigraphical Middle-Upper Paleozoic sections for these areas and their correlation chart.

On Brøggerhalvøya, the Lower Devonian rocks (390 m) are made up of red conglomerate, sandstone, and siltstone, resting on the eroded surface of Precambrian metamorphic schists of the folded basement. The Devonian redbeds are unconformably overlain by Middle Carboniferous conglomerates. The Carboniferous (535 m) and Permian (218 m) deposits on Brøggerhalvøya are mainly carbonate; only the Lower Carboniferous rocks are completely composed of sandstone, and thin conglomerates occur at the base of the Middle Carboniferous rocks. The Carboniferous/Permian boundary is drawn in the limestone beds, marked by the disappearance of a characteristic foraminifera assemblage. The Upper Permian is represented by the silico-carbonate Starostin Formation[7] (178 m) and the Selander Formation (40 m), made up of sandstone with glauconite.

Middle Carboniferous (326 m) and Permian (480 m) deposits, separated by an unconformity, are described at the top of St.Jonsfjorden. The Carboniferous part of section is built up of sandstone with thin layers of mudstone and dolomite. The Lower Permian (180 m) is dominated by dolomite with siliceous concretions in the lower part and gypsum in the upper part. The Upper Permian (300 m) is made up of siliceous rocks.

A Middle Carboniferous stratigraphic section (225 m), made up of intercalated conglomerate, sandstone, and siltstone, was compiled on Treskelen. The Middle Carboniferous deposits are unconformably overlain by a thin layer (4.3 m) of siliceous limestone, yielding an abundant fauna characteristic of the Lower/Upper Permian boundary beds.

The bitumen content of all the rocks is very low with the yield of chloroform bitumen "A" varying from traces to 0.08%. $C_{org.}$ is also low, 0.01-0.44%. The only exception is a horizon of fusuline limestone (4 m), occurring in the Upper Carboniferous section on Brøggerhalvøya. The chloroform bitumen "A" content here is as high as 0.6%, and $C_{org.}$ 0.17-5.45%. Porosity and permeability are very low.

USTRICKIJ, V.I., GAVRILOV, B.P. & LIVŠIC, JU.JA. 1966:

The main features of Upper Paleozoic stratigraphy and paleogeography on Spitsbergen

[Osnovnye čerty stratigrafii i paleogeografii verhnego paleozoja Špicbergena]

Thematic report based on data of fieldwork in 1962-1965

147 pages, 1 appendix, 3 illustrations, 1 table, 49 references

Data, obtained by the geologists of the Spitsbergen Expedition and other non-Russian scientists, were used to provide a brief description of Upper Paleozoic deposits in twelve areas of Spitsbergen (Brøggerhalvøya, St.Jonsfjorden, Kapp Starostin, northeastern Bellsund, Midterhuken, Hornsund, Sassenfjorden, Pyramiden mountain, east coast of Billefjorden, Nordaustlandet, Barentsøya, and Bjørnøya). These descriptions were accompanied by lists of fauna (brachiopoda, pelecypoda, foraminifera) which were used for subdivision into series; however, for the first time, the Middle Carboniferous is divided into stages (Bashkirian and Moscovian); and two formations (Starostin[7] and Selander) are recognized in the Upper Permian. A stratigraphical correlation chart is compiled for all the Upper Paleozoic sections. An attempt at restoring the paleogeographic environment both onshore and

offshore of Spitsbergen is made. Lithofacies charts are compiled for the Bashkirian and sedimentation rates are calculated for the Late Permian Selander Formation. The first chart shows an erosion area, stretching from north to south in central Spitsbergen. The second chart shows two areas of sedimentation in Selander time, namely, the southwestern (glauconitic sandstone) and northeastern (silico-carbonate) areas.

USTRICKIJ, V.I. & SOSIPATROVA, G.P. 1969:

Detailed stratigraphy of Moscovian, Upper Carboniferous and Lower Permian deposits in the Isfjorden area

[Detal'naja stratigrafija moskovskih, verhnekamennougol'nyh i nižnepermskih otloženij rajona Is-fiorda]
Report on fieldwork in 1967
41 pages, 1 appendix, 8 references

The report gives a description of five Upper Paleozoic sections in the Isfjorden area: Linnévatnet (C_3-P_1), east coast of Dicksonfjorden (C_2-P_1), east slopes of Yggdrasilkampen and Pyramiden (C_2-C_3), and the west slope of Wordiekammen (C_2-P_1). A detailed stratigraphic description is accompanied by lithological interpretation and numerous identifications of brachiopods and foraminifera, made by the authors.

Fauna from the section, indicated the presence of Moscovian, Upper Carboniferous, and Lower Permian deposits. The Moscovian and the Upper Carboniferous rocks are divided into fusulinid horizons, using the scheme adopted for the Russian platform and the Urals area. The Vereja, the Kašira, the Podolsk, and the Mjačkovo horizons are recognized in the Moscovian, and the Protricites, the Tricites, and the Pseudofusuline horizons in the Upper Carboniferous. The data obtained allowed the authors to more accurately outline the history of geological development of Spitsbergen in Middle-Late Carboniferous time. For instance, the horst, located in central Spitsbergen and eroded in Bashkirian time, was overlain by sediments not in Mjačkovo, as was previously thought, but in Kašira time. A monotonous sequence of dolomitic limestone giving way to subargillaceous and arenaceous limestone, on the east and west, accumulated in the horst area in Late Carboniferous and Early Permian time.

GAVRILOV, B.P. 1978:

Stratigraphy and composition of Carboniferous and Permian deposits of Svalbard

[Stratigrafija i veščestvennyj sostav kamennougol'nyh otloženij arhipelaga Sval'bard]
Report on the thematic project
444 pages, 26 appendices, 70 illustrations, 6 tables, 80 references

The report presents results of the study of the stratigraphy and lithology of the Carboniferous and Permian deposits of Svalbard. Most of the report deals with detailed description of 30 lithostratigraphical sections in various areas of Svalbard, including Bjørnøya. Field data were obtained by Gavrilov in 1962, 1963, 1964, and 1974, Pavlov in 1962 and 1963, Livšic in 1965, 1968 and 1970, Burov in 1963, and Klubov in 1963. All the sections are presented graphically; a correlation chart is compiled for the Middle Carboniferous-Permian sections. A description of each section is preceded by a review of earlier research, and is accompanied by various charts showing the subdivision of the Carboniferous and Permian rocks of Svalbard. The author adopts Cutbill & Challinor's (1965) stratigraphic scheme with recognition of series, stages and, in places, horizons.

The Lower Carboniferous is described separately for western, central, and eastern Spitsbergen. On western Spitsbergen, lithology and nature of coal occurrence are used to divide the Lower Carboniferous into two formations, namely, the Orustdalen (lower coal-bearing part of section, 700-750

m) and the Vegard (coal-free sequence, 100-350 m) formations. Their equivalents in the Hornsund area are the Hornsundneset Formation (720 m) and the Sergeijevfjellet Formation (250 m), respectively. In central Spitsbergen, the Lower Carboniferous coal measures are divided, after Cutbill & Challinor (1965), into the Hørbyebreen Formation (150-200 m) and the Sveenbreen Formation (up to 225 m), and have been dated by abundant fossil assemblages as Tournaisian-Visean and Visean in age, respectively. A similar age was obtained for conglomerate-sandstone deposits of Ny Friesland.

The best occurrence of the Middle Carboniferous rocks is on Brøggerhalvøya, in the Billefjorden area, and on Bjørnøya. Abundant faunal collections indicate Bashkirian and Moscovian rocks; the variations in thickness of these sections is shown on Fig. 2.

Two types of sections occur in the Bashkirian; the western (east of Billefjorden only), essentially clastic section with a characteristic sequence of red sandstone and conglomerate, and the eastern carbonate-gypsiferous section. The Moscovian is represented by three types of sections. Most sections fall into the first type, *Cyathophyllum* limestone. The second type is characteristic of Bünsow Land only and is mainly carbonate rocks with layers of gypsum. The third type, intercalated sandstone, dolomite, and limestone, was found on northeastern Spitsbergen.

The Middle/Upper Carboniferous boundary is drawn within the monotonous sequence of *Cyatho-phyllum* limestone based on foraminifera assemblages, which were used to recognize horizons in Moscovian and Upper Carboniferous successions of the Russian platform.

In most areas, the Upper Carboniferous rocks are conformably overlain by a basal Lower Permian dark fusuline limestone. Pre-Permian erosion, indicated by basal conglomerates and a predominantly clastic section, 100-120 m thick, is well defined on southern Spitsbergen and Bjørnøya only. Elsewhere the Lower Permian (300-400 m) is represented by dolomite with interbeds and units of gypsum. Carbonate fauna yielded Asselian, Sakmarian (?) and Artinskian foraminifera.

The Late Permian Period is represented by its lower part only, and is assigned, after Ustrickij (1967), to the Pai-Hoi. It is divided into the siliceous Starostin[7] Formation (180-400 m) and the silico-carbonate Selander Formation (up to 80 m).

The report provides detailed descriptions of the lithology of all the rock types, illustrated by photomicrographs of thin sections. The heavy fraction of sandy-silty deposits (94 analyses) was studied; carbonate rocks were investigated using reduced hydrochloric acid extracts (64 analyses) and phase analyses; X-ray crystal structure analyses and bulk chemistry analyses were made to examine argillaceous and siliceous rocks in more detail.

Paleotectonic reconstructions and six lithofacies charts were compiled for Svalbard for Early Carboniferous, Bashkirian, Moscovian, Late Carboniferous, Early Permian, and Late Permian time. An earlier suggestion that Svalbard (including Bjørnøya) belonged to the marginal part of the Barents platform in Late Paleozoic time is confirmed.

DIBNER, A.F. 1984:

Subdivision and correlation of the Lower Carboniferous of Spitsbergen

[Rasčlenenie i korreljacia nižnekarbonovyh otloženij Zapadnogo Špicbergena]

Book 2 of the thematic report by Evdokimova, N.K. and Dibner, A.F., 1984: Composition and quality of coals of Spitsbergen [Veščestvennyj sostav i kačestvo uglej ostrova Zapadnyj Špicbergen]

Report on thematical project, 1981-1984

45 pages, 2 illustrations, 20 references

The report presents results of a palynological study of Culm coal measures of Pyramiden, Wordiekammen, and Bünsow Land; the study is aimed at dating, subdivision and correlation of stages. In addition, correlation of the coal measures of Spitsbergen with other areas of the European region is made.

300 samples are examined of which 100 are from coal beds. 105 species and 39 genera are identified in more than 4000 miospores; the list is appended.

Palynological assemblages, dated as Tournaisian and Visean in age, are described for coal beds and the surrounding rocks enabling the compilation of a correlation chart.

A Tournaisian flora is identified including a limited number of species of lycopsids, arthrophytes, and pteridophytes. The author notes new species, indicating coal development as early as in Middle Carboniferous time. The rich and diverse Visean flora are the most abundant flora on Spitsbergen; lycopsids, especially lycopods and selaginella, figure prominently; arthrophytes (equisetums and calamites) are less common; diverse pteridophytes are also noted. Arborescent specimens of lycopsids were probably the main coal-formers.

GAVRILOV, B.P. & BIRJUKOV, A.S. 1986:

Preliminary report on reconnaissance work in the "Ferdinand Mountain[8]" area of the Pyramiden coal deposit

[Informacionnyj otčět o provedenii rekognoscirovočnyh rabot učastka "Gora Ferdinanda" mestorožděnija "Piramida" v 1985 g.]
31 pages, 2 appendices, 2 illustrations, 4 tables, 5 references

The report presents results of a reconnaissance survey of the "Ferdinand Mountain[8]" locality north of the Pyramiden coal-field. The locality is made up of Proterozoic metamorphic rocks (Atomfjella Group) and Lower and Middle Carboniferous deposits. The Lower Carboniferous succession is represented by coal measures, divided into basal (under)coal, lower coal, intercoal, and upper coal beds depending on coal content. Total thickness of the coal measures is no more than 150 m. Middle Carboniferous rocks are made up of dolomite, sandstone and gypsum with apparent thickness varying between 120-260 m.

The locality is associated with the Billefjorden Fault Zone. It is broken up into separate blocks by many large N-S or, less commonly, north-east-trending faults. As a rule, easternmost blocks are downthrown; throw varies from 50-100 to 1000 m and over. Some blocks are intensely deformed and dip angles of the rocks vary from gentle to vertical.

51 coal occurrences are discovered at the locality (49 in the lower and 2 occurrences in the upper coal beds). Almost all the seams are not completely exposed. Five seams with apparent thickness 0.7-0.8 m and two seams at least 1.6 and 1.8 m thick are recognized. The total number of seams and their true thickness remain uncertain.

Coals are gas, low-sulfur, type with low and medium ash contents. 31 proximate analyses and 25 ultimate analyses were made. Petrographic determinations (8) indicate vitrinite, fusinite and liptinite groups, accounting for 34-76%, 0-15%, and 12-56%, respectively. Reflectance of vitrinite (31 determinations) varies between 0.7-1.05, averaging 0.85-0.90.

GAVRILOV, B.P., BIRJUKOV, A.S. & EVDOKIMOVA, N.K. 1988:

Correlation of Carboniferous and Permian successions in the Billefjorden area and coal, gypsum and bitumen occurrences in them

[Sopostavlenie razrezov kamennougol'nyh i permskih otloženij v rajone Bille-fiorda i projavlenija v nih uglja, gipsa i bituma]
Report on the thematic project from 1986-1988
131 pages, 13 appendices, 13 illustrations, 12 tables, 32 references

The report, accompanied by a geological sketch map, scale 1:100,000, provides correlation of all Lower, Middle and Upper Carboniferous sections, made by non-Russian and Russian geologists in the Billefjorden and Austfjorden area (23 surface sections and 6 in coal-prospecting wells).

[8] Corresponds to the mountain Svenbrehøgda on official topographic maps [Norsk Polarinstitutt]

The Lower Carboniferous coal measures are divided into: (1) undercoal (basal), (2) lower coal, (3) intercoal, (4) upper coal, and (5) above-coal beds. Data on microflora, including new collections, are used for correlation.

The Middle-Upper Carboniferous deposits are divided into: (1) clastic variegated-red rock sequence (middle Bashkirian), (2) gypsum-bearing sequence (Bashkirian and middle Moscovian), and (3) limestone sequence (Kasimovian and upper Gzelian). The gypsum-bearing sequence is defined by new identifications of brachiopods and foraminifera as Bashkirian at Trikolorfjellet and Moscovian age at Ferdinandfjellet[8], with recognition of the Kašira, Podolsk, and Mjačkovo horizons in the Moscovian stage. At Gizehfjellet and Odellfjellet, new foraminifera occur in the limestone sequence.

The structure of the Lower Carboniferous coal measures is studied in detail at all the localities. The number, thickness, structure, lithology and chemistry of the coal seams are presented. New data on chemical analysis of coals (8 samples) and semiquantitative spectral analysis of ash (8 samples) are presented for Odellfjellet. Undiscovered coal resources are estimated at all the localities under study; an estimate of coal reserves for the Pyramiden deposit is taken from a report prepared by the Trust "Arktikugol".

Study of borehole samples in the Pyramiden deposit indicates that in the Lower Carboniferous coal measures $C_{org.}$ varies from 0.1 to 5.0% and the yield of bitumen "A" accounts for 0.02-0.5%; in the Middle-Upper Carboniferous deposits the values 0.1-3.0% and 0.01-0.22% were obtained, respectively.

Reservoir properties of the rocks are also studied from borehole logs. The porosity and permeability of the Lower Carboniferous sandstone vary from 0.1-17.4% (on average, 7.2%) and 0.1-446.4 mD (on average, 51 mD), respectively; values for the Middle Carboniferous sandstone are 2.7-9.8% and 0.1-26.7 mD. Middle Carboniferous gypsum, dolomite, limestone and high-carbonate clastic rocks display low porosity (0.1-3.1%) and low permeability (0.1-0.23 mD).

The report also covers gypsum content of the Bashkirian and Moscovian sections in the Billefjorden area. An aggregate thickness of the gypsum-bearing sequence, the number and thickness of seams of gypsum and anhydrite, and chemical analyses (9 determinations) are presented. Gypsum is of high quality and can be used to produce binding material. An estimate of probable gypsum reserves indicates a large gypsum deposit in the area.

4.2. The Mesozoic

The Mesozoic of Svalbard has been studied by the Spitsbergen Expedition since 1962 to determine its petroleum potential in Svalbard and on the adjacent Barents Shelf (Bjørnøya, Hopen). Geological and structural observations led to geological sketch maps, scale 1:50,000 and 1:100,000 of the main Mesozoic terrains. Over 30 Mesozoic sections were studied in detail (Fig. 8) and were divided into series, stages, and lithological horizons. Descriptions were made from the oldest Mesozoic beds, overlying the Upper Permian or the Caledonian folded basement (southern Sørkapp Land), to the contact with the Paleogene, in the west of Isfjorden, in Sassenfjorden, on the north coast of Van Keulenfjorden, and in Sørkapp Land.

Each report gives: detailed lithostratigraphical and paleontological information and a description of lithology; data on heavy minerals, hydrochloric acid extracts, and P_2O_5 determinations; data on bitumen content of the rocks and oil source rocks; and results of the study of granular, and in places fractured, reservoirs (Table 2).

All the lithostratigraphical and bituminological data, obtained by the beginning of the 1980s, including drill logs of the Colesbukta (Grumant) stratigraphic well, were summarized by Pčelina (*1983*) in a report, which contained a correlation chart for all the Mesozoic sections.

Scientists of VNIIOkeangeologia (formerly NIIGA) and other institutions identified fossils, namely, M.V. Korčinskaja and V.M. Petrenko (Triassic fauna), E.S. Eršova (Jurassic and Cretaceous fauna), A.A.Gerke (Triassic foraminifera), V.A.Basov and N.V.Šarovskaja (Jurassic and Cretaceous foramini-

fera), L.V.Nehoroševa (bryozoans), V.S.Zaspelova and E.K.Trusova, VSEGEI (conchostracans, phyllopods), L.V.Obručev, Paleontological Museum of the USSR (reptile bones and fish), L.B.Tihomirova, VSEGEI, and G.Ė.Kozlova, VNIGRI (radiolarians); spore and pollen assemblages were determined by V.D.Korotkevič (Triassic) and V.V.Pavlov (Cretaceous), leaf flora by N.D.Vasilevskaja, wood by I.A.Šilkina, Botanical Institute, Academy of Sciences, USSR; algae were examined by K.B.Korde, Paleontological Institute, Academy of Sciences, USSR.

PAVLOV, A.V., PČELINA, T.M., GAVRILOV, B.P., PETRENKO V.M., DANJUŠEVSKAJA, A.I. & FEDINA, I.P. 1963:

Geological study in central Spitsbergen

[Geologičeskie issledovanija v central'noj časti ostrova Zapadnyj Špicbergen (v svjazi s problemoj neftegazonosnosti)]
Report on fieldwork in 1962
478 pages, 13 appendices, 130 illustrations, 26 tables, 86 references

The report is compiled for two key sections in different structural zones: on the west, from the south coast of Isfjorden (Kapp Mineral - Festningen), and on the east, from the south coast of Sassenfjorden (Adventfjorden - Lusitaniadalen). The report also presents results of reconnaissance of the east coast of Spitsbergen and the north coast of Van Mijenfjorden.

In the Isfjorden area, a detailed stratigraphic reference section of Paleozoic (about 1650 m) and Mesozoic (about 2085 m) deposits was constructed down to the contact with Paleogene basal conglomerates. In the Sassenfjorden area, a detailed stratigraphic section of Permian (over 386 m) and Mesozoic (over 1370 m) deposits was constructed to the lower Aptian, inclusive.

The Paleozoic section is divided into series and lithological horizons.

The Lower Carboniferous rocks (800-900 m) unconformably overly the Precambrian rocks of folded basement with conglomerates at the base. The section is mainly made up of quartz-rich sandstone, containing lenses and thin seams of coal, and wood and vegetable debris.

The Middle-Upper Carboniferous rocks (about 350 m) unconformably rests on Lower Carboniferous rocks with conglomerates at the base. The section is dominated by dolomite, with limestone and sandstone in the lower part.

The Permian rocks (about 450 m in the Festningen area and over 385 m in the Sassenfjorden area) are composed of siliceous, silico-calcareous and silico-argillaceous rocks with layers of limestone. The eastern section contains rare units of mudstone; glauconite-quartzitic sandstone, overlain unconformably by Lower Triassic mudstone, appears higher in the section.

The Triassic, Jurassic, and Lower Cretaceous clastic deposits, divided into series, stages and lithological horizons, are described in detail. Particular attention was given to marker beds and concretionary horizons. Important phosphorite marker horizons were first found in the Middle Triassic succession.

Comparison of the key sections in the west and east revealed both similarities and differences in composition and thickness of deposits over the area. In the Lower and Middle Triassic strata of the eastern zone, fine-grained rocks increase in amount, sandstone disappears, and sediments become more marine and reduced in thickness, particularly in the Lower Triassic sequence.

In the Upper Jurassic-Valanginian sequence of the eastern zone, the sediments also become more marine and fine-grained. A significant variation in thickness of some stratigraphic units is found in post-Kimmeridgian time.

New collections of fauna and data on the composition of the rocks allow more accurate boundaries to be drawn between the Middle and the Upper Triassic, and the Triassic and the Jurassic successions. For example, a bed of silicified siltstone and sandstone (Fosse Sandstone), previously referred to as Late Triassic age, was placed into the Middle Triassic in the west. A bed of mudstone with ironstone concretions, yielding a marine fauna, was moved from Middle Triassic to Carnian age in the eastern zone. The Norian, yielding marine fauna, was first recognized in both zones. It is unconformably overlain by a thin bed of sandstone and conglomerate with phosphatic nodules, yielding Early-Middle

Jurassic fauna. The bed was known in the literature as the "Lias conglomerate". New data provides evidence for excluding late Norian and Rhaetic deposits in the sections and emphasizing a break in sedimentation between the Triassic and the Jurassic periods.

The report gives results of rare trace element analyses of coal seams and coal-bearing rocks from Lower Carboniferous, Upper Triassic, Lower Cretaceous and Paleogene deposits. The coals sampled were collected in surface outcrops and in the Barentsburg and Pyramiden mines. New data on the composition of the Paleozoic and Mesozoic deposits allowed the nature of their facies and the degree of saturation with organic matter to be determined. Joint geological-petrographical and analytical studies on bitumen content allowed the recognition of three sequences, showing increased chloroform bitumen "A" content: the Lower-Middle Triassic, the Upper Jurassic, and the Valanginian strata. In spite of the lack of good granular reservoirs, a positive petroleum potential is inferred for southern Spitsbergen.

PČELINA, T.M. & SOKOLOV, V.N. 1964:

The lithostratigraphy and bitumen content of Mesozoic deposits in the Van Keulenfjorden and Isfjorden (Selmaneset) areas

[Litostratigrafičeskaja i bituminologičeskaja harakteristika mezozojskih otloženij rajonov Van-Kejlen-fiorda i mysa Sel'maneset Is-fiorda]
Report on fieldwork in 1963
162 pages, 4 appendices, 40 illustrations, 16 tables, 3 references

The report presents results of investigation of Mesozoic rocks in two localities, namely, the north coast of Van Keulenfjorden, and the Selmaneset area on the north coast of Isfjorden. Two detailed stratigraphic sections (2010 m and 1790 m) were constructed in the Mesozoic rocks.

The Triassic, Jurassic, and Lower Cretaceous rocks were recognized in both sections. The Lower Triassic mudstone unconformably overlies the Upper Permian siliceous rocks. The Middle/Upper Triassic boundary was also drawn more accurately; the presence of middle Lias (Early Jurassic) sediments was proven. The Paleogene rests on the lower Albian in the Selmaneset area and on the middle Albian in the Van Keulenfjorden area. New collections of ammonites in both sections, and re-identification of previous collections from the upper Valanginian in the Festningen and the Sassenfjorden areas, enabled the Hauterivian to be reliably recognized for the first time beneath the Helvetiafjellet Formation.

Studies of the composition, bitumen content and reservoir properties of the rocks confirmed the presence of previously recognized strata containing bitumen. The bitumen content of the rocks was found to decrease southward in the west of Spitsbergen. The granular reservoirs are of poor quality. The Van Keulenfjorden area was found to incorporate four structural zones two of which were considered unprospective for hydrocarbon potential.

PČELINA, T.M., SOKOLOV V.N. & MURAŠOV, L.G. 1966:

The Mesozoic deposits of Sørkapp Land, Hornsund and Kjellströmdalen in the context of oil and gas potential

[Mezozojskie otloženija rajonov Zemli Serkap, Homsunna i K'el'stremdalen v svjazi s perspektivami neftegazonosnosti]
Report on fieldwork in 1965
276 pages, 15 appendices, 82 illustrations, 20 tables, 33 references

The report presents the lithostratigraphy of Mesozoic rocks in the south of Sørkapp Land, Treskelen in Hornsund, and the Kjellströmdalen area.

All three Mesozoic systems were studied in the south of Sørkapp Land. Abundant collections of ammonites, pelecypods and brachiopods enabled the Lower and the Middle Triassic, as well as the

Hauterivian, the Aptian, and the Albian to be recognized for the first time in Sørkapp Land. The whole section, about 1500 m in thickness, is divided into stages and horizons. Detailed description of the lithology and composition of the rocks is illustrated by many photographs and photomicrographs.

The Induan (Lower Triassic) silt-sand deposits (40 m) rest with a structural unconformity on the Caledonian folded basement surface. The bulk of the Ladinian and Anisian (Middle Triassic) rocks, 85 m thick, are composed of clay-carbonate siltstones (silicified in the Ladinian section) with abundant phosphatic nodules. The Carnian (45 m) and the Norian (30 m) stages, separated by an unconformity, were recognized; the Norian is made up of quartzitic sandstone with detritus and remains of arborescent flora.

Jurassic rocks unconformably overly the Upper Triassic sediments. At the base, a 14 m horizon is described in detail, and is made up of sandstone with thin layers of concretionary phosphorite and abundant remains of diverse Lower to Middle Jurassic fauna. The Upper Jurassic (Callovian-Volgian) is composed of a monotonous silty mudstone sequence about 170 m thick. A similar type of section persists in Valanginian (Early Cretaceous) time. Sandy material starts accumulating during the Hauterivian; the Barremian-Aptian is dominated by sandstone; the Albian is again dominated by silty mudstone. Marine pelecypods, inocerams, and foraminifera were found for the first time in the Barremian of Spitsbergen.

Triassic (370 m) and Jurassic (35 m) rocks were studied on Treskelen, and an incomplete Lower Cretaceous section (830 m) was measured in the Kjellströmdalen area. Abundant paleontological material was collected, allowing the division of the strata into stages. It was found that the thickness of most Mesozoic units reduced southward, but dramatically increases in the same direction at the start of Barremian time.

Analytical investigations into bitumen content and reservoir properties of the rocks are discussed in detail in the report in connection with appraisal of the petroleum potential of the area. Overall, a lower bitumen content and the lack of granular reservoirs were noted in sections of southern Spitsbergen. Special research on fractures showed that the Lower Triassic, Norian and Barremian sandstones are of interest as potential fractured reservoirs. The Kjellströmdalen area holds considerable potential in a hydrocarbon context.

PČELINA, T.M. & SOKOLOV, V.N. 1967:

Mesozoic deposits of the east coast of Spitsbergen in the context of petroleum potential

[Mezozojskie otloženija vostočnogo poberež'ja ostrova Zapadnyj Špicbergen v svjaži s perspektivami neftegazonosnosti]

Report on fieldwork in 1966

286 pages, 5 appendices, 82 illustrations, 11 tables, 39 references

The report presents the results of lithostratigraphical studies at three localities on the east coast of Spitsbergen (Wichebukta, Agardhbukta, Kvalvågen). Geological sketch maps, scale 1:100,000, were compiled for each locality; detailed stratigraphic sections were constructed for the Triassic (Wichebukta), the Jurassic and the Lower Cretaceous (Agardhbukta), and the Lower Cretaceous (Kvalvågen). New faunal collections permitted upper Volgian rocks to be recognized for the first time and the Jurassic/Cretaceous boundary to be confirmed in the Agardhbukta area.

Lower and Middle Triassic (about 300 m) sediments are dominated by mudstone and siltstone with abundant phosphorite in Middle Triassic time. Upper Triassic strata of intercalated sandstone, siltstone, and mudstone with interbeds and concretions of ferrocarbonate rocks rests with a stratigraphic unconformity on the Middle Triassic. A thin (2-5 m) Jurassic conglomerate and sandstone horizon with abundant phosphorite and ironstone, described in detail in Wichebukta and Agardhbukta, covers a wide stratigraphic range, including the Lower and Middle Jurassic series. The Upper Jurassic strata (235 m) of intercalated mudstone and siltstone with bands and concretions of carbonate rocks, continues into the basal 200 m of the Lower Cretaceous, including the Hauterivian. The coarser-grained Barremian and Aptian succession (280 m) overlies the Hauterivian succession with a stratigraphic unconformity; thin

coal seams and lenses of polymictic conglomerates with pebbles of igneous rocks were encountered in the Barremian at Kvalvågen. Albian (610 m) deposits are again composed of siltstone and mudstone with ferrocarbonate nodules.

A separate section of the report gives a comprehensive description of the composition of all the Mesozoic rock types, including various nodules which the authors believe can be used in stratigraphic correlation.

The study of bitumen content throughout the section indicated three bitumen-bearing beds: (1) Lower to Middle Triassic, (2) Upper Jurassic (but for the Callovian), and (3) the less promising Hauterivian (Lower Cretaceous) strata. Physical and chemical properties of bitumens suggest they belong to the petroleum series (oil, maltha). The presence of combined (fractured-porous) reservoirs is inferred, though measurements indicate that the rocks show low porosity and permeability. The Agardhbukta and Kvalvågen areas show favorable prospects for petroleum exploration.

KLUBOV, B.A. 1963:

Geological study on Edgeøya
[Geologičeskie issledovanija na ostrove Ėdž]
Report on fieldwork in 1962
161 pages, 7 appendices, 21 illustrations, 7 tables, 32 references

The report presents results of geological investigation of north-east (Kapp Heuglin), south (Negerpynten), and south-west (Kvalpynten) Edgeøya. Detailed lithostratigraphic sections were constructed for each locality; their correlation chart is given and a Late Triassic age was confirmed by abundant fauna and flora collections. The section is about 400 m thick and contains three rock units: mudstone (lower), transitional, and sandstone. Two approximately E-W trending, gentle anticlines were recognized in the north-east of Edgeøya.

Analytical investigation of the bitumen content and reservoir properties of the rocks (Table 2) allowed recognition of some sandstone beds (25-30 m), with high porosity and medium permeability, and led to the suggestion of a secondary nature of bitumens in the Triassic of Edgeøya.

KLUBOV, B.A. & VASIL'EV, V.N. 1964:

Geological studies in the Kapp Freeden area and on Wilhelmøya, Barentsøya and Edgeøya
[Geologičeskie issledovanija v rajone Mysa Freden i na ostrovah Vil'gel'ma, Barenca, Ėdž]
Report on lithostratigrafic studies of Permian, Triassic and Jurassic deposits in 1963
179 pages, 9 appendices, 18 illustrations, 16 tables, 40 references

The report gives results of geological investigation of Wilhelmøya, of the Kapp Freeden area, of the east coast of Barentsøya, and in the Kapp Lee area (Edgeøya). Detailed lithostratigraphic sections, scale 1:500, were constructed for each locality.

Fauna collected in the Kapp Freeden area confirmed the presence of Upper Permian silico-carbonate rocks and Triassic deposits. Additional fauna collected at Wilhelmøya allowed the Upper Triassic (over 540 m) to be reliably established here, and divided into the Carnian, Norian, and tentatively the Rhaetic. For the first time, fauna and microfauna collected led to the recognition of Pliensbachian-Toarcian mudstone and sandstone (15 m) and Bathonian-Callovian mudstone (5.5 m), separated by a break in sedimentation. At Wilhelmøya, the section is capped by Oxfordian-Kimmeridgian siltstone (above 27 m).

Upper Permian limestone, jasper, and sandstone (more than 290 m), overlain by Induan (Lower Triassic) mudstone with break in sedimentation between, were recorded for the first time on Barentsøya.

All the Triassic series and stages, except for the Rhaetic Stage, were recognized in over 510 m of sediment. The Anisian and Ladinian stages were found to be separated by a gap in sedimentation.

Anisian, Ladinian and Carnian deposits were discovered in 300 m of Triassic strata in the Kapp Lee area. A gap was ascertained between the Early and Middle Triassic.

Nodular phosphorite is ubiquitous in the Middle Triassic rocks. Macroshows of mineral tar and dispersed oil, and increased (up to 0.6%) dispersed bitumen were reported from the Middle Triassic rocks. Sandstone strata (15 m), showing high porosity and permeability, were found in the Upper Triassic.

KLUBOV, B.A. 1965:

Outline of the geology of Barentsøya and the north coast of Edgeøya
[Geologičeskoe stroenie ostrova Barenca i severnogo poberež'ja ostrova Ėdž]
Report on the thematic project from 1962-1964
144 pages, 7 appendices, 25 illustrations, 7 tables, 45 references

The report summarizes data from geological investigation of Barentsøya and the north coast of Edgeøya, between 1962-1964. The report contains a new geological sketch map, scale 1:1,000,000, of the area, and a lithostratigraphical section of Triassic deposits (about 800 m), plus a series of additional sections and correlation charts.

The Upper Permian Selander Formation deposits (250-300 m) were described in north-east Barentsøya. Triassic deposits of all three series are present and are subdivided into stages. The Induan mudstone rests on the Upper Permian siliceous rocks without apparent signs of an hiatus. In the author's view, the Permian rocks crop out in the axial zone of the north-northeast-trending swell-like structure with an amplitude of no less than 200 m (Barentsøya swell); the structure is conjugate with a narrow trough, inferred between Barentsøya and the east coast of Spitsbergen. Predominantly E-W trending, gentle, small scale folds are described in rocks formed during the Triassic.

The report describes a regionally high bitumen content of the Olenekian, Anisian, and Ladinian deposits, which are considered to compose up to 300 m thick oil-producing strata; the strata are noted for a bitumen "A" content up to 1.2% and macroshows of oil and mineral tar. Units of granular and fractured reservoirs were also established in the Upper Triassic rocks. The Barentsøya swell is proposed as a top priority target in the search for hydrocarbons.

PČELINA, T.M. & KORČINSKAJA, M.V. 1973:

Permian and Triassic deposits of the central and southwestern parts of Edgeøya and Hopen
[Permskie i triasovye otloženija central'noj i jugo-zapadnoj časti ostrova Ėdž i ostrova Nadežda]
Report on fieldwork in 1971-1972
92 pages, 2 appendices, 18 illustrations, 6 tables, 11 references

The report presents results of lithostratigraphical studies in the central (Kroká) and the southeastern (Tjuvfjorden and Russebukta) parts of Edgeøya, and in the south-west of Hopen Island.

Stratigraphic sections were constructed for the Upper Permian (15 m) and the Triassic, including Carnian deposits (500 m), at Edgeøya. A new direct Permian/Triassic contact was recognized: the Upper Permian is unconformably overlain by the Induan (Tjuvfjorden) and the Olenekian (Kroká). A new complete Lower Triassic section was also described on Edgeøya. The age of the stratigraphic units is confirmed by abundant remains of fauna and microfauna. The Olenekian and Carnian deposits contain algal beds, which serve as markers on Spitsbergen.

A lithostratigraphical log (over 385 m) of the Upper Triassic section, divided into Carnian and Norian stages, was constructed on Hopen Island. Remains of fauna, flora, and algal beds were found. A bedrock of black bitumen-rich carbonate, possibly Late Jurassic in age, outcropped in the south-west of the island.

At Edgeøya and Hopen Island, bitumen analysis of the Permian and Triassic rocks were made and granular reservoirs were studied. A bitumen-rich silt-clay bed and a bed with sandy reservoirs, containing secondary bitumen, were recognized in the Middle Triassic at Edgeøya and Hopen Island, respectively.

PČELINA, T.M. 1983:

Mesozoic stratigraphy and paleogeography of Svalbard
[Stratigrafija i paleogeografija mezozoiskih otloženij arhipelaga Sval'bard]
Report on the thematic project in two books
600 pages, 35 appendices, 186 illustrations, 12 tables, 111 references

The report generalizes data on the Mesozoic of Spitsbergen, obtained from detailed studies of type sections. It incorporates lithostratigraphical and bitumen investigations from earlier reports, and additional information on all areas under study (Fig. 8D). The report also presents results of the study of Triassic, Jurassic and Cretaceous deposits, from the Grumant Well at Colesbukta: lithostratigraphical and bitumen studies of the cores were made by the author.

The report proposes radically new implications concerning the stratigraphy, paleontology, paleogeography, catagenesis and bitumen content of the Mesozoic of Spitsbergen; the history of Mesozoic sedimentation is considered on Spitsbergen and on the adjacent Barents Shelf.

All litho- and biostratigraphical data on the archipelago are presented in two volumes of the report. Separate detailed sections and local charts for individual islands and structural-facies zones are used to provide lithostratigraphical data. Previously recognized lithological horizons, are used as a basis for the construction of new stratigraphic units, formations, and members; coeval formations are joined into horizons (Fig. 8). A clear correlation is given with the lithostratigraphic units previously established by non-Russian scientists (Fig. 9). Effusive and tuffaceous rocks were first described in the Upper Triassic and Barremian successions, respectively.

The author examined, and reexamined, over 3000 thin sections, including 200 sections to determine the composition of organic matter and 500 sections for studying the character of bitumens and their distribution in the rocks. Detailed bitumen analysis is given separately for the rocks from outcrops and from a well (Table 2). The geochemistry of insoluble organic matter and results of X-ray crystal analysis of minerals are given; the morphology of heavy clay minerals is described from results of 600 mineral analyses. Correlation charts for all 32 Mesozoic sections studied, and density, porosity and magnetic susceptibility logs of the rocks are attached.

Examination of thin sections allowed many diversified planktonic and benthic algae and many groups of fossils (radiolarians in the Middle Triassic and the Late Jurassic; planktonic foraminifera in the Aptian and Albian; foraminifera in the Barremian, etc.) to be determined. Phosphorites of nodular, oolitic and ooid types, discovered by the author in 1963 in the Middle Triassic deposits, were found to be biogenic and are important markers in the whole of the Middle Triassic of Spitsbergen. Phosphate is mainly accumulated by blue-green algae, whose climax fell in the Anisian, the time of greatest transgression in the Mesozoic Era. Many carbonate concretions are also biogenic in origin and vital marker horizons. Systems of "fissures" observed in the Lower and Middle Triassic carbonate concretions, and infilled with calcite and bitumen represent fossil bones of reptiles; bitumens from them are related to animal organic material. Practically all the algae identified are new forms and still require systematic description. K.B. Korde believes that the algae belong to a new province, radically different from the south of Eurasia.

Description of paleontological remains, minerals, rocks and bitumens is accompanied by many black-and-white and color photographs and photomicrographs.

Data on the composition of the Mesozoic rocks were used to correlate and control the boundaries of biostratigraphic zones; they confirmed the presence of a break in sedimentation and revision of some boundaries between stratigraphic units to be made. For instance, the Middle/Upper Triassic boundary was drawn more precisely; the Triassic/Jurassic boundary beds were studied in detail; it was established that throughout the archipelago the Upper Triassic series contains the Carnian and the lower Norian stages only, whereas younger sediments are missing. Hettangian-Sinemurian and Pliensbachian marine strata were found in the north-east of Spitsbergen. The Hauterivian/Barremian boundary is drawn more accurately; a gap between the stages, recognized over much of Spitsbergen, is proven to be absent in the south of Sørkapp Land where the Barremian increases thickness, offshore facies appear and coals disappear.

Using the results of integrated lithofacies analysis, 17 new paleogeographic maps, scale 1:1,000,000, were compiled for Spitsbergen and the adjacent shelf, including Hopen Island and Bjørnøya, for each stage of the Triassic, the Late Jurassic, and the Early Cretaceous, and one map for the Early-Middle Jurassic Period. Some maps show substage boundaries, along which marked variations in paleogeographic environments take place; variations in the salt regime of the Mesozoic basin are traced. Along with basic lithologies, the maps depict probable volcanic and crustal terranes, as well as localities where various groups of fossils were found. Inferred outlines of paleouplifts (including ancient land areas) and paleotroughs, isopachs with inferred depths of paleobasins, and boundaries of facies zones, including the boundary of the North deep-sea basin, are shown. The maps provide data on the composition of hydrochloric acid extracts of carbonates and on heavy minerals of clastics. Thorough petrographical and mineralogical studies led to the conclusion that most of the leucoxene and other titaniferous minerals are authigenic in origin and cannot therefore act as provenance indicators. On the other hand, a peculiar metamorphic mineral assemblage with glaucophane, staurolite, kyanite, and almandine, obtained from the Lower-Middle Jurassic deposits on Kong Karls Land, and observed nowhere else in Svalbard, suggests that the metamorphic rocks with glaucophane schists, probably associated with fault zones, may have been transported to the erosion area north and north-east of Kong Karls Land at that time.

Detailed paleoclimatic analysis for stages in Triassic time, based on a mixture of lithological and paleontological characters, is given. Data on rock composition and paleontological remains of East Greenland and Kotel'nyj Island (New Siberian Islands), information on faunal distribution in the Spitsbergen area, and in marginal seas in the east of the Pacific were used. As a result, approx. N-S facies zoning is shown to have existed within the archipelago in Triassic time. A deep-sea zone, connected with the North deep-sea basin, is believed to have existed to the east, between Svalbard and Franz Josef Land. This zone may have stretched to the south-west and graded into a shallow sea south of Bjørnøya. In the Early Cretaceous Period, probably in Barremian time, the northern islands must have joined together to form a single land area (or, possibly, large separate source areas) on the site of the deep-sea basin of the Arctic Ocean, from where an intense removal of clastic material occurred.

Paleogeographic and paleoclimatic reconstructions allowed four sedimentary cycles to be recognized in the Mesozoic.

The first cycle comprises Early and Middle Triassic time, when the climate was hot and sufficiently arid and vegetation cover played an insignificant part in source areas. Deposition took place in a warm shelf seas, with 'peculiar' organic matter. In post-Induan time, the high salinity of the basin waters decreased as the transgresion built up and peaked in Anisian time. The Middle Triassic was the time when phosphate formation reached a maximum in Svalbard. Late Ladinian time witnesses considerable sea bottom elevation, accompanied by formation of separate paleouplifts.

The second cycle covers Late Triassic and Early-Middle Jurassic time, when deposition took place in a hot, but intermittently humid climate. At the Middle/Late Triassic boundary, tectonic processes became more active; onshore, offshore and lagoonal sediments were formed in the Carnian Stage. Submarine basalt activity in early Carnian time occurred with sea shoaling. The middle Bathonian represents a break point with formation of subaerial igneous rocks in the north-east of the archipelago.

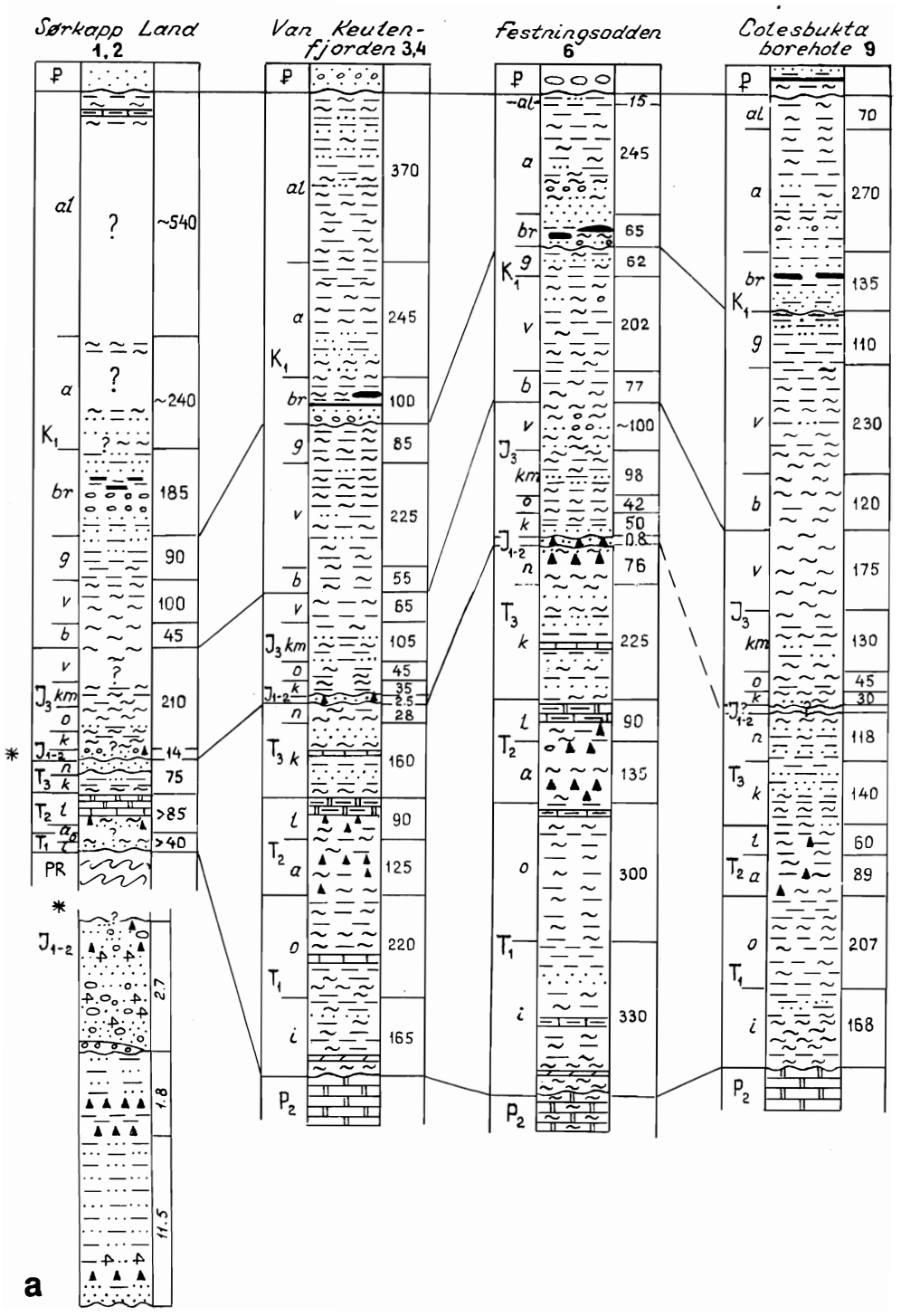
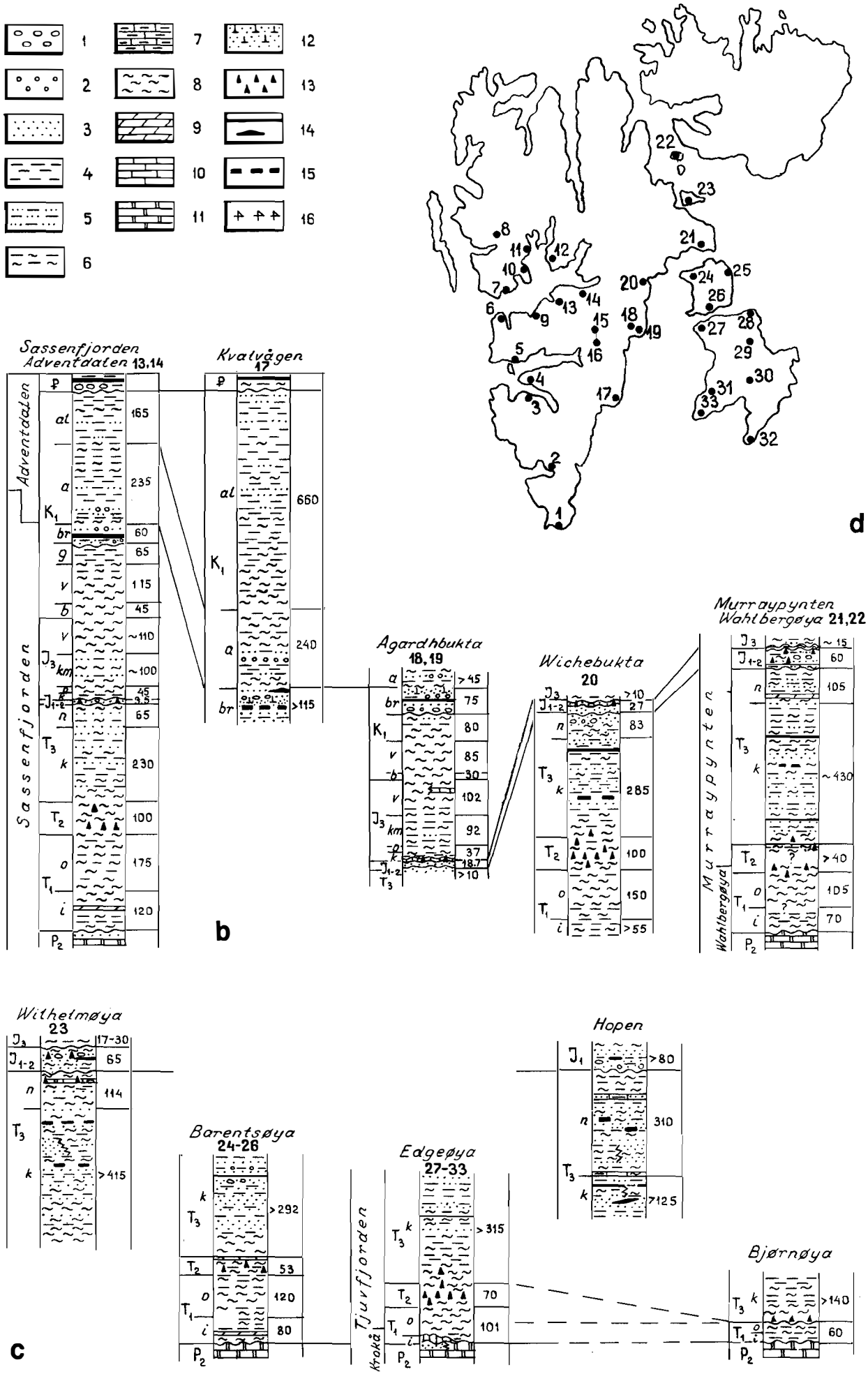


Fig. 8: Correlation of main stratigraphic sections of the Mesozoic of Svalbard.
a: Western areas of Spitsbergen; **b:** Eastern areas of Spitsbergen; **c:** Eastern islands; **d:** Studies on the Mesozoic of Svalbard (numbers refer to columns in Figs. 8a-c)
1 conglomerate; **2** gravelstone; **3** sandstone; **4** siltstone; **5** sandy siltstone; **6** clayey siltstone; **7** carbonate siltstone; **8** mudstone; **9** dolomite; **10** limestone; **11** siliceous rock; **12** tuff; **13** phosphorite; **14** coal (beds and lenses); **15** coaly mudstone; **16** siderite


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Sassenfjorden
Adventdalen 13,14
Kvalvågen
17
Agardhbukta
18,19
Wichebukta
20
Murraypynten
Wahlbergøya 21,22
Withelmøya
23
Barentsøya
24-26
Edgeøya
27-33
Hopen
Bjørnøya
Tjuvfjorden
Kroka
b
c
d

During the first two cycles, Svalbard was under the influence of an arid climate, which is more evident in East Greenland.

The third cycle comprises the Late Jurassic Period[9] and the Berriasian-Barremian (Early Cretaceous) stages. Deposition took place in a humid climate with cooling at the beginning of the cycle. Stable marine depositional environments persisted to the end of the Hauterivian Stage, followed by basin shoaling and distinct regression in late Hauterivian time. The onset of the Barremian Stage was marked by a break, followed by accumulation of coal measures in Barremian time. In Late Jurassic time, facies zonation in Svalbard became E-W; this was probably related to the opening of the Atlantic. The late Kimmeridgian was the time of formation of the West-Spitsbergen trough with its northern part (Grumant Well area at Colesbukta and Bohemanflya) showing maximum rates of sedimentation and its flanks having a minimum volume of sediments.

The fourth cycle, incorporating the Aptian and Albian stages, completes Mesozoic sedimentation in Svalbard. Deposition took place under humid cool climatic conditions. The beginning of the cycle was associated with minor transgression in early Aptian time. Extensive transgression began in late Aptian time and continued into early Albian time. Albian time was marked by uplift in the north of the West-Spitsbergen trough and intense downwarping in its southeastern part, where a maximum volume of early and middle Albian sediments accumulated. Distinct regression occurred at the end of middle Albian time.

The report generalizes all the data available on the contents of $C_{org.}$ and chloroform bitumen "A", presents data on its group and hydrocarbon composition, and on the physical properties of the rocks. A thorough study of the composition of organic matter and bitumens was related to the type of organic matter. Based on analysis of oil and bitumen shows and geochemical data, potential oil source beds were recognized in Mesozoic rocks; reservoirs, including sandstone beds with secondary bitumens, and cap rocks were also identified. New data on vitrinite reflectance and rock density were obtained. Charts of catagenesis zoning, which allow tracing of the degree of catagenic transformations of the Triassic and Barremian rocks and organic matter proper, were compiled for the whole area, based on the combined data from bitumen content, density and porosity of the rocks, and vitrinite reflectance.

[9] In present-day terminology, the cycle starts with the middle-upper Bathonian Stage.

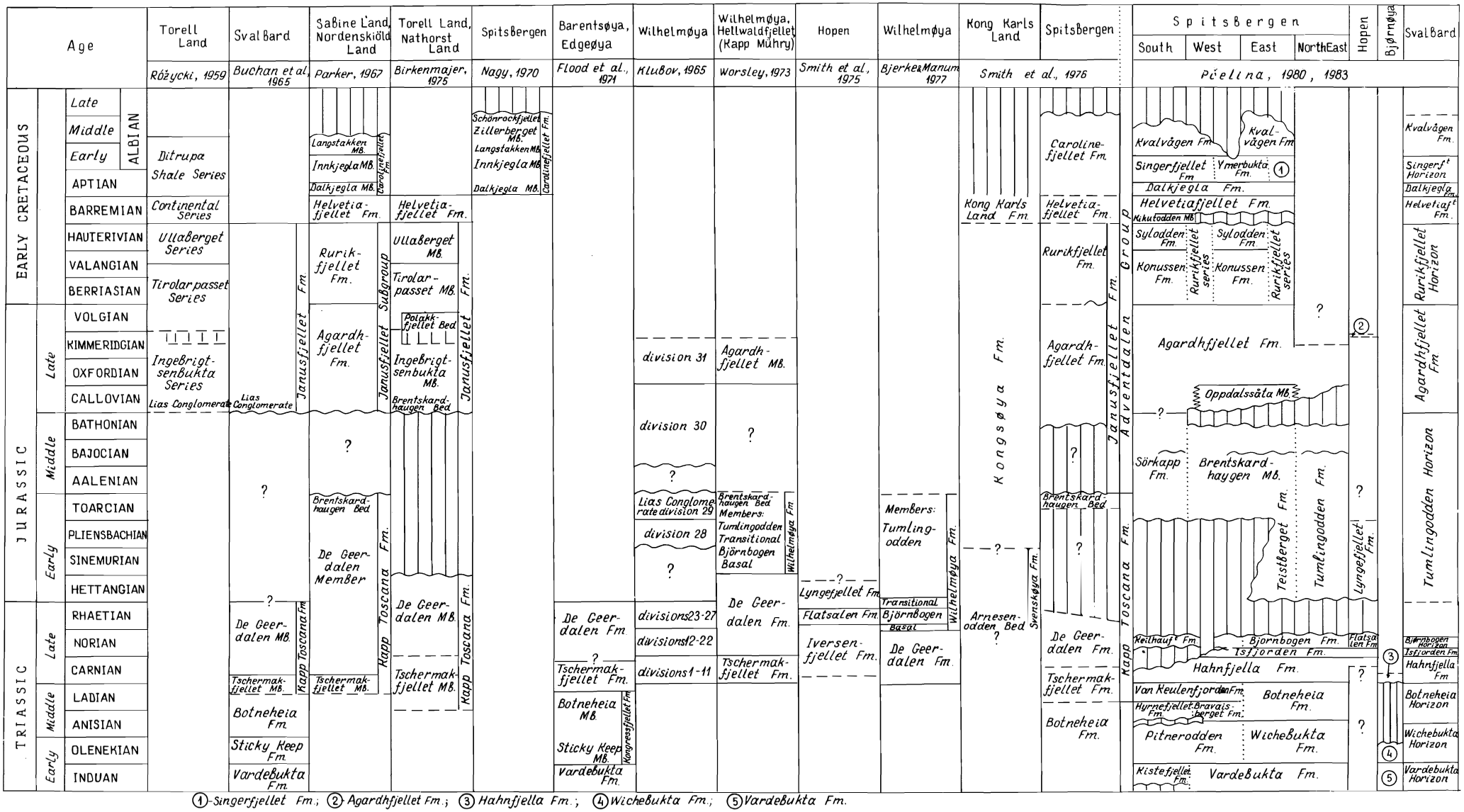


Fig. 9: Correlation of stratigraphic nomenclature for the Mesozoic of Svalbard.

Type of analyses	PAVLOV ET AL. 1963	PČELINA & SOKOLOV 1964	PČELINA ET AL. 1966	PČELINA ET AL. 1967	KLUBOV 1963	KLUBOV 1965	PČELINA & KORČINSKAJA 1973	PČELINA 1983	
								Grumant outcrops	borehole
Mineralogical analysis of heavy fraction	36	29	50	36	5				
Hydrochloric acid extracts	64	26	46	66					
P_2O_5 determination	24	20	13	25	3	5	25	158	
Fluorimetric capillary analysis	783	339	151	197	189	176	110		
Organic matter determination	243	135	135	197	92	87	98	152	78
Bitumen "A" extraction	8	6	5	5	4	5	9	152	78
Detailed bitumen analysis	8	6	5	5	4	5	9	135	43
Determination of porosity / permeability	297 / 99	102 / 66	106 / 1	97 / 14	126 / 19	161 / 34	41 / 15		

Table 2: Type and number of analyses of Mesozoic deposits of Spitsbergen.

4.3. Quaternary Deposits and Geomorphology

Specialized research on Quaternary deposits, geomorphology and neotectonics was performed in various areas of Spitsbergen, namely, Hornsund and Bellsund, Van Keulenfjorden, Van Mijenfjorden, Bohemanflya, Billefjorden, Brøggerhalvøya, Bockfjorden, Sorgfjorden, and Murchisonfjorden on Nordaustlandet. In addition, incidental observations and the compilation of geomorphological maps were carried out during the production of medium-scale geological maps in Nathorst Land, Nordenskiöld Land, Dickson Land, and Andrée Land.

A wide distribution of Pleistocene deposits was confirmed, and a stratigraphic subdivision was made; previous and new identifications of marine fauna, including molluscs, brachiopods and barnacles, were summarized and the systematics produced throughout the area; the main morphological features of Spitsbergen were recognized; doming of Spitsbergen in late Pleistocene-Holocene time, caused mainly by tectonic and, to a lesser degree, by glacio-isostatic processes was confirmed.

Quaternary sediments were subjected to detailed analytical examinations (granulometry, mineralogy, various kinds of chemical analysis, micropaleontological studies). Macrofauna was determined by V.D. Semevskij, and microfauna (foraminifera) by V.Ja.Slobodin.

SEMEVSKIJ, D.V. & ŠKATOV, E.P. 1964:

Quaternary deposits, geomorphology and recent tectonics on the north coast of Van Mijenfjorden and the east coast of Billefjorden

[Četvertičnye otloženija, geomorfologija i projavlenija novejšej tektoniki na severnom poberež'e Van-Mejen-fiorda i vostočnom poberež'e Bille-fiorda]

Report on fieldwork in 1963

209 pages, 1 appendix, 50 illustrations, 101 references

The report presents results of research on the Quaternary deposits and geomorphology of two localities, namely, the north coast of Van Mijenfjorden and the east coast of Billefjorden.

The Quaternary (predominantly Holocene) deposits of the two localities are divided into marine (including glaciomarine) and continental (mainly glacial) sediments. Marine sediments form Holocene marine terraces ranging in height from 2 to 50 m (Van Mijenfjorden, terraces I-IV) and from 2 to 85 m (Billefjorden, terraces I-VII). The thickness of sediments, making up each terrace, varies from 2 to 20 m. The terraces are bipartite in structure: upper and lower sections are composed of shingle and loam, respectively. The marine sediments are fossiliferous with about 100 species of molluscs, brachiopods and barnacles described.

Glaciomarine sediments, up to 45 m thick, occur on the north coast of Van Mijenfjorden (Fridtjovhamna, Braganzavågen, and Sveabukta with the so-called "Damesmorena"). They are composed of loam, which contains lenses of clay and sand of variable thickness, and ice lenses, up to 2 m thick. An upper section is made up of laminated gravel-pebble material, 1 to 11 m thick. All the sediments contained molluscs and barnacles.

Continental sediments are composed of glacial, aqueoglacial, alluvial and lacustrine facies with thicknesses varying from a few metres to 15 m (for each type), and eluvial and deluvial sediments, 1-2 m thick.

The widely developed terrace-like structure of the coasts in question suggests, on the one hand, fast elevation of the area and the absence of glacial processes for the last 10,000-15,000 years. On the other hand, the presence of glaciomarine sediments points to an abrupt advance of separate ice sheets (for instance, Nathorstbreen, Damesmorena at Van Mijenfjorden). A new geomorphological map, scale 1:100,000, showing in detail surfaces of denudation and accumulation, of different origin, was compiled for Nordenskiöld Land.

The complex study of Quaternary deposits and analysis of the geomorphological structure of the area allowed neotectonic movements to be constructed. It was established that they were inherited from the ancient structural grain of the area. Present-day coasts and coastal processes of the north shore of Van Mijenfjorden and the east shore of Billefjorden are described. Coasts of abrasion (mainly cliffed) and accumulation (deltaic and marine) type are recognized.

Appendices give a list of foraminifera from the marine sediments of the Van Mijenfjorden area and brief geomorphological interpretations of Oxfordhalvøya and Prins Oscars Land (Nordaustlandet).

SEMEVSKIJ, D.V. & ŠKATOV, E.P. 1965:

Quaternary deposits and geomorphology of some areas of Spitsbergen
[Četvertičnye otloženija i geomorfologija otdel'nyh rajonov arhipelaga Špicbergen]
Report on fieldwork in 1964
155 pages, 35 illustrations, 2 tables, 33 references

The report presents results of field investigation of the Quaternary deposits and geomorphology of some localities on Spitsbergen (Treskelen, Van Keulenfjorden, Tempelfjorden, Bohemanflya, Bockfjorden) and Nordaustlandet (Murchisonfjorden, Duvefjorden, Wahlenbergfjorden). A brief description of the geomorphology and Quaternary deposits of Barentsøya and Edgeøya is also given. Problems of Quaternary deposition and neotectonic movements on Spitsbergen are discussed in the final sections of the report.

A complex of terrace-like features is recognized and described in detail at all localities; height and morphological parametres of the terraces are given. Sections of marine sediments have been constructed and their paleontology and relationships with glacial drift are described. Glaciomarine sediments (north and south till of Nathorstbreen) are studied at Van Keulenfjorden. Present-day glacial dynamics are constructed for some localities; the trend toward intense deglaciation is noted. An age range of 4000-6500 years is inferred for the volcano Sverrefjellet from analysis of the morphology of terrace surfaces of the Bockfjorden area and the composition of Quaternary deposits building up the terraces.

Microfaunal assemblages found in the marine sediments of Brøggerhalvøya and Van Keulenfjorden are correlated with those discovered elsewhere on Spitsbergen. The report also gives a systematic list of species of recent and fossil fauna of molluscs, brachiopods, and barnacles of Spitsbergen and its offshore waters and indicates localities where they were found. The list substantially complements that presented by Feyling-Hanssen (1955).

SEMEVSKIJ, D.V. 1967:

Pleistocene deposits, neotectonics and paleogeography of the Spitsbergen archipelago
[Plejstocenovye otloženija, neotektonika i paleogeografija arhipelaga Špicbergen]
Report on fieldwork in 1966
86 pages, 26 illustrations, 57 references

The report presents a description of Pleistocene deposits with new type sections constructed in the south of Bellsund and on the east coast of Billefjorden. A comparative study of specific sections showed a weathered surface (up to 0.5 m), separating the bedded Pleistocene and the Holocene. It was found that the Pleistocene deposits on Spitsbergen accumulated during two glaciation periods and two interstadials in Würm time.

Analysis of the elevation of dated marine terraces enabled the construction of the neotectonics of Spitsbergen and its adjacent shelf. Semevskij considers that the doming of the archipelago, with maximum elevation reaching 400 m, was complicated by vertical displacement of crustal blocks.

Based on paleogeomorphology and historical biogeography the report presents a comprehensive interpretation of the main stages of the Quaternary history of Spitsbergen and its adjacent shelf.

4.4. The Geology of the West-Spitsbergen Trough

The West-Spitsbergen trough and adjacent eastern areas, together forming the major structures affecting the sedimentary cover of Spitsbergen, were mapped by the Spitsbergen Expedition between 1962-1969 (Fig. 10). Results of fieldwork were presented in eight annual reports, accompanied by geological and structural maps, scale 1:100,000. Most maps were based on topographic maps of the same scale, published by the Norsk Polarinstitutt (sheets B9, B10, B11, C9); topographic maps for the eastern areas (sheets C10 and D9) were made by enlarging the 1:500,000 maps. Most reports have the same format. Introductory chapters contain reviews of the geography and geology of the area, its geological structure, and techniques of compilation of the structural maps; this technique is described in great detail in the reports presented by Livšic and others in 1963 and 1964 and reviewed here. The main contents are given under the headings of stratigraphy, tectonics, and mineral resources; some reports present data on intrusive rocks, geomorphology, and the history of geological evolution.

The Carboniferous-Permian, Mesozoic and Paleogene deposits were investigated in different amounts of detail in the course of geological-structural mapping. Fig. 11 and Table 3 present a correlation chart of the stratigraphic columns from reconnaissance reports being reviewed. All analyses (Table 4) were made at NIIGA laboratories. Fauna and flora were identified mostly by NIIGA scientists, namely, V.I.Ustrickij (Late Paleozoic fauna), A.A.Gerke and M.F.Solov'eva (microfauna); M.V.Korčinskaja and

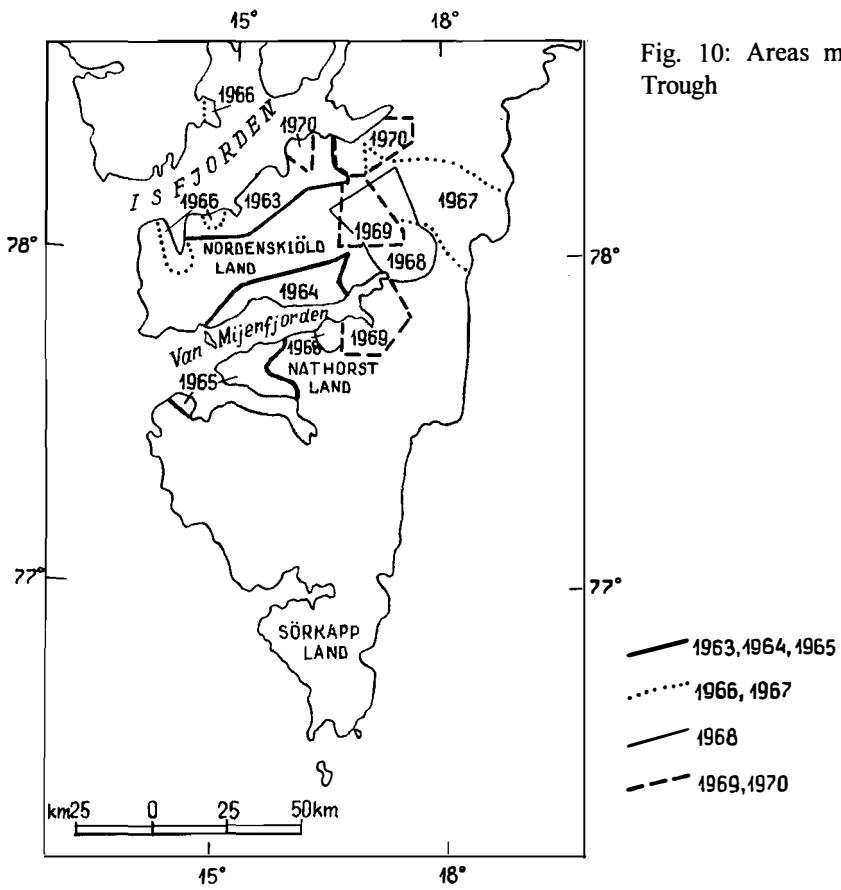


Fig. 10: Areas mapped in the West-Spitsbergen Trough

V.M.Petrenko (Triassic fauna), E.S.Eršova and O.V.Čerkesov (Jurassic-Cretaceous fauna), V.D.Korotkevič, A.S.Monahova and V.V.Pavlov (Mesozoic spore-pollen assemblages); I.A.Korobkov (Paleogene fauna), N.K.Subbotina (microfauna), T.N.Bajkovskaja, L.Ju.Budancev, N.D.Vasilevskaja, E.N.Kara-Murza and I.N.Svešnikova (flora), and A.S.Vakulenko (spore-pollen assemblages). All polished sections of coals were described by A.B.Alekseeva and I.N.Drozdova.

LIVŠIC, JU.JA., PANOV, A.I. & MARIENGOF, B.B. 1963:

Ouline of the geology and mineral occurrences of the south coast of Isfjorden between Grønfjorden and Sassenfjorden

[Geologičeskoe stroenie i poleznye iskopaemye južnogo poberež'ja Is-fiorda na učastke Gren-fiord - Sassen-fiord]
Report on geological mapping, scale 1:50,000, and structural studies in 1962
390 pages, 23 appendices, 62 illustrations, 12 tables, 55 references

The report presents results of geological mapping, scale 1:100,000, and structural investigations carried out in 1962 south of Isfjorden in an area between Grønfjorden and Sassenfjorden (Fig. 10). A special chapter gives details of the techniques used in structural investigations; an attached chart shows the distribution of ten marker beds throughout a section.

The Section entitled "Stratigraphy" gives the characteristics of the Mesozoic, Paleogene, and Quaternary deposits of the area. The Mesozoic section under study, about 150 m in aggregate thickness, contains five lithological units: mudstone (Middle Triassic); sandstone (Upper Triassic); mudstone - siltstone (Upper Jurassic - Valanginian) with Lower Jurassic conglomerates at the base; intercalated coal-bearing sandstone, siltstone, mudstone (Hauterivian-Barremian); and feldspathic-quartzitic sandstone with thin layers of siltstone (Aptian-Albian). Abundant fauna, allowing allocation into stages, are scattered over the section.

The Paleogene deposits, unconformably overlying the Aptian-Albian beds, are divided into formations and members in the final report in general agreement with the scheme proposed by Nathorst in 1910. However, the correlation chart (p.111 in the report) gives possible proper names for five formations recognized in the type areas (Paleocene: Grumant, Barentsburg, Hollendardalen; Eocene: Colesdalen, Trodalen). The strata, up to 1700 m thick, are intercalated sandstone and mudstone, of roughly equal thickness, with the lower and upper beds containing coal. Many sections yielding remains of flora and, less commonly, fauna, were described both from outcrops and coal-prospecting wells in the Barentsburg and Colesbukta areas. Detailed microscopic description is given for the most common Aptian-Albian and Paleogene rocks. In the area, the Quaternary is represented by Late Quaternary and Holocene marine-terrace deposits, as well as a different-facies of Holocene continental sediments.

Under the heading "Intrusive rocks" three types of intrusions are described: (1) a poorly differentiated intrusion (50-60 m thick) of olivine-dolerites - quartz gabbro-dolerites of Grønsteinfjellet; (2) sills (a few metres to 40 m thick); (3) dykes (up to 15 m) of olivine- and olivine-bearing dolerites. All of the intrusions differ slightly in mineralogy, but are dominated by olivine-dolerite.

In the Section entitled "Tectonics", the present-day structural grain of the area is described; different-order folds, major faults, and fault zones are described. The Central Tertiary Graben-Syncline, located between the Western and the Eastern "marginal zones", is regarded as a main structure of the sedimentary cover of Spitsbergen. A structural map, scale 1:100,000, along the Paleogene base ("lower" coal seam) serves as a basis for recognition and description of the structures within the central graben-syncline; ten additional structural maps for separate localities and horizons are also attached. A generalized tectonic sketch map shows (from west to east): east-dipping Grønfjorden monocline; Iradalen depression; Kapp Laila swell; Colesdalen syncline; and the west-dipping Adventdalen monocline.

From all available evidence, faults are classified into two main groups: (1) faults of pre-Cretaceous origin in the Western and the Eastern marginal zones; (2) faults of Cretaceous (WNW-ESE) and post-

Cretaceous (NE-EW, N-S) movement. Both groups are dominated by high-angle faults with throw varying from a few tens to hundreds of metres.

The Chapter entitled "Geomorphology" is accompanied by a map, scale 1:100,000, based on the recognition of genetically similar surfaces of denudation and accumulation. Various combinations of the surface features are recognized which have formed due to structural denudation, accumulative denudation, and accumulative types of relief.

In the Chapter entitled "Mineral Resources", most attention is given to the description of Cretaceous and Paleogene hard coals, and to oil and gas shows and reservoir properties of rocks throughout the succession. In the authors' view, the presence of a petroleum bitumen horizon in the Paleogene basal beds, combined with other shows of dispersed oil and bitumens, are very favorable factors for petroleum potential of the area, even though good porous reservoirs are lacking in the section. The Kapp Laila swell is proposed as the top priority structure for oil exploration.

In terms of other mineral resources, sulfide mineralization is noted in dolerites, and phosphorites in Lias conglomerates; underground waters of the area are described.

LIVŠIC, JU.JA. & PANOV, A.I. 1964:

Outline of the geology and mineral occurrences of the Van Mijenfjorden area
[Geologičeskoe stroenie i poleznye iskopaemye rajona Van-Mejen-fiorda]
Report on reconnaissance, structural studies and project in 1963
235 pages, 18 appendices, 40 illustrations, 5 tables, 44 references

The report presents results of geological mapping, scale 1:100,000, structural observations, and projects, from the study of Tertiary deposits of the Van Mijenfjorden area, aiming to determine the petroleum potential. Fieldwork was carried out in 1963 as a continuation of that of the year before, with the same goals and using the same techniques.

The lower part of the section under study, up to 40 m thick, is assigned to the Upper Triassic, overlain by the "Lias conglomerate" with no apparent unconformity. The overlying Mesozoic deposits, mudstone, siltstone, and sandstone, are divided into three sequences: Jurassic-Valanginian (460-640 m), Hauterivian-Barremian (up to 100 m), and Aptian-Albian (420-580 m). All three sequences are fossiliferous.

Following Nathorst's scheme (1910) the Paleogene is divided into six formations; the age of the three lower formations has been determined by flora and pelecypoda to be Paleocene, and that of the three upper formations is Eocene as suggested by flora from the upper section. All types of Paleogene rocks, including concretions, have been examined microscopically.

Tectonically, the area is considered to be part of the Central graben-syncline of Spitsbergen. This major structure is divided into: the Grønfjorden monocline, the graben-synclinal trough, and the Adventdalen monocline. The Grønfjorden monocline dips north-eastward at angles 10-12° to 4-6° nearer to the Central syncline. The Adventdalen monocline dips to the south-west (3-4°). The Central syncline is complicated by relatively gently sloping small scale folds, shown in structural maps. The structural maps, scale 1:100,000, have been compiled using seven marker beds. A structural correlation has been ascertained for separate horizons; this has assisted the compilation of a composite map along the base of the upper mudstone formation. The following structures are recognized with the Central syncline from west to east: Iradalen depression, Kapp Laila swell, Skiferdalen swell, Reindalen swell, Tverrdalen depression; they are complicated in turn by minor anticlines and synclines.

As in northern Nordenskiöld Land (*Livšic et al. 1963*), the fractures are predominantly high-angle faults. The oldest (pre-Cretaceous) faults form the Western and the Eastern marginal fault zones, with associated folds, similar to the Grønfjorden anticline. Most of the major faults outside the marginal zones were traced from the northern area mapped in 1962. The authors concluded that reactivation of movement occurred along the major fractures and pointed out that high rates of sedimentation in the Paleogene may be linked to this.

Under the heading "Mineral resources", Lias phosphorites and Paleocene coals are described and the petroleum potential of the area is indicated. The similarity is noted of bitumens from the lower formation of coal-bearing sandstone to oil from the Barentsburg area. The study of reservoir properties of the Paleogene deposits and their comparison with fractured reservoirs of combined type of known oil regions suggest that the rocks of the lower formation of coal-bearing sandstone can serve as fractured, combined oil-and-gas reservoirs. Structures which seem to be promising for hydrocarbon accumulation at depth are identified for the first time and the location of particular areas deserving petroleum exploration, are noted.

LIVŠIC, JU.JA. & PANOV, A.I. 1965:

Outline of the geology and mineral occurrences of western Nathorst Land and Paleogene deposits of eastern Prins Karls Forland and the Renardodden area

[Geologičeskoe stroenie i poleznye iskopaemye zapadnoj časti Zemli Nathorsta i paleogenovye otloženija vostočnoj časti ostrova Princa Karla i rajona mysa Renardodden]

Report on reconnaissance, structural studies and project in 1964

214 pages, 22 appendices, 31 illustrations,10 tables, 44 references

The report is based on the results of geological mapping and structural observations in western Nathorst Land, as well as lithostratigraphical studies of Paleogene deposits in the east of Prins Karls Forland and in the Renardodden (Bellsund) area.

The study of western Nathorst Land resulted in compilation of: geological and geomorphological maps, scale 1:100,000; eight structural maps for separate marker beds recognized in the Mesozoic-Cenozoic section; and a composite structural map, scale 1:100,000, along the top of the Eocene Green Sandstone Formation. Charts of the stratigraphic subdivision of the Mesozoic and Paleogene deposits are similar to those used in earlier reports (*Livšic et al. 1963, 1964*). Newly acquired data in favour of an unconformity at the base of the Jurassic (Lias phosphate-bearing conglomerates) and the Paleogene are presented. In particular, the lower part of the lower formation of coal-bearing sandstone yielded the first remains of pelecypods, allowing a precise age for the Early Paleogene to be determined as Thanetian (Late Paleocene). Referring to I.A.Korobkov, who identified pelecypods from the entire section, the authors suggest an Oligocene-Miocene age for the upper formation of coal-bearing sandstone.

A tectonic sketch map of western Nathorst Land shows: a western marginal fault zone, divided into subzones and incorporating extensive linear anticlines; and a central graben-like trough, composed of the Grønfjorden monocline (western slope) and a synclinal trough. Analysis of particular structural maps showed a general structural correlation for separate horizons and revealed minor structures in the synclinal trough. The internal structure of these major features is described in detail and illustrated by photographs and sketches.

Paleogene deposits, forming the western slope of the Forlandsundet graben-like trough, were studied in the Selvågen area on eastern Prins Karls Forland. A geological map, scale 1:50,000, and two lithostratigraphical sections of Paleogene rocks were constructed. Four formations, tentatively given an Eocene age, were recognized in the 1200 m thick section, as follows: Selvågen (30-130 m), Sesshøgda (115 m), Reinhardpynten (250 m), and at the top, Marchais (over 700 m) formations. The Selvågen Formation and the upper part of the Marchais Formation are dominated by conglomerates; the rest of the beds are intercalated mudstone, siltstone, and sandstone. Remains of flora, collected from the Sesshøgda Formation, tentatively suggest an Eocene age.

A 400 m thick lithostratigraphical section of Paleogene-Neogene(?) deposits was constructed in the Renardodden area on the south coast of Bellsund. The Skilvika (sand-silt-mudstone) and the Renardodden (essentially sandstone) formations were recognized. Thin coal beds occur throughout the section; the mudstone yields abundant remains of leaf flora and spore-pollen assemblages, allowing tentative allocation of both formations to Oligocene-Miocene time.

Hard coals from the lower coal-bearing sandstones and phosphorites from the "Lias conglomerate" are described as mineral resources in the west of Nathorst Land.

A special section deals with petroleum potential of the areas in question. Even though macrobitumen shows are absent and the Paleogene deposits show low dispersed bitumen content (up to 0.01%), western Nathorst Land is considered a sufficiently prospective area because of favorable structural conditions and by analogy with geologically similar areas north of the region in question. The Selvågen and Renardodden areas are considered unprospective.

PANOV, A.I., LIVŠIC, JU.JA. & KORČINSKAJA, M.V. 1966:

Outline of the geology of the Bohemanflya and Kapp Laila-Grønfjorden areas, Spitsbergen
[Geologičeskoe stroenie učastkov tundra Bohemana i mys Lajla - Gren-fiord (Is-fiord, o. Zapadnyj Špicbergen)]
Report on reconnaissance and structural studies in 1965
136 pages, 15 appendices, 25 illustrations, 4 tables, 28 references

The report presents results of systemmatic mapping and structural investigations, carried out in 1965 in Bohemanflya and on the south coast of Isfjorden (Grønfjorden and Kapp Laila areas). Geological and structural maps, scale 1:50,000, were compiled for all the localities surveyed.

The Bohemanflya area is made up of Upper Triassic and Jurassic - Lower Cretaceous deposits. Detailed stratigraphic descriptions of the Upper Triassic strata and new faunal collections allowed the recognition of Carnian and Norian stages; their composite thickness is up to 700 m, i.e. it far exceeds thicknesses of the Upper Triassic elsewhere on Spitsbergen. Jurassic sediments start with the Callovian siltstone-mudstone sequence, unconformably overlying the Upper Triassic sandstone. The Upper Jurassic-Lower Cretaceous deposits (including Aptian beds) are 820 m in thickness.

Structural investigations showed that Bohemanflya represents an asymmetric anticline trending approx. N-S, located at the north end of the West-Spitsbergen trough; the axial zone of the trough is situated near the east coast of Bohemanflya. The central anticline limbs are complicated by minor folds. A major fault, along which the eastern block is downthrown by 400-500 m, is associated with the axial zone of the central anticline.

At the localities on the south coast of Isfjorden, preference was given to structural observations since the stratigraphy and lithology of the Mesozoic and Paleogene deposits, had been described in some detail in earlier reports.

The Grønfjorden area is located in the eastern part of the Western marginal fault zone where the subzone of "major thrusts" (on the west) and the subzone of the "linear folds", hidden for the most part under water in Grønfjorden, had previously been recognized.

The Kapp Laila area is located near the axial part of the Central graben-like trough at the junction of the Iradalen depression and the Kapp Laila swell. A structural map of the area clearly shows the northwestern trend of the Kapp Laila swell along the top of the Eocene green sandstone formation; the Kapp Laila swell dome has 400 m elevation over the axial part of the Iradalen depression.

No radically new data are presented on coal and bitumen contents, or on reservoir properties of the rocks of the areas under study. The Kapp Laila swell, the Grønfjorden and the Bohemanflya anticlines are considered promising for hydrocarbon accumulations.

PANOV, A.I. & NEPOMILUEV, V.F. 1967:

Outline of the geology of the Agardhbukta-Sassendalen area
[Geologičeskoe stroenie učastka Agard-buhta - Sassendalen]
Report on reconnaissance and structural studies in 1966
95 pages, 7 appendices, 16 illustrations, 6 tables, 10 references

The report gives results of systemmatic mapping and structural observations in the Sassendalen-Agardhbukta area on eastern Spitsbergen.

Upper Permian to Aptian strata (inclusive) strata are described. The Upper Permian is composed of siliceous rocks of the Selander Formation (220-235 m). Unconformably overlying this are Triassic deposits (740 m), divided into series only.

Phosphatic nodules are characteristic of the Middle Triassic beds. An increase in number and thickness of sandstone units is noted in the Upper Triassic sediments. The Lias conglomerate, saturated with numerous phosphatic nodules, lies at the base of the Jurassic-Hauterivian mudstone sequence. The upper section is represented by a sandstone unit (100 m), divided into the Barremian and the Aptian stages by remains of flora and ammonites.

The geology and the petrography of dolerites forming sills in the Triassic and Jurassic rocks, are outlined.

The area under study is located within the Sassendalen monocline, recognized by Livšic (1965), and the western margin of the East Spitsbergen uplift. A structural map along the top of the Middle Triassic shows: some approx. N-S and north-east-trending anticlines and synclines, complicating the Sassendalen monocline; the approx. N-S Roslagenfjellet anticline is adjacent to the regional Lomfjorden-Agardhbukta fault; and a western fault scarp at the contact with the Eastern marginal fault zone.

A positive conclusion concerning the petroleum potential of the area was drawn from favourable structural and tectonic conditions and general geological prerequisites. In the area under study, the beds showing increased bitumen content, lie near the erosional surface and good granular reservoirs are lacking in the section. The report also provides data on shows of hard coal in the Upper Triassic and Barremian beds and phosphates in the Middle Triassic and in the Jurassic basal bed.

PANOV, A.I., NEPOMILUEV, V.F., KORČINSKAJA, M.V. & MOKIN, JU.I. 1968:

Geological study in eastern Nordenskiöld Land (Kjellströmdalen, Danzigdalen and Agardhdalen areas)
[Geologičeskie issledovanija v vostočnoj časti Zemli Nordenšel'da (rajony K'ellstremdalen, Dancigdalen i Agarddalen)]
Report on reconnaissance, structural and lithostratigraphical studies in 1967
170 pages, 11 appendices, 23 illustrations, 12 tables, 32 references

The report presents results of geological mapping, structural observations, and lithostratigraphical studies in eastern Nordenskiöld Land (Kjellströmdalen area, southeastern coast of Van Keulenfjorden, Agardhdalen). Geological and structural (for four beds) maps of the first two localities were compiled at a scale of 1:100,000.

The Kjellströmdalen area is composed of Mesozoic deposits (T_3-K_1), divided into series and stages. A contact between the Lower Cretaceous siltstone and the Paleocene formation of lower coal-bearing sandstone is described. The Agardhfjellet and the Tronfjellet anticlines and the Upper Reindalen and the Lundströmdalen synclines, with axial planes up to 25 km in length, are recognized.

Eocene-Oligocene deposits, up to 1200 m thick, are described formation-by-formation on the coast of Van Mijenfjorden. The Langlidalen anticline and the Lundgrenfjellet syncline are recognized along the top of the "green sandstone formation" (Eocene in age).

Triassic strata (454 m), divided into Induan, Olenekian, Anisian, Ladinian, and Carnian stages, are described in detail in the Agardhdalen area; the stages are divided into horizons using lithology and paleontological assemblages. Separate sections of the report deal with biostratigraphy of the stratigraphic subdivision of the Triassic rocks and monographic description of twelve species of ammonoids.

Bitumen content and reservoir properties of the section are taken from the previous reports. All the structures with positive relief, recognized in the areas in question, are considered prospective in a hydrocarbon context.

Three nearby coal seams, 0.4-0.8 m high, were found in Barremian deposits in the Kjellströmdalen area. Coal beds (each 2.3 m in working height) are described in the lower coal-bearing sandstone of the Paleogene formation.

PANOV, A.I. & NEPOMILUEV, V.F. 1969:

Geological study in eastern Nordenskiöld Land and western Heer Land (upper reaches of Adventdalen-Rindersbukta)

[Geologičeskie issledovanija v vostočnoj časti Zemli Nordenšel'da i zapadnoj časti Zemli Heera (verhov'ja Adventdalen - Rinders-buhta)]

Report on fieldwork in 1968

95 pages, 5 appendices, 17 illustrations,1 table, 15 references

The report presents results of geological mapping and structural observations in eastern Nordenskiöld Land (upper reaches of Adventdalen-Reindalen) and in western De Geer Land (Rindersbukta area). Geological and structural maps along the base of the Barremian Stage were compiled at a scale of 1:100,000. Ten marker beds are recognized in about 2000 m of section; partial and complete structural maps were compiled using correlation of marker beds.

Both areas are located at the junction of the West-Spitsbergen trough and the Sassendalen monocline. The Mesozoic deposits are divided into series and stages; their description is supplemented by new collections of paleontological remains. As in previous studies, the Paleogene deposits are divided into formations, after Livšic (1967), they are named in ascending order the Barentsburg, Colesbukta, Grumant, Frysjaodden, Collinderodden, and Storvola formations.

In spite of the presence of a regional break at the Triassic/Jurassic and the Cretaceous/Paleogene boundaries, structural lineaments are practically the same for both horizons. The approx. N-S Agardhfjellet and the Tronfjellet anticlines, recognized by Panov et al. (*1968*), are traced along the base of the Barremian Stage in the structural map.

Under the heading "Mineral resources", the area is considered prospective in a hydrocarbon context, using data from previous studies (1963-1967); hard coal shows are described in the Barremian and the Paleogene.

PANOV, A.I., LIVŠIC, JU.JA., MOKIN, JU.I. & MURAŠOV, L.G. 1970:

Geological study in northern Nordenskiöld Land and western Sabine Land (south coast of Sassenfjorden and Tempelfjorden)

[Geologičeskie issledovanija v severnoj časti Zemli Nordenšel'da i zapadnoj časti Zemli Sabine (južnye poberež'ja Sassen-fiorda i Tempel'-fiorda)]

Report on reconnaissance and structural studies in 1969.

99 pages, 3 appendices, 21 illustrations, 4 tables, 21 references

The report contains data obtained from geological mapping and structural investigations south of Sassenfjorden and Tempelfjorden. Geological and structural (along the top of the Upper Permian) maps,

scale 1:100,000, were compiled; five marker beds, namely, the base and the top of the Upper Permian, the top of the Upper Triassic, the base of the Barremian, and the base of the Paleogene were used.

The lower part of the section under study is built up of a Middle-Upper Carboniferous carbonate sequence (200-250 m), yielding abundant foraminifera no older than Bashkirian in age. The Permian consists of a Lower Permian carbonate (350-360 m) and an Upper Permian clay-carbonate sequence (310-360 m). The Triassic, represented by all three series, rests unconformably upon the Upper Permian (740 m) and is unconformably overlain by the "Lias conglomerate" (Jurassic). Undifferentiated Jurassic-Lower Cretaceous silty-mudstone strata are about 300 m thick. The overlying Lower Cretaceous sandstone (up to 500 m) is divided into stages (including Albian); three nearby coal seams, 1.5 m in height, were found in the Barremian Stage. The Paleogene is divided into five formations; two are assigned to the Paleocene, and the three upper formations are placed in the Eocene.

Tectonically the area under study is situated between the West-Spitsbergen trough and the Sassendalen monocline; the report provides new data on the structure of the Eastern marginal fault zone, separating these major structures.

Data on bitumen content and reservoir features are given separately for each system. The authors came to the conclusion that the structural position of the area in the major fault zone reduces its hydrocarbon potential.

POZDEEV, V.S., KERBIC, V.K. & LIVŠIC, JU.JA. 1964:

Efficiency of a superficial seismic survey using reflection shooting on Spitsbergen

[Effektivnost' nazemnyh sejsmorazvedočnyh rabot metodom otražennyh voln v central'noj časti Zapadnogo Špicbergena]

Report on experimental methods of seismic survey in central Spitsbergen in 1963

107 pages, 14 appendices, 12 illustrations, 1 table, 20 references

The report presents results of experimental seismic profiling in central Spitsbergen in 1963. The main goals of the work were: investigation into seismograms made onshore and development of the technique of reflection shooting on Spitsbergen, as well as clarification of the structural relations for various horizons of sedimentary cover within the Kapp Laila structure.

The profiling was carried out along the south coast of Isfjorden (3 profiles, total length 28.3 km) and along the north coast of Van Mijenfjorden (2 profiles, 21.9 km). Underwater and hole shots (in the Kapp Laila area) were made; geophones were arranged on the beach. Fieldwork techniques and interpretation of the seismic data obtained were described in detail.

Seismic data from the section are as follows:

- the section displays high effective velocity (up to 4200 m/sec at a depth of about 2.5 km);
- up to eight reflecting horizons were recognized in the Cenozoic - Upper Paleozoic sedimentary cover;
- a complicated wave pattern, observed on all the profiles, is mainly determined by numerous faults;
- a low-velocity zone is practically absent because of permafrost.

Three tentative reflecting horizons were distinguished in the Mesozoic and three in the Upper Paleozoic deposits on the seismic profile along the south coast of Isfjorden; crests of all the tentative horizons point to the presence of the Kapp Laila dome at a depth down to at least 3 km. The profile along the north coast of Van Mijenfjorden shows seven tentative reflecting horizons and one marker; the latter is probably related to the top of the Aptian (Early Cretaceous) Stage.

The report is supplemented with composite structural maps constructed along the base of the Lower Coal-Bearing Sandstone Formation of (Isfjorden) and along the base of the Upper Mudstone Formation (Van Mijenfjorden); the maps are from the report of Livšic et al. (*1963*).

POZDEEV, V.S. & LIVŠIC, JU.JA. 1965:

Results of superficial seismic profiling in central Spitsbergen

[Rezul'taty provedenija nazemnyh sejsmorazvedočnyh nabljudenij v central'noj časti ostrova Zapadnyj Špicbergen v 1964 godu] 114 pages, 20 appendices, 12 illustrations, 25 references

The report gives results of seismic reflection observations at three localities in Nordenskiöld Land, namely, Reindalen (four profiles, total length 45.4 km), south coast of Isfjorden (two profiles, 13 km), and north coast of Van Mijenfjorden (one profile, 12.6 km). The report presents detailed description of original seismic data from the localities, determines their quality, and describes the interpretation technique.

The Section entitled "Results of work" concerns the seismic character of the area and describes seismic profiles obtained. The earlier conclusion (*Pozdeev et al. 1964*) about the complicated seismic conditions was supported; record quality deterioration was noted in the valleys, coinciding, as a rule, with faults. Velocity characteristics allow the subdivision of the whole of the seismically surveyed sedimentary complex into two parts with a boundary drawn roughly at a depth of 1100 m. Up to ten reflections were recorded on seismograms. The most persistent reflections were traced in 0.5-0.6 and 1.0-1.1 sec intervals at the Reindalen locality.

Seismic profiling conducted in the area confirmed the existence of local positive structures for the deep-seated horizons in the areas of the Kapp Laila dome, Reindalen swell, Grønfjorden anticline. A deep prospecting well was advised in the roof part of the Kapp Laila dome, outside the zone of faults.

<table>
<tr><td colspan="2" rowspan="2">Reports</td><td rowspan="2">MAJOR & NAGY 1972</td><td rowspan="2">LIVŠIC 1967</td><td colspan="5">Symbols of the sections from reports 1-8 (see Fig. 11)</td><td rowspan="2">LIVŠIC 1965</td><td rowspan="2">NATHORST 1910</td></tr>
<tr><td>3-8</td><td>1, 2</td><td>1</td><td>2</td><td>3</td><td>4,6</td><td>7,8</td></tr>
<tr><td>OLIGO -CENE</td><td rowspan="3">E O C E N E</td><td>Aspelin-toppen Fm.</td><td>Storvola Fm.</td><td>Pg22</td><td>Pgc2</td><td>Pg3-N1?</td><td>Pg3</td><td>Pg3st</td><td colspan="2">Upper Coal-bearing sandstone</td></tr>
<tr><td rowspan="3">E O C E N E</td><td>Battfjellet Fm.</td><td>Collinder-odden Fm.</td><td></td><td>Pgb2</td><td>Pgb 2-3</td><td>Pgb 2-3</td><td>Pg 2-3cl</td><td>Upper Tran-sitional Fm.</td><td>Flaggy Sandstone</td></tr>
<tr><td>Gilson-ryggen Fm.</td><td>Frysjaodden Fm.</td><td>Pg12</td><td>Pga2</td><td>Pga 2-3</td><td>Pga 2-3</td><td>Pg 2-3fr</td><td>Upper Ar-gillite Fm</td><td>Upper Black Shale</td></tr>
<tr><td rowspan="3">P A L E O C E N E</td><td rowspan="2">Sarkofagen Fm.</td><td>Hollendar-dalen Fm.</td><td rowspan="2">Pg31</td><td rowspan="2">Pgc1</td><td>Pgb2</td><td>Pgb2</td><td rowspan="2">Pg2 gr</td><td>Lower Tran-sitional Fm.</td><td>Green Sandstone</td></tr>
<tr><td rowspan="3">P A L E O C E N E</td><td>Grumant Fm.</td><td>Pga2</td><td>Pga2</td><td colspan="2">Green Sandstone Fm.</td></tr>
<tr><td>Basilika Fm.</td><td>Colesbukta Fm.</td><td>Pg21</td><td>Pgb1</td><td>Pgb1</td><td>Pgb1</td><td>Pg1 cl</td><td>Lower Ar-gillite Fm.</td><td>Lower Dark Shale</td></tr>
<tr><td>Firkanten Fm.</td><td>Barentsburg Fm.</td><td>Pg11</td><td>Pga1</td><td>Pga1</td><td>Pga1</td><td>Pg1 br</td><td colspan="2">Lower Coal-Bearing Sandstone</td></tr>
</table>

Table 3: Correlation of Paleogene stratigraphical nomenclature of Spitsbergen.

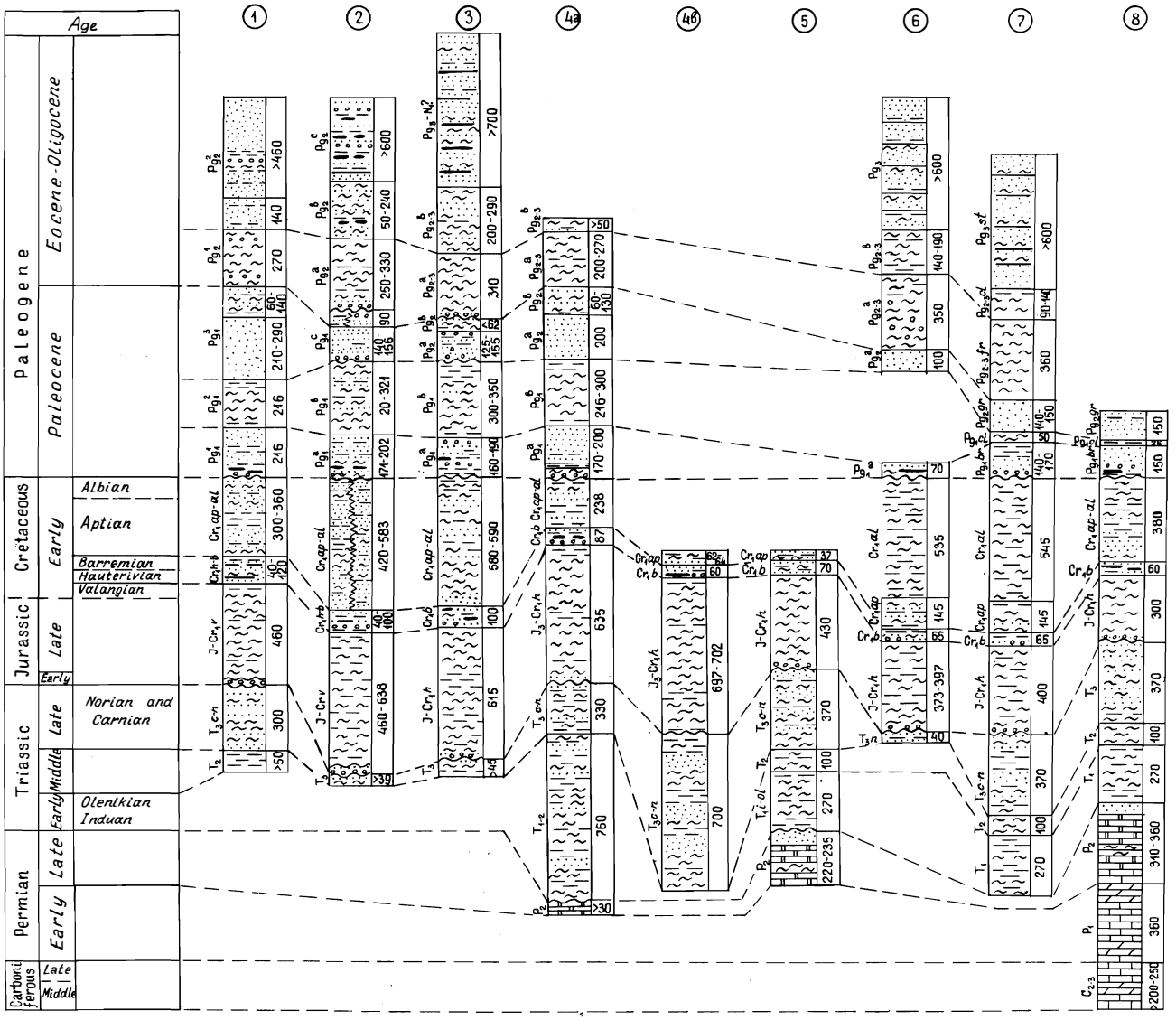


Fig. 11: Correlation of composite stratigraphic sections, accompanying geological maps from reports of 1963-1970 outlined in Fig.10 (see also Tables 3 and 4). For legend see Fig. 8.

Type of analyses	1	2	3	4	5	6	7	8
Fluorimetric-capillary analysis	231	674	161	90	45	92		89
Organic matter determination	65	12	63	27	25	92		65
Porosity determination	66	261	123	79	23			35
Permeability determination	25	20	9		6			34
Proximate analysis of coals	2	3	3	6		4		3
Spectral semiquantitative analysis of coal ash	30	16	21	44		16	10	

Table 4: Analytical studies in geological mapping of the West-Spitsbergen Trough. **1:** Livšic, Panov & Mariengof 1963; **2:** Livšic & Panov 1964; **3:** Livšic & Panov 1965; **4:** Panov, Livšic & Korčinskaja 1966; **5:** Panov & Nepomiluev 1967; **6:** Panov et al. 1968; **7:** Panov & Nepomiluev 1969; **8:** Panov et al. 1970

4.5. The Geology of Bjørnøya

The fundamental work of Horn & Orvin (1928) was followed by a long break until biostratigraphical work was resumed by British and German geologists in the 1960s. At the same time the island was repeatedly visited by geologists of the Research Institute of Arctic Geology (NIIGA, Leningrad, Russia) for reconnaissance work. In 1970, an areal geological map of Bjørnøya, scale 1:50,000, was made (*Krasil'ščikov et al. 1971*) and the main results were published in an article on the tectonics of the island (Krasil'ščikov & Livšic 1974). Other articles deal with the stratigraphy of the Upper Precambrian (Krasil'ščikov & Mil'štejn 1975) and the Triassic (Pčelina 1972) rocks. In 1979, magnetic profiling was carried out on the island (*Piskarev & Rahin 1981*) and in 1978, the coal potential was studied (*Pavlov & Evdokimova 1981*).

KRASIL'ŠČIKOV, A.A., LIVŠIC, JU.JA., MOKIN, JU.I., & PČELINA, T.M. 1971:

Outline of the geology of Bjørnøya
[Geologičeskoe stroenie ostrova Medvežij]
Report on fieldwork in 1969-1970
192 pages, 7 appendices, 38 illustrations, 6 tables, 29 references

The report presents detailed description of the geological structure of the island, accompanied by: (1) a geological map, scale 1:50,000 (Fig. 12), with sections; (2) a composite stratigraphic column (Fig. 13); and (3) numerous individual sections of stratigraphic units.

Late Precambrian microphytolite assemblages were studied by V.E.Mil'štejn (Krasil'ščikov & Mil'štejn 1975). A section of Ordovician deposits was compiled by V.I.Bondarev and Ė.M.Krasikov; and Ordovician fauna identified by V.I.Bondarev and L.V.Nehoroševa (bryozoans) and Z.V.Balašov (nautiloids). Devonian and Lower Carboniferous flora were examined by N.M.Petrosjan; Carboniferous foraminifera were studied by M.F.Solov'eva, and pelecypoda by V.A.Muromceva. Carboniferous and Permian brachiopoda and bryozoans were identified by V.I.Ustrickij and I.P.Morozova, respectively; Permian pelecypoda were identified by O.V.Lobanova. All Triassic fauna were examined by M.V.Korčinskaja.

Stratigraphy

Much of the island is made up of Middle to Upper Paleozoic deposits; Upper Precambrian and Ordovician rocks outcrop at its south end only; a Triassic sequence has been preserved at the top of Miseryfjellet. A composite section, about 3000 m thick, is divided into formations, most names for which are proposed for the first time. Stratigraphic charts, made by previous researchers, are compared (Fig. 14).

The Upper Precambrian rocks incorporate the Russehamna Formation (in excess of 500 m) and the Sørhamna Formation (115-125 m). The Russehamna Formation, mostly dolomitic, is subdivided into five units; two upper units (about 200 m) are markedly rich in sandy material (up to 40%). Microphytolites, found throughout the section, form late Riphean and late Riphean-Vendian assemblages (Krasil'ščikov & Mil'štejn 1975). The type section of the Sørhamna Formation is described in Røedvika[10], where the lower mudstone and the upper sandstone-siltstone members are recognized. No fossils have been found in the formation and a Vendian age is tentatively assumed, although the Russehamna and the Sørhamna formations are believed to be separated by a stratigraphic unconformity.

[10] The name "Røedvika" has already been used by Cutbill & Challinor (1965) for the Upper Devonian coal measures.

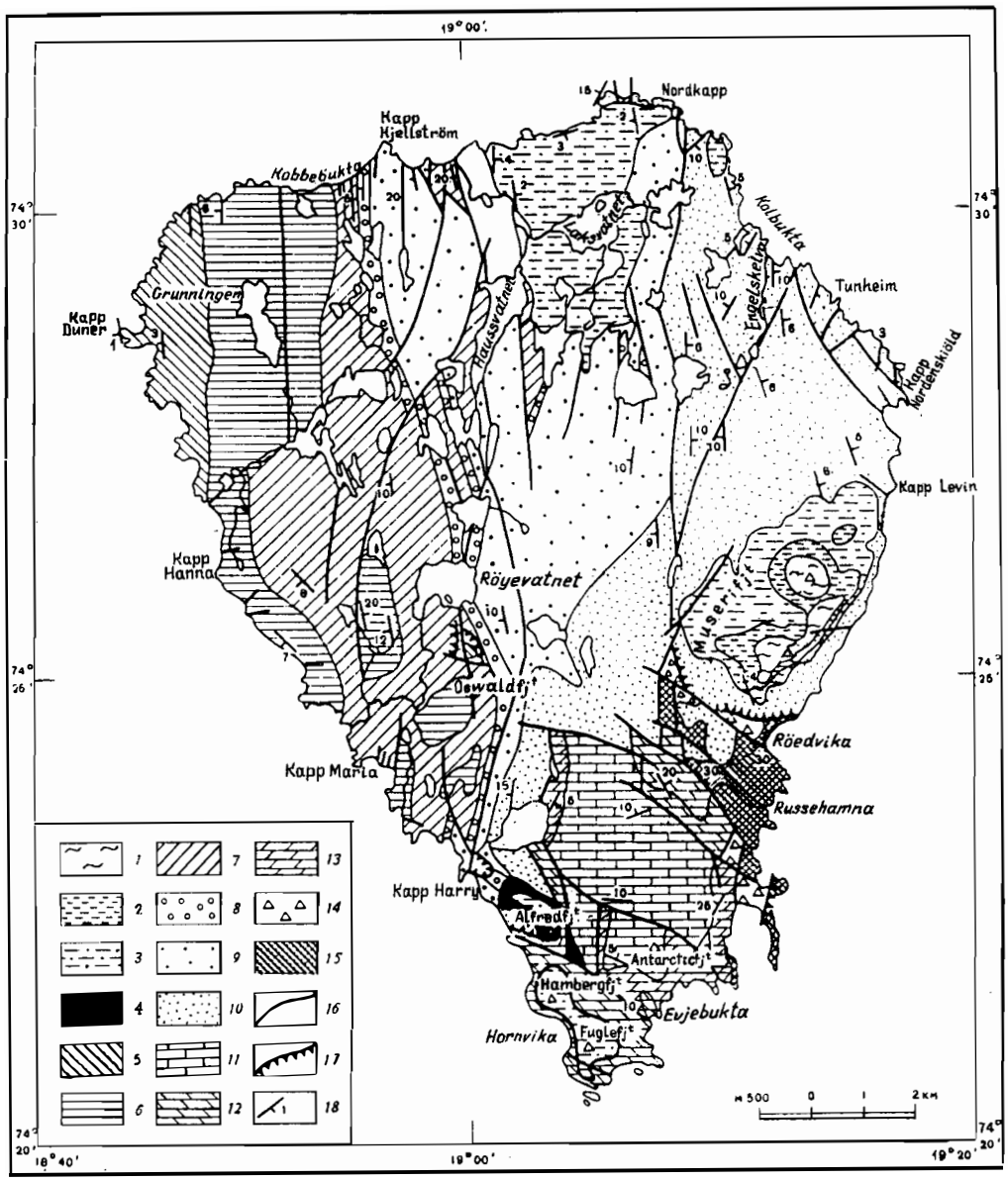
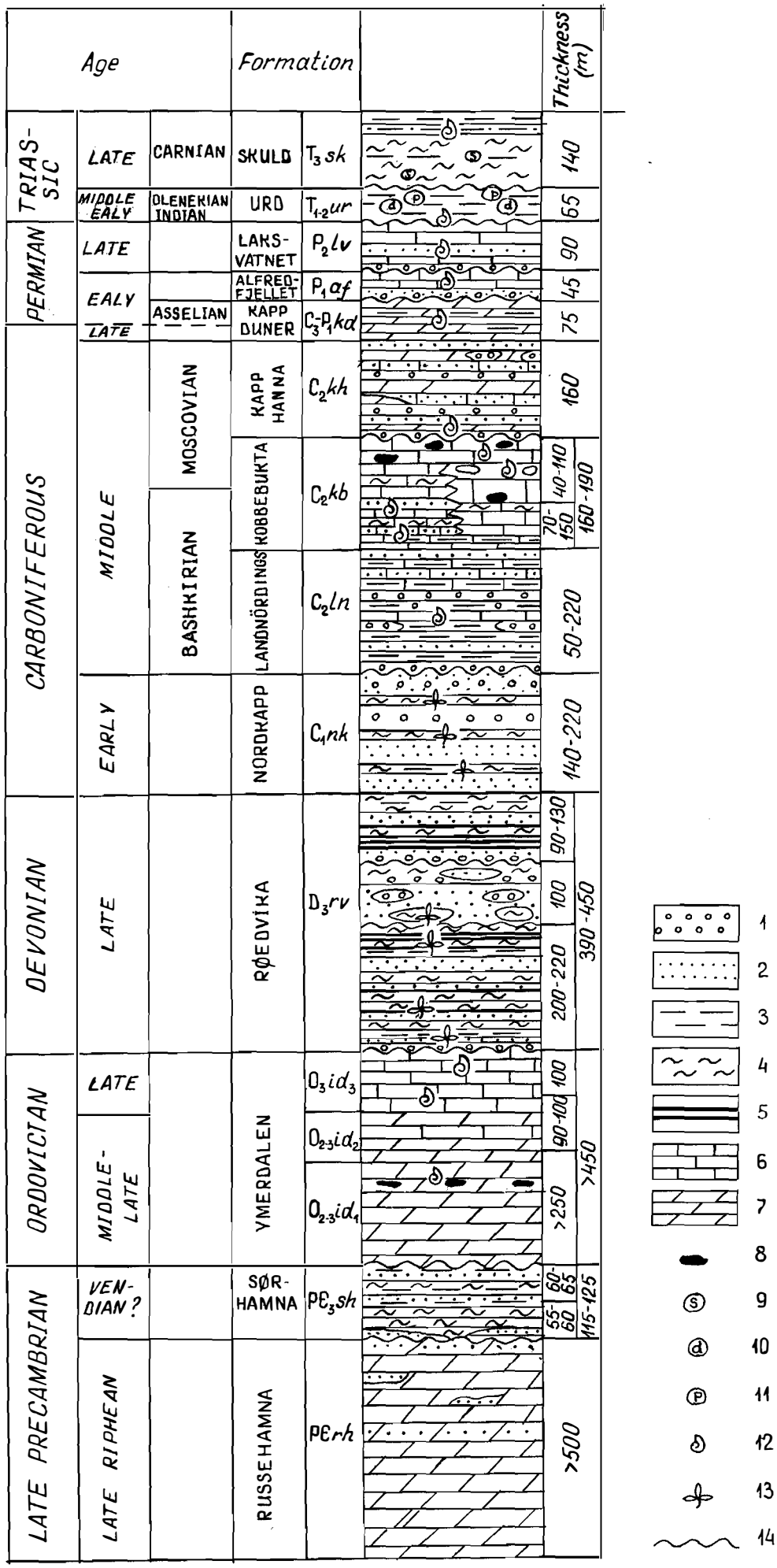


Fig. 12: Geological map of Bjørnøya.
1 Upper Triassic, Skuld Fm.; **2** Lower-Middle Triassic undivided, Urd Fm.; **3** Upper Permian, Laksvatnet Fm.; **4** Lower Permian, Alfredfjellet Fm.; **5** Upper Carboniferous-Lower Permian undivided, Kapp Dunér Fm.; ***6-8*** *Middle Carboniferous:* **6** Kapp Hanna Fm.; **7** Kobbebukta Fm.; **8** Landnørdingsvika Fm.; **9** Lower Carboniferous, Nordkapp Fm.; **10** Upper Devonian, Røedvika Fm.; ***11-13*** *Ordovician Ymerdalen Fm.:* **11** Upper Ordovician, upper member (subformation); **12** Middle-Upper Ordovician, middle member (subformation); **13** Middle-Upper Ordovician, lower member (subformation); ***14-15*** *Upper Precambrian:* **14** Sørhamna Fm.; **15** Russehamna Fm.; **16** fault; **17** thrust; **18** bedding plane

Ordovician deposits forming the Ymerdalen Formation, 450 m thick, make up Antarcticfjellet. All the observed contacts with Precambrian rocks are tectonic. Various horizons of the formation are overlain by Permian deposits with insignificant angular unconformity. The formation is subdivided into the dolomitic (lower), the transitional (middle), and the limestone (upper) members, each roughly equal in

Fig. 13 (opposite page): Composite stratigraphic section of Bjørnøya.
1 conglomerate; **2** sandstone; **3** siltstone; **4** mudstone; **5** coal; **6** limestone; **7** dolomite; **8** lenses of siliceous rock; ***9-10*** *concretions:* **9** siderite, **10** dolomite, **11** phosphorite; **12** fossils; **13** plants; **14** unconformable boundary


Age
Formation
Thickness (m)
TRIAS-SIC
PERMIAN
CARBONIFEROUS
DEVONIAN
ORDOVICIAN
LATE PRECAMBRIAN
LATE
MIDDLE EALY
EALY
LATE
EARLY
MIDDLE-LATE
LATE RIPHEAN
VEN-DIAN?
CARNIAN
OLENEKIAN INDIAN
ASSELIAN
MOSCOVIAN
BASHKIRIAN
SKULD
URD
LAKS-VATNET
ALFRED-FJELLET
KAPP DUNER
KAPP HANNA
KOBBEBUKTA
LANDNØRDINGS
NORDKAPP
RØEDVIKA
YMERDALEN
SØR-HAMNA
RUSSEHAMNA
$T_3 sk$
$T_{1-2} ur$
$P_2 lv$
$P_1 af$
C_3-$P_1 kd$
$C_2 kh$
$C_2 kb$
$C_2 ln$
$C_1 nk$
$D_3 rv$
$O_3 id_3$
$O_{2-3} id_2$
$O_{2-3} id_1$
$PE_3 sh$
$PE rh$
140
65
90
45
75
160
40-110
70-150
160-190
50-220
140-220
90-130
100
200-220
390-450
100
90-100
>250
>450
60-65
55-60
115-125
>500
1
2
3
4
5
6
7
8
9
10
11
12
13
14

thickness. The lower member yielded fragments of bryozoans of "no older than Middle Ordovician age". The upper member contains remains of bryozoans, unidentifiable tabulate corals, and an assemblage of nautiloids, characteristic of the Late Ordovician Period.

The Devonian System is represented by the Upper Devonian only, corresponding to the Røedvika coal measures (Cutbill & Challinor 1965). The section is made up of intercalated conglomerates, sandstones, mudstones, and coals, showing cyclic sedimentation of lagoonal-continental type. Following Horn & Orvin (1928), the formation is divided into three members: lower coal-bearing member (200-220 m) with conglomerates at the base; middle sandstone (100 m), and upper coal-bearing (90-130 m) members. Drilling logs, presented by Horn & Orvin (1928), were used in the report to describe the members. Numerous remains of flora were collected throughout the section, however, the authors give a Late Devonian age to the Røedvika Formation until the collection is studied monographically.

The Carboniferous System is represented by three series. Lower Carboniferous clastic deposits, integrated into the Nordkapp Formation by Cutbill & Challinor (1965), are lithologically related to the Upper Devonian Røedvika Formation. They also contain coal and show a lagoonal-continental cyclic sedimentation. The Nordkapp Formation, reaching thicknesses of about 140-220 m and thinning northward, is divided into three units. The lower (115-150 m) and the upper (20-65 m) units are essentially composed of quartz-sandstone. The thin (up to 10 m) middle unit contains a 0.8-2.05 m coal seam. Plant remains suggest an Early Carboniferous age for the formation; this is fully consistent with an early Tournaisian to late Visean age of spore and pollen assemblages, according to Playford (1962) and Kaiser (1970).

SYSTEM	HORN & ORVIN, 1928	CUTBILL & CHALLINOR, 1965		WORSLEY & EDWARDS, 1976			KRASIL'ŠČIKOV, LIVŠIC & PČELINA, KRASIL'ŠČIKOV & LIVŠIC, 1974 1971			PERIOD	
	Series		Stage	Stage	Formations		Formations		Stage		
Triassic	Shales and sandstones with Miophoria		Carnian				Skuld		Carnian	L	Triassic
							Urd		Olenikian	M	
									Induan	E	
Permian	Spirifer Limestone		Kungurian	Kungurian	Miseryfjellet		Laksvatnet			L	Permian
	Cora Limestone		Artinskian	Sakmarian	Hambergfjellet		Alfredfjellet			E	
	Fusulina Limestone		Orenburgian Asselian	Orenburgian	Kapp Dunér		Kapp Dunér		Asselian	L	
Carboniferous	Yellow Sandstone		Gzelian		Kapp Hanna		Kapp Hanna		Moscovian	M	Carboniferous
	Ambigua Limestone		Moscovian	Moscovian	Kapp Kåre		Kobbebukta		Bashkirian		
	Red Conglomerate				Landnørdingsvika		Landnørdingsvika				
	Ursa Sandstone	Nordkapp	Namurian	Visean	Nordkapp		Nordkapp			E	
		Røedvika	Visean	Tournaisian	Røed-vika	Tunheim	Røed-vika	upper		L	Devo-nian
			Tournaisian	?		Kapp Levin		middle			
				Famennian(D)		Vesalstranda		lower			
Ordovi-cian	Tetradium Limestone						Ymer-bukta	upper		L	Ordovi-cian
	Younger Dolomite							middle		L_+	
								lower		M	
Ordovician Cambrian (Ozarkian)	Slate-Quartzite						Sør-hamna	upper	Vendian ?	Late Proterozoic	
	Older Dolomite						Russehamna	lower	Late Riphean		

Fig. 14: Correlation of stratigraphic nomenclature of Bjørnøya.

The Middle Carboniferous is represented by the following formations: Landnørdingsvika, Kobbebukta, and Kapp Hanna (the names are proposed for the first time).

The Landnørdingsvika Formation rests unconformably on the Lower Carboniferous Nordkapp sandstone. The formation, with conglomerates at the base, is a rhythmic alternation of red siltstone and minor sandstone and conglomerate. From the variation in rock type and colour, the formation is divided

into five units in the type section (Landnørdingsvika); the units reach 220 m in aggregate thickness, which reduces to 50 m in the north. Abundant foraminifera and pelecypod remains were found in the middle part of the formation (unit 3) for the first time. According to M.F.Solov'eva (foraminifera) and V.A.Muromceva (pelecypoda), the faunal assemblages are most characteristic of the late Early Carboniferous. However, the authors of the report give a Middle Carboniferous age to the Landnørdingsvika Formation by analogy with the Bashkirian variegated conglomerate sequence of Spitsbergen.

The Kobbebukta Formation rests conformably, locally with gradual transition, upon the upper sandstone-siltstone unit of the Landnordings Formation. The Kobbebukta Formation, comprised mostly of limestone, is divided into two members. The lower member (70-150 m) is noted for its variegated colour, a large amount of clastic beds and disordered rhythmic units. The upper member (40-110 m) is made up of grey massive limestone with bands and inclusions of siliceous rocks. Because of local variation in thickness of the members, the thickness of the Kobbebukta Formation remains approximately the same, 160-190 m. Abundant remains of brachiopoda, pelecypoda and foraminifera were collected over the section. Relying on comparison of the faunal assemblages, the authors of the report assign the lower and the upper members to Bashkirian and Moscovian ages, respectively.

The Kapp Hanna Formation rests unconformably, and with conglomerates at the base, on different horizons of the Kobbebukta Formation. The entire section exhibits a variable rhythmic alternation of variegated conglomerates, quartzitic and calcareous sandstones, and thin-platy dolomites. The sedimentology of the formation was studied in detail in cliffs of the west coast of the island where the authors recognized seven units, composing three cycles, totalling 160 m in thickness. Brachiopods and foraminifera, found in carbonate layers of the lower unit for the first time, give a Moscovian (Middle Carboniferous) age.

The Kapp Hanna Formation is conformably overlain by undifferentiated Upper Carboniferous to Lower Permian carbonate deposits, recognized as the Kapp Dunér Formation, 75 m thick. It occurs in the extreme west of the island. The formation is built up of dolomites with rare layers of bioaccumulated limestone and dolomitic siltstone. The limestone yielded brachiopods of wide stratigraphic range and Asselian (Lower Permian) foraminifera.

The Lower and Upper Permian are represented by two formations, namely, the Alfredfjellet and the Laksvatnet formations, respectively.

The Alfredfjellet Formation is mainly developed in the mountains of the southwestern end of the island where it rests with an angular unconformity on Ordovician, Upper Devonian and Lower to Middle Carboniferous deposits. The type section (Alfredfjellet) contains three units, 45 m in total thickness. The lower unit is made up of basal conglomerates with layers of sandstone. The two upper units are limestones containing Lower Permian brachiopods; the upper unit contains a great deal of silty material.

The Laksvatnet Formation (90 m) is found resting with an angular unconformity on the underlying deposits at three separate sites: in the Laksvatnet area in the north of the island, on the Miseryfjellet slopes, and at the tops of the mountains in the south of the island. The formation is mainly composed of biogenic limestone; a unit of massive quartzitic sandstone (14-18 m) was found in the middle part only. Brachiopods and pelecypoda, collected over the section, belong to the Late Permian; they can be clearly correlated with the faunal assemblage of the Starostin Formation[11] on Spitsbergen.

The Triassic includes deposits from three series which form the upper part of Miseryfjellet.

The Lower and Middle Triassic, both recognized for the first time on the island, form the Urd Formation, 60 m thick. The strata are intercalated clayey siltstone and mudstone with thin layers and concretions of argillaceous dolomites. The lower 20 m is tentatively assigned to the Induan stage. The upper 40 m is made up of siltstone and dolomite, containing bitumen and yielding Olenekian ammonites. The uppermost horizon of the formation, 20 cm thick, consists of phosphatic-sand nodules, typical of all Middle Triassic sections of Spitsbergen.

[11] Formation name according to Burov et al. (1965); corresponds to lower members of the Kapp Starostin Formation (Cutbill & Challinor 1965) [Norsk Polarinstitutt]

The Skuld Formation rests with stratigraphic unconformity on the underlying deposits. It is divided into the lower mudstone unit (118 m) and the upper siltstone unit (22 m). Ironstone concretions are spread throughout the section. Carnian pelecypoda and ammonites were found in the concretions and separate siltstone layers.

The Quaternary contains thin Holocene layers only, including marine, lacustrine, alluvial, deluvial, and organogenic deposits. The latter are represented by peat bogs (1-2 m) at the tops of Fuglefjellet and Hambergfjellet.

Tectonics

The present structure of the island is regarded by the authors as the northern part of a pericline, the core of which protrudes in an inlier at the south end of the island. The authors recognize three structural terrains, separated by distinct unconformities, namely, the Upper Precambrian - Lower Paleozoic, the Upper Devonian - Lower Permian (Asselian), and the Lower Permian (Artinskian?) - Triassic terrains.

The lower terrain, forming the 'arch' of the uplift, is divided into the Upper Precambrian and the Ordovician structural divisions. Later on, Krasil'ščikov & Livšic (1974) considered the divisions as separate structural terrains. The Upper Precambrian formations of the "lower division" form a monocline, dipping north-eastward at 20-30°; it is dissected by northeast-trending faults. The Ordovician formations of the upper division form a gently sloping trough, opening to the north. On the margins, dip increases from 0-3° at the south end of the island to 10-20° at Russelva.

The Late Devonian - Early Permian terrain forms a thick nappe, thrust from the north over the formations of the lower terrain. It is composed of two cycles and tentatively divided into two structural divisions along the unconformity at the base of the second cycle (base of the Kapp Hanna Formation) within Moscovian rocks. An approx. N-S trend of all the structural features is characteristic. The Bjørnøya anticline and the Kapp Dunér trough, are major structures. The anticline, made up of the formations of the lower structural division, is dissected by a major fault along the axial zone; it is asymmetric in structure. The Framnes and the Kapp Forsberg depressions, separated by the Engelskelva arch, are recognized, respectively, in the east and west of a more gently sloping (up to 5-6°) eastern limb. The downthrown western limb is complicated by narrow (up to 1 km) grabens and noted for steeper dip (8-15°) of the rocks. The formations of the upper structural division make up the Kapp Dunér trough and the smaller superimposed depression in the center of the island. These gently sloping structures are complicated by narrow (up to 200 m) anticlines and synclines with 10-12° dip angles.

The Lower Permian - Triassic structural terrain is developed in the east of the island where its structure is described in the Laksvatnet area and on Miseryfjellet. At the first site, it is a gently sloping N-S depression, opening northward. A structural nose with an axis gently plunging north-eastward is located in Miseryfjellet.

Displacement of the island results from three fault systems, namely, the oldest northwestern, the northeastern, and an approx. N-S orientated system. Thrusts, mapped in the south, are associated with movements which predated the formation of the Permian-Triassic terrain. At the end of the chapter, the authors consider some problems of the structural interpretation of the island.

The tectonics of Bjørnøya were later discussed by Krasil'ščikov & Livšic (1974) in an article in which the information from the report was analysed again, refined and supplemented with general regional constructions for the western Barents Shelf.

Mineral resources

In this chapter, the authors consider at some length petroleum potential and describe coal and vein barite-sulfide mineralization.

A description of galena occurrences in the south-east of the island in the Russehamna area is based on data from Horn & Orvin (1928) and Flood (1969). Crystals of Iceland spar, up to 1.5 cm^3 in size, were first found in the calcite-barite veins.

As was previously known (Horn & Orvin 1928), the commercial coal potential of the island is associated with the upper member of the Upper Devonian Røedvika Formation. Three seams, 0.6-1.4 m thick, were mined at the Tunheim deposit between 1916-1925. The authors of the report were the first to study petrographically twelve coal samples (taken by I.N.Drozdova) which are divided into six petrographic types from vitrinite content. Giving results of proximate analysis of four coal samples from different sites of the island and noting their difference from the results of Horn & Orvin (1928), the authors tentatively classify the coals as gas, transitional, and fat coals.

Special studies of the coal potential of Bjørnøya were carried out by Pavlov & Evdokimova in 1978 and concluded in 1981 (this report is reviewed in detail later, and only a brief summary is given here with relevance to Bjørnøya). Detailed description of the section allowed them to subdivide the Upper Devonian Røedvika Formation into five members, named after the localities. In the authors' view, the second, Misery (80 m) and fourth, Tunheim (20-50 m) members contain commercial coal. Petrographical study showed that coals of the Misery Member are clarain for the most part, but locally they are entirely represented by vitrinite; clarodurain and durain varieties are more common in the Tunheim Member. 30 reflectance analyses permitted most of coals to be classified as coking coals. Pavlov & Evdokimova made comparative analysis of the results, obtained by the earlier authors (Horn & Orvin 1928; Krasil'ščikov et al. 1971), and new data of chemical proximate examination of coals (chemical composition, ash composition, concentrating). They estimated probable coal reserves at $26.8 \cdot 10^6$ tons on Bjørnøya. A complete abstract of the report, prepared by Pavlov & Evdokimova (1981), is given in the Section entitled "Mineral Resources" in this volume.

Petroleum Potential

This Section includes description of bitumen and reservoir properties of the entire section and discussion of tectonic criteria and recommendations for further studies.

Generalized data from bitumen studies, made in NIIGA laboratories, are given in Table 5 from which it is evident that the entire section is characterized by low bitumen "A" (up to 0.8%) and organic carbon. Anomalously high concentrations of organic carbon were found in two samples of Upper Devonian mudstone (20.7% and 54%) and in one sample of Lower Carboniferous sandstone (25.5%); the authors consider these to be the result of enrichment in coal crumbs from adjacent coal seams. Nevertheless, ultimate analysis of two samples of argillo-carbonate rocks from the Lower Triassic Urd Formation showed the presence of petroleum bitumen in them.

32 determinations of open porosity and 14 determinations of permeability were made for the Upper Devonian - Lower Carboniferous strata. The results obtained suggest the lack of good granular reservoirs. However, the section contains units of sandstones having thicknesses up to a few tens of metres; porosity factors up to 10%; and high permeability in places; these factors, combined with intense fracturing of the rocks, suggest local porous fractured reservoirs.

The authors note a number of favourable tectonic criteria for petroleum potential which they recommend could be used for extrapolation onto the surrounding shelf. Seismic profiling along an approx. E-W line, combined with gravity and magnetic measurements and bottom sampling, should be carried out there first.

PISKAREV, A.L. & RAHIN, V.A. 1981:

Magnetic and petrophysical investigations on Bjørnøya
[Magnitometričeskie i petrofizičeskie issledovanija na ostrove Medvežij]
Report on fieldwork in 1980
32 pages, 1 appendix, 6 illustrations, 3 tables, 4 references

The report presents results of magnetic profiling (150 kilometres in length) and petrophysical investigations (531 samples) on Bjørnøya. Mean profile spacing is 1 km; measuring interval along a

profile 50 m; survey accuracy 25 m; survey error 10 nT. Profiling resulted in the construction of: a map of anomalous magnetic field patterns, scale 1:25,000; an isoline sketch map, scale 1:100,000. The techniques of profiling, variation observations, and construction of the resultant maps are detailed in the report.

The anomalous magnetic field is quiet, being predominantly negative (up to -20 nT) in the north-west of the island and positive (up to +20 nT) in the east and south-east. The authors relate a main approx. N-S positive anomaly in the Miseryfjellet area to a deep fault, bounding the anomaly on the west. Rare local anomalies (over 50 nT), recorded in the central and north-eastern parts of the island, are probably caused by hypothetical "ore zones".

Petrophysical investigations included density and magnetic susceptibility determinations. The section contains four density intervals, corresponding to alternating carbonate and clastic successions, namely, 2.67-2.78 g/cm^3 density for Upper Precambrian-Ordovician carbonate rocks; 2.41-2.43 g/cm^3 for Upper Devonian-Lower Carboniferous clastic rocks; 2.57-2.71 g/cm^3 for Middle Carboniferous-Permian carbonate rocks; and 2.35-2.40 g/cm^3 for Triassic clastic rocks.

Magnetic susceptibility of most rocks under study is less than 1 x 10^{-6} SI. Magnetic susceptibility of the seritized mudstone of the Upper Precambrian Sørhamna Formation is as high as 2.5 x 10^{-6} SI. Some samples of mineralized rocks in Devonian conglomerates and in Ordovician deposits show essential magnetic susceptibility (10-35 x 10^{-6} SI).

Lithostratigraphic complexes	No. of samples	Concentration (%)	
		organic carbon	bitumen "A"
Late Precambrian			
carbonate	6	1.76-5.80	< 0.01
clastic	6	0.15-0.66	< 0.01
Ordovician			
carbonate	4	4.00-6.01	< 0.01
Late Devonian - Early Carboniferous			
clastic	73	0.14-1.50	< 0.80
Middle Carboniferous - Permian			
carbonate	88	0.02-2.13	< 0.02
Triassic			
(clastic)	31	0.12-1.40	0.01-0.08

Table 5: Investigation of bitumen from the sedimentary complexes of Bjørnøya.

5. MAGMATISM

The present section contains reviews of generalized or specialized reports on the magmatism of Spitsbergen, although all the reports on separate areas of the archipelago usually contain chapters concerning the description of igneous rocks. For instance, Burov & Murašov (*1965*) were the first Russian geologists to describe the volcano Sverrefjellet in the otherwise mainly Devonian report. Young plateau-basalts and monchiquite dykes were first described in Andrée Land by Burov et al. (*1974*). Abundant descriptions of Mesozoic dolerites of Edgeøya and Barentsøya were given by Klubov (*1963*) and Klubov & Vasil'ev (*1964*). In summary reports compiled by Kovaleva & Burov (*1981*), Abakumov et al. (*1984*), the authors used geological and analytical data from previous reports, concerning both Precambrian igneous and ultrametamorphic complexes and platform magmatism. The last report in this chapter (*Evdokimov 1991*) is the monographic summary on the Quaternary volcanic rocks of the Bockfjorden area.

The classification of igneous rocks used by the authors is based on the "formational principles" (rock assemblages, associations), defined by the Russian school of petrologists (Kuznecov 1964).

TEBEN'KOV, A.M. 1980:

Late Precambrian magmatism in Svalbard
[Pozdnedokembrijskij magmatizm Sval'barda]
Project report based on fieldwork in 1976-1979
174 pages, 82 illustrations, 15 tables, 68 references

The investigations carried out allowed igneous complexes, localized in particular tectonic structures, to be recognized in the Precambrian rocks of the archipelago. A geological sketch map of the typical terrain, and the chemical composition of the main types of igneous rocks present, are given for each complex.

Magmatism of spilite-diabase (practically pervasive) and closely related basalt-trachyandesite (in the Chamberlindalen area) rock association was ascertained on the west coast of Spitsbergen, noted for the eugeosynclinal Riphean section. Magmatism of the gabbro-diorite-plagiogranite rock association, a plutonic equivalent of the effusive spilite-diabase rock association, occurs at the junction of the geosynclinal trough with an ancient basement block in the upper reaches of Revdalen.

Basalt-andesite-liparite magmatism (Botniahalvøya, Rijpdalen area) is shown on the west margin of the ancient Barents platform, whose relics are represented by a pre-Riphean basement inlier. Gabbro-diorite complexes of Storøya and Kapp Laura are probable plutonic equivalents of effusive magmatism on Nordaustlandet.

Bulk chemistry analysis of 117 samples led the author to the conclusion that tholeiitic magma was parental material for rocks of the spilite-diabase association and earlier phases of the gabbro-diorite and gabbro-diorite-plagiogranite associations. Formation of diorite, quartz-diorite, plagiogranite and a wide suite of rocks of the basalt-trachyandesite association was caused by migration of magma chambers to upper structural levels and assimilation of the continental type crustal material by the magma. The relation with deeper magma chambers is undisputed for ultrabasic rocks of some of the associations.

The author correlates the rock associations recognized with early Riphean igneous rock associations flanking the North Atlantic region. In particular, the volcano-sedimentary rocks of the nunatak area of Petermanns Bjerg in Eastern Greenland are probable equivalents of the spilite-diabase rock associations of the west coast of Spitsbergen. Uriconian volcanic associations, such as the effusives of Mona and Pembrokeshire fall into the same type. Following Krasil'ščikov (1973), the quartz porphyry of Botniahalvøya, Nordaustlandet, is correlated with the Dala quartz porphyry in the sub-Jotnian of Sweden. This points to a similar tectonic-magmatic evolution of the entire North Atlantic region in Late Precambrian time.

BUROV, JU.P. & LATUŠKIN, G.O. 1963:

Results of the study of dolerite intrusions in central and eastern Svalbard
[Rezul'taty izučenija intruzij doleritov v central'noj i vostočnoj časti arhipelaga Špicbergen]
Report on fieldwork in 1962
165 pages, 10 appendices, 50 illustrations, 2 tables, 37 references

The report presents results of geological, petrographical and analytical (bulk chemistry) investigations and prospecting, carried out in 1962 in the Mesozoic dolerite terrain at five localities on the archipelago, namely, southern Dickson Land (Kapp Thordsen area), east coast of Lomfjorden (Kapp Fanshawe area), Wahlbergøya in Hinlopenstretet, Kapp Mühry area in the east of Spitsbergen, and the northern end of Barentsøya. Using comprehensive analysis of findings of previous studies, the authors give geological details of all the localities, accompanied by geological sketch maps, scale 1:100,000.

Most of the intrusive bodies under study are sills of quartz- and quartz-bearing dolerites with thicknesses varying from 10-20 m to 100-150 m. In the east of Spitsbergen, schlieren and beds of pegmatoid gabbro-dolerite were found in thick dolerite intrusions. Thin dykes of microdolerite, occur at all the localities, connecting different levels of the sills.

Bulk chemistry analysis of 14 samples and petrographic rock studies indicate that dolerites at all the localities are represented by undifferentiated intrusions. The pegmatoid gabbro-dolerites of the upper parts of the intrusions of the eastern archipelago are the same composition as the rest of the rocks, and differ only in setting. As previous studies have shown the authors determined the age of dolerite emplacement to be Cretaceous-Paleogene on the basis of general geological setting.

In the course of field investigations, prospecting, which included hard rock sampling (497 specimens) and Quaternary sediment sampling (600), panning (150), and hydrochemical sampling (10), was performed at each locality. The investigations resulted in finding some sites showing unprospective sulfide mineralization. The bulk of the sulfides are hydrothermal-metasomatic in origin; they are localized in fault zones or at the contact of dolerites and host rocks and are related to the post-magmatic stage of intrusive emplacement.

BUROV, JU.P. & MURAŠOV, L.G. 1964:

Trachybasalts in Bockfjorden, undifferentiated dolerite intrusions and Permian deposits on the southwest coast of Nordaustlandet and poorly differentiated intrusions on Barentsøya
[Trahibasal'ty Bok-fiorda, nedifferencirovannye intruzii doleritov i permskie otloženija jugo-zapadnogo poberež'ja Severo-Vostočnoj Zemli i slabo differencirovannye intruzii ostrova Barenca]
Report on fieldwork in 1963
191 pages, 9 appendices, 47 illustrations, 28 tables, 30 references

General data on the geological structure of the west coast of Bockfjorden, southwest coast of Nordaustlandet, and northwestern Barentsøya were obtained.

Ancient (Proterozoic?) metamorphic rocks and associated granitoids, Devonian sedimentary rocks, Quaternary deposits, and trachybasalt flows forming the volcano Sverrefjellet, form the west coast of Bockfjorden. The volcano is located on the post-Devonian regional north-west-trending fault.

The volcano is made up of trachybasalt flows, mainly differing in styles of jointing, dominated by spherulitic, radiating and prismatic jointing. Separate trachybasalt flows do not differ from each other in chemistry and mineralogy. They are porphyritic rocks, showing intersertal, tholeiitic, and trachytic textures, and are composed of fine grained clinopyroxene, plagioclase, olivine, alkalic volcanic glass, and magnetite. Phenocrysts are represented by olivine, enstatite, clinopyroxene and, rarely, plagioclase and spinel. Large fragments of these minerals and quartz, probably suggesting the presence of foreign material in the basalt, also occur. In addition to fragments of individual minerals, the trachybasalt contains inclusions of peridotites, accounting for 5-70% of rock volume. They are composed of olivine,

enstatite, chrome-diopside, and spinel. The inclusions show greenish-grey colour, coarsely crystalline structure and hypidiomorphic-granular texture.

The geological and petrological study of the trachybasalts and enclosed peridotites led the authors to the conclusion that the peridotites are xenoliths of ultrabasic rocks. The Bockfjorden regional fault could provide a route for rising undifferentiated magma carrying fragments of ultrabasic rocks. On the basis of geomorphological analysis of the Bockfjorden area, by Hoel & Holtedahl (1911) and the results of investigations in 1963, the authors concluded a Riss-Würm age for the volcano Sverrefjellet.

On Nordaustlandet, Permian strata on the north coast of Palanderbukta and Selanderneset, intruded by dolerite, were investigated; dolerite outcrops were observed along the south coast of Wahlenbergfjorden and the east coast of Hinlopenstretet. Without dwelling on the problems of stratigraphy in the review, it should be noted only that the authors were the first to recognize the Upper Permian Selander Formation, characteristic of the deposits on eastern Spitsbergen.

The intrusion of dolerites in Wahlenbergfjorden is similar to other undifferentiated Mesozoic intrusions of the archipelago and is made up of olivine- and quartz-bearing varieties. Thicker bodies on Barentsøya are noted for the presence of porphyritic leucocratic gabbro-dolerites in the central parts of the intrusions. Petrochemical data, as a whole, equate to dolerites elsewhere in Svalbard.

Prospecting revealed ten small 'economically non-viable' shows of sulfide mineralization. Results of panning (60), trace element analysis of dolerites (100) and sediments (205) are given.

KOVALEVA, G.A. & BUROV, JU.P. 1981:

Mesozoic and Cenozoic complexes of basic rocks in the northern Barents Shelf
[Bazitovye kompleksy mezozojsko-kajnozojskogo vozrasta severnoj časti Barencevomorskoj provincii]
Report on the project, 1979-1981
147 pages, 5 illustrations, 8 tables, 74 references

The Svalbard structural zone, representing a long-lived center of basic magmatism, is recognised as comparable with other centers of magmatic activity in the Atlantic, namely, Iceland and the Azores. In comparison with Svalbard, Franz Josef Land (FJL) is a lower-order structure. Evolution of basic magmatism of both archipelagos in Mesozoic-Cenozoic time is considered; comparison with basalts of the British-Arctic and the Norwegian-Greenland provinces, Siberia, and Taimyr is made. Complexes of Mesozoic trap-, Paleogene plateau-basaltic, and Quaternary rift-originated rock associations were found in the basic rocks of the northern flanking regions of the Barents Sea.

The trap rock association is represented by intrusive and effusive facies. The former occurs in Svalbard and FJL and probably in the platform beneath the Barents Sea basin. Intrusive bodies of typical traps form, as a rule, thick sills or, less commonly, small dykes of dolerites, cutting through the Proterozoic to Cretaceous host rocks. Petrographically, quartz- and olivine-dolerites, gabbro-dolerites and, in rare cases, pegmatoid gabbro-dolerites were found. Petrochemically (21 analyses of the rocks of FJL and 20 analyses of the dolerites of Svalbard), they equate to rocks of the classic undifferentiated or weakly differentiated tholeiitic series.

Effusive equivalents of the Mesozoic trap association, occurring on Kong Karls Land and pervasive in Franz Jozef Land, show wider compositional variations; they are represented by basalt, trachybasalt, trachyandesite-basalt and, less commonly, andesite. Petrochemically (two analyses of effusives from Kong Karls Land and 52 analyses of basalts from Franz Josef Land), they are similar to their plutonic equivalents and equate mainly to quartz- and, rarely, olivine-tholeiites.

Paleogene plateau-basalts, locally occurring in northern Svalbard, are represented by lava sheets and flows (up to 260 m), lying on the subhorizontal surface of the Late Cretaceous(?) peneplain. In norm (27 analyses), the rock equates to olivine-basalt and resembles the basalts of the British Isles and, to a lesser degree, Iceland.

Occurrence of Quaternary alkali-basalt magmatism on northwestern Spitsbergen is associated with rifting in the North Atlantic. Most study was given by the authors to the volcano Sverrefjellet in the

Bockfjorden area, the partly denudated pile of which is formed by lava flows of alkali basalts with abundant plutonic inclusions of peridotites. Chemically, the basalts equate to typical alkali varieties (7 analyses) and are most consistent with the lavas of Jan Mayen Island. The authors concluded that the evolution of magmatism in the Svalbard structural zone proceeded as follows: reducing amount of activity; decreasing volumes of magma produced; a change in the type of magmatism from quartz-tholeiitic in the Mesozoic to olivine-tholeiitic in the Paleogene and alkali-basaltic in the Quaternary Period.

ABAKUMOV, S.S., KOVALEVA, G.A. & TEBEN'KOV, A.M. 1984:

Magmatism of Svalbard
[Magmatizm Špicbergena]
Report on the project, based on the data obtained in fieldwork in 1981-1984
305 pages, 1 appendix, 108 illustrations, 77 tables, 166 references

The report is a first generalization of the magmatism of Spitsbergen, based on many years of observations by the authors, and using all the data, published by Russian and non-Russian scientists.

The studies carried out led to recognition of about twenty igneous rock associations, characterizing four main tectonomagmatic stages of the development of Spitsbergen, namely, the Early Proterozoic, the Late Proterozoic, the Caledonian, and the epi-Caledonian (Table 6). The lateral distribution of igneous rock associations on the present erosional surface is shown on a map, scale 1:1,000,000, compiled on a tectonic base. The structural-geological position of known different-age igneous rock complexes was determined; petrographical, petrochemical, and metallogenic characteristics of the rocks were given.

The Early Proterozoic magmatism of Spitsbergen is represented by spilite-keratophyre and gabbro-diabase (ancient trap) rock associations. Complexes of the first type occur in the northern and the southern parts of western Ny Friesland; they are associated with a section, characteristic of eugeosynclinal troughs. Gabbro-diabase complexes were described in the north-west of Spitsbergen and in the east of Nordaustlandet, i.e. in the blocks which were tectonically more stable in Early Proterozoic time.

The Early Proterozoic stage of the development of Spitsbergen culminated in Karelian folding and metamorphism. Regional metamorphism and ultrametamorphism, superimposed on the predominantly Karelian basic complexes, predetermined the appearance of the migmatite-plagiogranite rock association. Migmatized plagio-gneisses and plagiogranites, belonging to this rock association, have been preserved as xenoliths in Late Proterozoic(?) and Caledonian granite-gneiss complexes.

The differences in the character of the Late Precambrian magmatism (*Teben'kov 1980*) is due to variation in the structures superimposed on the heterogeneous Early Proterozoic basement.

The igneous rock associations of the Riphean trough of the west coast of Spitsbergen, the spilite-diabase, basalt-trachyandesite, and gabbro-diorite-plagiogranite rock associations, are typical of initial eugeosynclinal stages of the development of geosynclines. Outcrops of the gabbro-peridotite rock association, related to deep faults, were found north of the geosynclinal trough on the Biskayer Peninsula.

Extensive effusive andesite-liparite and plutonic gabbro-diorite magmatism, took place on the margin of the ancient platform, represented by outcrops of the Lower Proterozoic granite-gneiss complex of Nordaustlandet; this activity was related to the geosyncline which developed on the west. On Nordaustlandet, the emplacement of a lower Riphean volcanosedimentary sequence of the rapakivi-granite intrusion may also have been related to this stage.

According to the authors, the development of the Riphean geosyncline of Spitsbergen culminated in folding, metamorphism, and inversion of the geosynclinal troughs. The authors related the granite-leucocratic rock association, incorporating normal granites (Rijpfjorden and Hornemantoppen intrusions) and granosyenites of Ny Friesland, to the inversion stage of the Baikalian cycle.

In the authors' view, only the migmatite-granite ultrametamorphic rock associations, widely represented by protrusions of the Karelian granite-gneiss basement, which are most consistent with the composition of granites (northwestern Spitsbergen, western Ny Friesland, Nordaustlandet), is correlated with the Caledonian epi-platform (?) epoch of folding and metamorphism.

The epi-Caledonian platform stage of the development of Spitsbergen incorporates six igneous rock associations, related to four episodes. The post-orogenic Devonian Period is characterised by insignificant outcrops of the porphyry (rhyolite) rock association in the Raudfjorden area. The Hercynian block movements on the platform are responsible for the Late Devonian(?)-Carboniferous lamprophyre rock association (western Andrée Land, central Nordaustlandet) and eruption of alkali basalt during Late Triassic time in central Spitsbergen.

The early Alpine history of the development of Spitsbergen is characterized by the wide manifestation of Jurassic to Cretaceous trap magmatism, predominantly its intrusive rock association. The late Alpine stage of the epi-platform orogeny was accompanied by the Neogene plateau-basalt rock association (in Andrée Land) and the Quaternary alkali-basalt rock association, represented by volcanics of the Woodfjorden area.

The authors believe that reliable geochronological dates would enable recognition of some more important tectonic-magmatic episodes, in particular, at the Early/Late Proterozoic boundary (1900-1650 Ma) and between early and middle Riphean time (1400-1200 Ma).

The last section of the report shows metallogenic details of the recognized igneous rock associations on the basis of analysis of geological and geochronological data. The spilite-diabase association and serpentinites of the east coast of Forlandsundet, and the basalt-trachyandesite rock association in Recherchefjorden, containing titanium-vanadium, copper-nickel, and lead-zinc mineralization, are recommended as promising targets for exploration of chrome, cobalt, and nickel.

A separate volume contains 50 tables, detailing the results of 565 bulk chemistry analyses of igneous rocks of Spitsbergen and their conversions to CIPW classification.

EVDOKIMOV, A.N., GERMANOV, E.V., DAŠEVSKAJA, D.M. & GENŠAFT, JU.S. 1991:

Cenozoic magmatism, hydrothermal activity and ore potential of Ekmanfjorden and Woodfjorden fault zone, Spitsbergen

[Kajnozojskij magmatizm, gidrotermal'naja dejatel'nost' i perspektivy rudonosnosti zony razlomov Ekman-fiord - Vud-fiord, ostrov Zapadnyj Špicbergen]

Report on the project, 1989-1991

186 pages, 3 appendices, 117 illustrations, 35 tables, 19 references

Quaternary eruptive phases are known to take place on northwestern Spitsbergen, where they were first described by Hoel & Holtedahl (1911). Volcanic edifices, pipes and dykes partly form some mountains, for instance, Sverrefjellet, Sigurdfjellet, and Halvdanpiggen. They are located in the junction zone of metamorphic basement rocks and Devonian clastic rocks. The volcanic products are made up of consolidated lavas of subalkali olivine basalt, and its tuff, breccia and pyroclastic facies. Of particular interest are numerous fragments of crustal and mantle rocks, represented by inclusions in basalt lavas.

The main sections of the report concern the geology, structural setting, lithology of Spitsbergen volcanics and, to a greater extent, plutonic xenoliths in them, and results of studies of active thermal springs, associated with the volcanoes.

Detailed distribution patterns of volcanic facies at individual localities, as well as geological sections and brief geomorphological descriptions, are given. Complete petrographical descriptions of volcanic facies, including the chemistry and composition of rocks, is provided. Evolution of basic magma in separate volcanoes is plotted on standard petrochemical diagrams. Comparison with older basic magmatic episodes in the region is made. An evolutionary time path of the magmatism from relatively primitive to depleted is established from the Mesozoic plateau-basalt rock association in Franz Josef Land and coeval intrusive facies on Spitsbergen, to the Paleogene sheet facies and Quaternary volcanic

Types of igneous rock associations				
meta-morphic	geosynclinal stages	young platforms	activization phase	tectonic-magmatic stages
		Plateau-basaltic (N)	Alkali-basaltic (Q)	Epi-Caledonian
			Alkali-basaltic (T3)	
		Trappean (J-K) a) intrusive b) extrusive	Lamprophyric (D3-C)	
Migmatite-granitic				Caledonian (Early Paleozoic)
	Granite-leuco-granitic of the inversional stage			
	Basalt-trachy-andesitic a) basic and acid effusives b) intrusions of gabbro-peridotites		Rapakivi-granites	Baikalian Grenvillian* (Late Proterozoic)
	Spilite-diabasic a) effusive b) intrusive		Andesite-liparitic a) effusive b) intrusive	
	Gabbro-diorite-plagio-granitic			
	Gabbro-peridotitic		Gabbro-dioritic	
	Serpentinites of uncertain rock association class			
Migmatite-plagio-granitic a) rheomorphic granites b) migmatites	Spillite-keratophyric a) acid tuff b) diabases Gabbro-diabasic			Karelian (Early Proterozoic)

Table 6: Igneous rock associations of Svalbard. (* Grenvillian ages were received post-1984.)

basalt of Spitsbergen. The alkalinity (Na) of the rocks increases in the same direction. New data on absolute age determinations of basalts are presented.

Studies of xenoliths of plutonic rocks and megacrysts were made from analysis of rocks, rock-forming and accessory minerals. The mechanism of formation of nodules and faceted forms of plutonic inclusions is shown; statistical data on the occurrence of xenoliths of certain composition and their morphology within three centers of volcanic activity are given. Analysis of rock fabrics suggests a considerable role of metasomatic and secondary processes in formation of the xenoliths. Bulk chemistry analyses, X-ray spectroscopy of olivine, ortho- and clinopyroxene, spinel, garnet, amphibole, titano-

magnetite, ilmenite, sulfide, mica, plagioclase, and carbonate are given. Natural geothermometers and geobarometers are considered separately; crystallization P and T are determined; and coexisting mineral pairs were used to estimate possible depths of formation.

Active thermal springs were studied; water temperatures in them were measured; their salt and microcomponent contents were determined; analyses of crystalline products of hydrothermal activity and analyses of spontaneous gases are given. Recurrent observations of springs suggest repeated subvolcanic hydrothermal activity.

Analysis of petrological and geophysical data on xenoliths of plutonic rocks and the enclosing volcanic basalts allowed construction of a rock model for the structure and evolution of the interior of northwestern Spitsbergen.

6. MINERAL OCCURRENCES

The chapter presents reviews of the reports on special surveys, carried out between 1979-1990 mainly along the west coast of Spitsbergen. In addition to geological mapping, it included a comprehensive study of ore mineralization and other kinds of raw mineral products. A report on the coal potential of Svalbard (*Pavlov & Evdokimova 1981*) is given at the end of the chapter.

TURČENKO, S.I., BARHATOV, D.B., SERGEEV, D.B. & BARMATENKOV, I.I. 1981:

Ore mineralization on Spitsbergen and Bjørnøya
[Metallíčeskie poleznye iskopaemye Špicbergena i ostrova Medveżij]
Report on fieldwork in 1989-1980
203 pages, 9 appendices, 39 illustrations, 21 tables, 51 references

The report presents results of the study between 1979-1981 of mineralization and geological structure of four localities, incorporating mineral occurrences in Svalbard. The work took place within the Precambrian terrains along the west coast of Spitsbergen at the following localities (from north to south): (1) Magdalenefjorden and Danskøya, (2) Nordenskiöld Land, (3) Recherchefjorden area, (4) north and south coast of Hornsund. In addition, the report gives a brief review of lead-barite occurrences on Bjørnøya.

A review of previous studies, and analyses of geological structure, based on structural observations, were made for all the localities; geological sketch maps were compiled.

Two types of mineralization incorporating skarns were discovered by the authors at locality 1: a) garnet-diopside skarns, containing iron and copper sulfide; b) epidote-hedenbergite skarns, containing magnetite, hematite, and chalcopyrite. The former are of mineralogical interest only, however, the latter can be classified with minor mineral occurrences.

In western Nordenskiöld Land (locality 2), the authors explored both known outcrops on Sinkholmen and at Kapp Mineral and similar lead and zinc occurrences first recognized in the northern part of the area under study. In addition, some iron and copper occurrences at the contacts of Precambrian complexes and Carboniferous deposits were described.

In the Recherchefjorden area (locality 3), the authors described: occurrences of ilmenite-magnetite- and sulfide copper-nickel ores in Chamberlindalen, associated with layered gabbro-peridotite bodies and an occurrence of magnetite at Magnethøgda.

On the north coast of Hornsund (locality 4), the authors found three types of quartz-carbonate veins, showing signs of essentially sulfide mineralization, associated with the Precambrian Isbjornhamna and Eimfjellet groups. On the south coast of Hornsund, the authors described occurrences of galena-sphalerite mineralization, localized in quartz-carbonate reefs in the zones of brecciation of carbonate deposits of the Riphean Höferpynten Formation.

All the studies were accompanied by geochemical sampling (1110) and petrographic study of rocks and ores (1870 thin sections). Statistical processing of analyses was made; maps, showing isolines of ore element contents, were compiled for some occurrences.

In conclusion, the authors consider the history of the tectonic evolution of Spitsbergen and recognize six lithotectonic complexes from Proterozoic to Recent time. On the basis of lithological and tectonic parametres, some complexes (first of all the Riphean geosynclinal complex) were indicated that deserved exploration for mineralization.

TURČENKO, S.I., BARHATOV, D.B., BUTOMO, N.I. & BARMATENKOV, I.I. 1984:

Geology and mineral occurrences of Spitsbergen
[Geologija i poleznye iskopaemye ostrova Zapadnyj Špicbergen]
Report on fieldwork in 1981-1983
253 pages, 5 appendices, 76 illustrations, 25 tables, 59 references

This work continued metallogenic studies, begun by the authors in 1979. The association of particular types of minerals with specific structural-formational complexes was established; geological sketch maps, scale 1:100,000, were compiled for the following localities: (1) Martinfjella in northern Wedel Jarlsberg Land, (2) western Oscar II Land from Isfjorden to Engelskbukta, (3) southwestern Ny Friesland, (4) the peninsula at Kapp Petermann. A geological description, accompanied by a review of earlier data, was given for each locality; problems of stratigraphy and tectonics were considered.

In the course of the work, 1500 thin sections were examined; 2810 geochemical samples were taken and analysed; some new mineral occurrences were found; a map, scale 1:1,000,000, and a catalogue (cadastre) of occurrences (numbering 83) of metallic, non-metallic and combustible minerals, studied up to 1984, were compiled.

Metal occurrences, studied to date on Spitsbergen, are divided by geochemical evidence into three groups, namely, siderophile, chalcophile and lithophile groups.

The siderophile group is represented by: (1) magmatogenic formations, such as skarn-iron formation (occurrences at Magnethøgda and Magdalenefjorden), iron-titanium-vanadium formation (in gabbroids of Ny Friesland and Chamberlindalen), copper-nickel formation (in peridotites of Chamberlindalen and in Jurassic-Cretaceous dolerites of Dickson Land), chromite formation (in ultrabasic rocks of Oscar II Land); (2) exogenic formations, such as goethite-hematite formation (in laterites of Oscar II Land), silicate-nickel formation (in serpentinites on Kaffiøyra and Sarsøyra); (3) vein siderite formation (Daudmannsøyra).

The chalcophile group consists of: (1) vein formations, such as barite-lead-zinc formation (Bjørnøya), lead-zinc formation (Revdalen, Andvika, Kapp Mineral, Kapp Petermann); (2) stratiform formations, such as zinc-chalcopyrite, lead-zinc carbonate formations (occurrences in western Nordenskiöld Land and Oscar II Land), bornite-chalcocite volcanogenic and chalcopyrite metamorphogenic formation (Bockfjorden); (3) metasomatic arsenic-nickel formation (St.Jonsfjorden).

The lithophile group consists of the magmatogenic-metasomatic rare-metal - rare-earth formation (in granitoids of Nordaustlandet and northwestern Spitsbergen).

Nonmetals are represented by occurrences of: gem material, namely, jasper (Sarsøyra) and rock crystal (Nordaustlandet, Kapp Petermann Peninsula); tremolite-asbestos (Recherchefjorden); muscovite (pegmatites of Biskayer Peninsula); phosphorite (Dickson Land); marble (Blomstrandhalvøya); and many gypsum occurrences.

In the report the above-mentioned occurrences were considered in association with particular structural-formational complexes, and some conclusions were drawn regarding the metal and nonmetal discovery potential of the complexes. Hydrocarbon shows, coal occurrences and mineral water springs, shown in the map and catalogue, were not treated in the report.

TEBEN'KOV, A.M., KORAGO, E.A., IL'IN, V.F., BUTOMO, N.I., KUBANSKIJ, A.P., HAJLOV, V.V., STARICYN, V.F., KARNOUŠENKO, E.P. & MILOSLAVSKIJ, M.JU. 1988:

Specialized geological-geophysical investigations of mineral occurrences on Spitsbergen
[Specializirovannye geologo-geofizičeskie raboty po izučeniju poleznyh iskopaemyh arhipelaga Špicbergen]
Report on fieldwork in 1986-1988
253 pages, 67 appendices, 37 illustrations, 41 tables, 65 references

The study was mainly aimed at the evaluation of known mineralization potential, and prospecting for other minerals in the central part of the west coast of Spitsbergen. The study included the following work: (1) an aerial geological survey and prospecting, scale 1:50,000, conducted in western Nordenskiöld Land, bounded by Grønfjorden on the east, was accompanied by a surface magnetic survey in the southern part only (scale 1:25,000), a hydrogeology survey, and radiometric observations; (2a) listwaenite outcrops in a narrow zone from Isfjorden in the south to Engelskbukta in the north, and (2b) Riphean-Vendian(?) aged black phyllite-like shales were studied and evaluated in terms of mineral potential and its genesis.

The work conducted in Nordenskiöld Land resulted in: the compilation of a geological map, scale 1:50,000; the study of known occurrences; and the discovery of new small mineral occurrences. Of the latter the greatest promise is held by phosphorites in Triassic deposits on the west coast of Grønfjorden and gypsum and coal in the Carboniferous-Permian sequence. Prospecting was accompanied by bottom sampling (400), geochemical (4080) and hydrochemical (40) sampling. The geochemical characteristics of individual rock types in western Nordenskiöld Land, and the distribution patterns of the most important ore elements (Pb, Zn, Cu and others) over the area are given.

A surface magnetic survey permitted the general structure of the complexes, overlain by loose sediments in the southern part of the locality, to be determined; and sites of hematite-magnetite mineralization in the Precambrian rocks to be located. The maps of magnetic anomaly graphs and isolines as well as interpretation charts were compiled.

The study of listwaenites on the west coast of Spitsbergen revealed their clearly-defined restriction to thrust zones and vertical faults along the contacts of the Precambrian and Lower Paleozoic complexes. The listwaenites were traced and studied through the outcrop from Motalafjella in the south to Engelsbukta in the north. It was found that they were formed as the result of metasomatism of basic and ultrabasic igneous rocks of the area. Typical listwaenites consist of quartz, carbonate and fuchsite; subordinate types are: serpentine, talc; iron, copper, nickel sulfide; magnetite, chromite, gold.

Minor occurrences of ore elements are related to the listwaenites; they include: lead-zinc quartz-vein associations, locally containing copper and silver; copper-nickel and magnetite-chromite associations. The last two types suggest listwaenite derivation from basic and ultrabasic rocks. The listwaenites also show high gold contents, which is generally typical of metasomatites of the listwaenite-beresite formation. Geochemical examination of the listwaenites (25 bulk chemistry analyses, over 100 core samples, 416 hand specimens) enabled the main element associations to be recognized; geochemical (statistical) parametres were given both for separate outcrops and to the listwaenites as a whole.

The study and evaluation of mineral potential was carried out for black phyllite-like shales in the Riphean-Vendian(?) deposits along the west coast of Spitsbergen. Targets, differing in stratigraphic position, were chosen as standards in the upper reaches of Dunderdalen, on the south coast of St. Jonsfjorden, and in the southern part of Sarsøyra. In the survey 100 trench samples, hand specimens to prepare thin sections; 368 samples for trace element analysis and 115 samples for C_{org} determination were taken.

Analysis of the data obtained revealed geological, mineralogical and geochemical differences for shales, differing in age and position in a section; basic geochemical (statistical) parametres were determined both for separate shale outcrops and the complex as a whole. It was found that the shales under study rank among unprospective coal-bearing formations rather than potentially metalliferous black shale or coal-bearing formations. Rare occurrences of iron and copper sulfide in the strata under study are localized in superimposed quartz-veins and are of little interest.

MAKAR'EV, A.A., HAJLOV, V.V., KARNOUŠENKO, E.P., KUBANSKIJ, A.P., SOROKIN, S.V., STARICYN, V.F., MAKAR'EVA, E.M. & AVETISOV, G.P. 1991:

Report on specialized geological-geophysical exploration, aimed at the study of geological structure and mineral occurrences of Spitsbergen in 1988-1991

[Otčët o specializirovannyh geologo-geofizičeskih rabotah po izučeniju geologičeskogo stroenija i poleznyh iskopaemyh arhipelaga Špicbergen v 1988-1991 godah]

228 pages, 2 text supplements of 110 and 19 pages, 19 appendices, 70 illustrations, 29 tables, 81 references

The report presents results of specialized geological-geophysical survey in Oscar II Land and James I Land.

The main aims of the survey were: (1) investigation of the geological structure of Oscar II Land and James I Land; (2) an evaluation of the discovery potential of metals, gems, phosphates and other minerals; (3) evaluation of the possibility of studying the Earth's deep crustal structure of Spitsbergen from waves caused by remote earthquakes.

The main techniques used to achieve these aims were: (1) geological survey, scale 1:100,000; (2) specialized structural-stratigraphic and metallogenic investigations; (3) surface magnetic survey, scale 1:25,000, of coastal plains in western Oscar II Land; (4) rock and geochemical sampling of primary and secondary aureoles, panning and other kinds of sampling; (5) - experimental earthquake studies with the use of "Čerepaha" ("Turtle") equipment along the northwestern coast of Isfjorden.

The surveys gave the following outcomes:

1. Geological map, scale 1:100,000, was compiled for Oscar II Land and James I Land.
2. Surface magnetic survey, scale 1:25,000, was conducted in western Oscar II Land (Kaffiøyra, Svartfjellstranda, Daudmannsøyra) over an area of 170 sq. km. High magnetic anomalies, caused by serpentinites (Kaffiøyra), Proterozoic metabasic rocks, and dykes of Mesozoic dolerites, were recorded at the above-mentioned localities.
3. Detailed sections of Riphean, Lower Paleozoic and Devonian deposits were constructed from results of specialized stratigraphic studies. The stratigraphic scheme for the Riphean rocks was revised. An essentially carbonate assemblage, occurring between the Vendian and Ordovician, was first recognized as a formation (Ankerfjellet), tentatively assigned to the Cambrian from recognition of microphytolites.
4. Differentiation of the Paleozoic (Devonian and Permian) and Mesozoic deposits was paleontologically confirmed for the first time for the area. Study of fish and ichthyoliths from the Lower Devonian deposits in James I Land provide the most important results of not only local but also regional significance.
5. Late Paleogene and Middle Quaternary erosional surfaces and weathering crusts were found in western Oscar II Land. The Middle Carboniferous erosion level, shown by a significant content of monazite, was recognized in the mountain glacier part of the area under study.
6. The results of geochemical examination of the bedrock (3600 samples) gave estimates of the distribution of index elements, which characterise all stratigraphic units and igneous complexes in the area, and hydrothermally altered rocks; most Paleozoic and Mesozoic deposits were found to show high mean content of copper, chromite, cobalt, and nickel, suggesting potential ore mineralization.
7. The occurrence of gold sulfide ores, as replacements, were found in the central part of the west coast of Oscar II Land. The mineral composition of the ores, high metal (primarily gold) content, and apparent gold size suggest a chance of discovering endogenic and exogenic gold occurrences in further prospecting.
8. Maps of: mineral occurrences; sites of rock and geochemical sampling (1582) and panning (462); and radiometric studies were compiled at scale 1:200,000 for the entire area under study; some areas were indicated as being worthy of further prospecting for various genetic types of chromite placers (Sarsøyra, Kaffiøyra, south coast of Brøggerhalvøya), gold and complex ores (from St.Jonsfjorden to Eidembukta).

Separate supplements to the report present:

- paleontological classification of Paleozoic and Mesozoic deposits;

- results of microphytolite examination of Upper Proterozoic and Paleozoic rocks;
- catalogue of occurrences of ore mineralization, geochemical anomalies and concentrate aureoles;
- results of determination of physical properties of rocks and heavy mineral composition, correlation charts and plots of factor loads.

In a brief report about the results of earthquake studies (by G.P.Avetisov and V.V.Vasil'ev) the authors confirmed the possibility of using the technique of exchange waves, caused by remote earthquakes, with the aid of the "Čerepaha" ("Turtle") system.

PAVLOV, A.V. & EVDOKIMOVA, N.K. 1981:

Coal-bearing deposits of Svalbard
[Uglenosnye otloženija arhipelaga Sval'bard]
Report on the project, 1976-1981
736 pages, 4 appendices, 64 illustrations, 114 tables, 276 references

The fossil coals of Spitsbergen are summarized and described in the report. The following are provided: a geological description of the archipelago and the history of exploration of coal-bearing areas; coal accumulation patterns; the grade and metamorphism of coals; an economic framework, accompanied by the recognition and description of five regions with 30 coal areas (Fig. 15), undiscovered coal resources, and possibilities for future development.

Coal is present in Devonian, Lower Carboniferous, Upper Triassic, Lower Cretaceous (Barremian), and Paleogene deposits. Phases of short-term coal accumulation were responsible for the small thickness of coal measures and a small number of coal seams. Two genetic types of coal-bearing deposits are ascertained. Deposits of the first type accumulated following a long break and deep erosion in a continental basin and culminated in marine transgression (Culm, Paleocene, Oligocene). The deposits of this type are workable. Deposits of the second type are represented by impersistent coal-bearing seams in purely marine sediments (Carnian, Barremian, and Eocene-Oligocene coals). Their accumulation began after sea shallowing and formation of coastal plains and ended, as in the first case, in sea invasion. Coals of this type occur in thin seams. Coal content of the main productive coal measures of Spitsbergen (Culm, Barremian, Paleocene) decreases from east and north-east to west and south-west. Oligocene economic coal-bearing deposits are known in the west only.

The coals of Spitsbergen are hard humic, mainly clarain, with a large predominance of vitrinized components. Devonian coals, composed of abundant miospores, and Upper Triassic coals, typified by the parenchyma type of gelified matter and containing abundant cuticles, are unusual. The Barentsburg deposit of Paleocene coals differ in the amount of reduction present. Oligocene coals of the Ny-Ålesund deposit are probably highly reduced.

Chemical processing properties of coals vary with age and metamorphic grade. Devonian coals have a peculiar chemical composition and are distinguished by a very high yield of volatile substances, increased hydrogen content, and a high yield of resin. In vitrinite reflectance and spore colour, the coals are either transitional from long-flame to gas, or gas. Culm coals of the Pyramiden deposit are gas, low- to medium ash, low-sulfur, low-phosphorus, changing into gas fat coals in the most subsided part of the deposit and on the east side of Billefjorden. Along the west coast of Spitsbergen, Culm coals are metamorphosed to coking, forge, and even meagre coals. On Bjørnøya, Culm coals are classed as coking and forge. Upper Triassic coals are probably gas coals; Barremian coals are gas fat, low- and high-ash, low-sulfur. Paleocene coals (Barentsburg, Grumant, Longyear deposits) are gas or, less commonly, gas fat, low- and medium-ash and low- and medium-sulfur; Oligocene coals (Ny-Ålesund) are gas, low- and medium-ash, differing in sulfur content, with high yield of resin. Spitsbergen is characterized by a relatively distinct zonal distribution of coals in metamorphic grade both across the area and over individual sections.

A high content of alumina is found in ash of Culm (up to 42%) and Barremian (up to 37%) coals; trace element composition of the ash of all coals of Spitsbergen is monotonous; element contents are close to clarkes; in places, higher concentrations of Ni, Pb, Mo and Zn only were determined.

The coals of Spitsbergen are usually regarded as energy resources. Thickness of a plastic layer of coals in some deposits (Pyramiden, Barentsburg) varies from 8 to 20 mm, and therefore the coals can be used as coking coals to prepare coke burden. Coals of the Ny-Ålesund deposit, characterized by an extremely high yield of low-temperature carbonization resin, can be considered as a valuable resource to produce liquid fuel and domestic gas. Following preparation, coals of Bjørnøya, tentatively classed with coking coals, can be used for producing metallurgical coke. Ash of coals of the Pyramiden deposit and Bjørnøya, noted for high Al_2O_3, can be used, after special processing, to produce alumina.

Probable coal reserves of Spitsbergen are estimated at 836 x 10^6 with 96% of them represented by gas or gas coking coals. 208 x 10^6 t, 138 x 10^6 t, and 490 x 10^6 t of coal reserves located in the Culm, Barremian, and Paleocene, respectively.

EVDOKIMOVA, N.K. 1984:

Composition and quality of coals of Spitsbergen
[Veščestvennyj sostav i kačestvo uglej ostrova Zapadnyj Špicbergen]
Report on the project, 1981-1984
144 pages, 1 appendix, 42 illustrations, 29 tables, 56 references

The report provides details of coal composition and grade in five Lower Carboniferous deposits and occurrences (Pyramiden, Wordiekammen, and Bünsow Land deposits; Struvefjella and Isfjorden occurrences) and in six Paleogene deposits and occurrences (Barentsburg, Grumantbyen, Berzeliusdalen, and Adventfjorden deposits; Festningen and Hedgehogfjellet occurrences).

The work is based on results of: petrographic description of the main groups of coal matter; calculation of microcomponents (210 determinations); measurements of vitrinite reflectance (117 determinations); proximate and element analyses (209 and 166, respectively); plastic range tests (86); determination of chemical composition of ash (70); and trace element analyses of ash (90).

Descriptions of separate deposits and occurrences include: general data on coal content; investigation of coal type, based on petrographic composition; chemical processing properties of coals with determination of their rank.

Lower Carboniferous and Lower Paleogene coals are humic. Lycopsids, selanginella, pteridosperma-phytes (in the Carboniferous) and plane-, yew-, cypress-, pine- and other trees (in the Paleogene) served as source material for the coals. Plant material accumulated in flooded peat bogs, which dried out and led to fusain formation. However a "Fire" origin of fusain components cannot be excluded. Lower Carboniferous coals vary in rank from gas and gas fat to fat, coking fat, and coking coals, whereas Paleogene coals change from long-flame to gas fat coals. The author relates these variations to the depth of coal-bearing deposits.

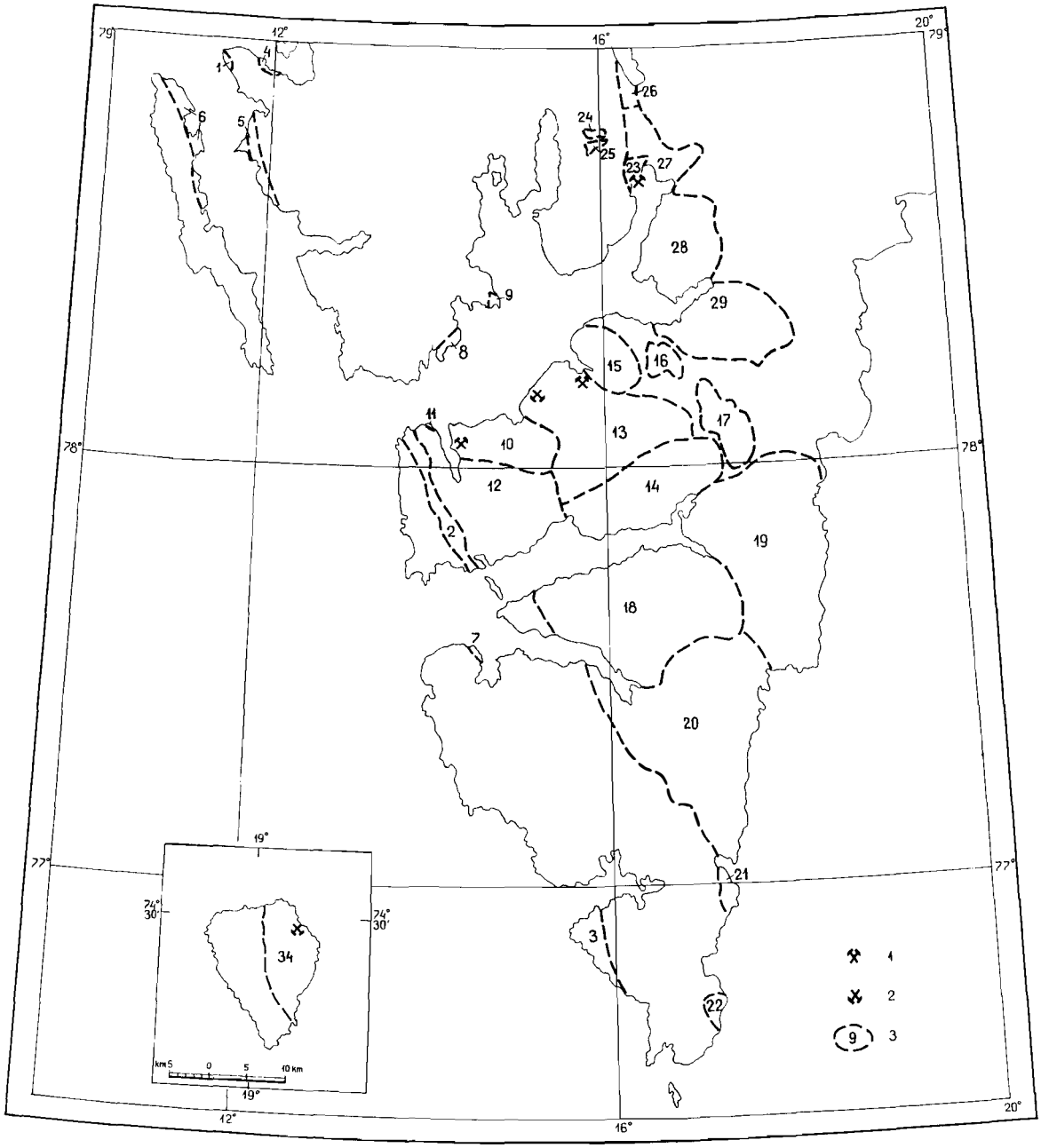


Fig. 15: Sketch map of coal areas of Svalbard.

1 coal mine, active; **2** coal mine, abandoned; **3** coal areas (D: Devonian, C: Carboniferous, K: Cretaceous, P: Paleogene):

A *West coast of Spitsbergen and Prins Karls Forland:* **1** Keerwyck (C1); **2** Isfjorden-Bellsund (C1); **3** Struvefjella (C1); **4** Ny-Ålesund (P3); **5** Sarsøyra (P2); **6** Prins Karls Forland (P3); **7** Renardodden (P3)

B *Central and southern parts of Spitsbergen:* **8** Erdmannflya (P1); **9** Bohemanflya (K1); **10** Barentsburg (P1); **11** Festningen (P1); **12** Berzeliusdalen (P1); **13** Longyear-Grumant (P1); **14** Sveagruva (P1); **15** Adventdalen (K1); **16** Arctowskifjellet (K1); **17** Lundströmdalen (K1); **18** Nathorst Land (P1); **19** Heer Land (K1); **20** Torell Land (P1); **21** Hedgehogfjellet (P1); **22** Dumskolten (P1)

C *Eastern part of Spitsbergen:* **23** Pyramiden (C1); **24** Citadellet (C1); **25** Triungen (C1); **26** Mittag-Lefflerbreen (C1); **27** Wordiekammen (C1); **28** Bünsow Land (C1); **29** Sassenfjorden (C1)

D *Bjørnøya:* **30** Tunheim (D3)

REFERENCES

In this volume, references to unpublished reports are written *in italics*. Those not represented by abstracts in this volume, are listed at the end of the reference list.

Published literature:

Birkenmajer, K. 1958: Preliminary report on the stratigraphy of the Hecla Hoek Formation in Wedel Jarlsberg Land, Vestspitsbergen. *Bull. Acad. Polon. Sci. VI (2)*, 143-150.

Birkenmajer, K. 1960: Geological sketch of the Horsund area. *Int. Geol. Congr., Rep. 21st Ses. Supplement to Guide for Excursion A.16*, København. 1-12.

Birkenmajer, K. 1964: Devonian, Carboniferous and Permian formations of Hornsund, Vestspitsbergen. *Studia Geologica Polonica 11*, 47-123.

Birkenmajer, K. 1975a: Caledonides of Svalbard and plate tectonics. *Bulletin Geological Society of Denmark 24*, 1-19.

Bjærke, T. & Manum, S.B. 1977: Mesozoic palynology of Svalbard I. *Norsk Polarinstitutt Skrifter 165*, 1-48.

Buchan, S.H., Challinor, A., Harland, W.B. & Parker, J.R. 1965: The Triassic stratigraphy of Svalbard. *Norsk Polarinstitutt Skrifter 135*, 1-92.

Burov, Ju.P. & Semevskij, D.V. 1976*: Osnovnye čerty tectoničeskogo stroenija devonskogo grabena (ostrov Špicbergen). (The main features of the tectonic structure of the Devonian graben.) In: *Geologija Sval'barda*, NIIGA, Leningrad, 103-116.

Burov, Ju.P., Gavrilov, B.P., Klubov, B.A., Pavlov, A.V. & Ustrickij, V.I. 1965: Novye dannye o verhne-permskih otloženijah Špicbergena. (New data on Upper Permian deposits of Spitsbergen.) In Sokolov, V.N. (ed.): *Materialy po geologii Špicbergena.* Leningrad.

Burov, Ju.P., Krasil'ščikov, A.A., Firsov, L.V. & Klubov, B.A. 1976*: Vozrast doleritov Sval'barda. (The age of Spitsbergen dolerites.) In: *Geologija Sval'barda*, NIIGA, Leningrad, 117-125.

Cutbill, J. & Challinor, A. 1965: Revision of the stratigraphical scheme for the Carboniferous and Permian rocks of Spitsbergen and Bjørnøya. *Geological Magazine 102 (5)*, 418-439.

Feyling-Hanssen, R.W. 1955: Stratigraphy of the marine Late Pleistocene of Billefjorden, Vestspitsbergen. *Norsk Polarinstitutt Skrifter 107*, 1-186.

Flood, B. 1969: Sulphide mineralizations within the Hecla Hoek complex in Vestspitsbergen and Bjørnøya. *Norsk Polarinstitutt Årbok 1967*, 109-128.

Flood, B., Nagy, J. & Winsnes, T.S. 1971: Geological map of Svalbard, 1:500,000, sheet 1G Spitsbergen, southern part. *Norsk Polarinstitutt Skrifter 154A.*

Føyn, S. & Heintz, A. 1943: The Downtonian and Devonian vertebrates of Spitsbergen. VIII. The English-Norwegian-Swedish expedition 1939. Geological results. *Norges Svalbard og Ishavsundersøkelser Skrifter 85*, 1-51.

Friend, P.F. 1961: The Devonian stratigraphy of north and central Vestspitsbergen. *Proc. Yorks Geol. Soc. vol. 33, pt. 1 (5)*, 77-118.

Friend, P.F., Heintz, N. & Moody-Stuart, M. 1966: New unit terms for the Devonian of Spitsbergen and a new stratigraphical scheme for the Wood Bay Formation. *Norsk Polarinstitutt Årbok 1965*, 59-64.

Gee, D.G. & Hjelle, A. 1966: On the crystalline rocks of northwest Spitsbergen. *Norsk Polarinstitutt Årbok 1964*, 31-45.

Gee, D.G. & Moody-Stuart, M. 1966: The base of the Old Red Sandstone in central north Haakon VII Land, Vestspitsbergen. *Norsk Polarinstitutt Årbok 1964*, 57-68.

Gramberg, I.S., Krasil'ščikov, A.A. & Semevskij, D.V. (eds.) 1990*: *Stratigrafičeskij slovar' Špicbergena (Stratigraphical dictionary of Svalbard).* Nedra, Leningrad. 1-203.

Harland, W.B. 1961: An outline of the structural history of Spitsbergen. Pp. 68-132 in Raasch, G.O. (ed.): *Geology of the Arctic.* University of Toronto Press.

Harland, W.B., Wilson, C. 1956: The Hecla Hoek succession in Ny Friesland, Spitsbergen. *Geol. Mag. 93 (4)*, 265-289.

Harland, W.B., Wallis, R. & Gayer, R. 1966: A revision of the Lower Hecla Hoek succession in central north Spitsbergen and correlation elsewhere. *Geological Magazine 103 (1)*, 70-97.

Hoel, A. & Holtedahl, O. 1911: Les nappes de lave, les volcans et les sources thermales dans les environs de la Baie Wood au Spitsberg. *Videnskapsselskapets Skrifter 1, Matematisk-Naturvitdenskapelig Klasse No. 9.* Kristiania.

Horn, G. & Orvin, A.K. 1928: Geology of Bear Island. *Skrifter om Svalbard og Ishavet 15*, 1-152.

Kaiser, H. 1970: Die Oberdevon-Flora der Bäreninsel 3: Mikroflora des höheren Oberdevons und des Unterkarbons. *Palaeontographica Abt. A: Paläozoologie, Stratigraphie, 129*, 71-124.

Klitin, K.A. 1960: O tectonike Špicbergena (On the tectonics of Spitsbergen). *Izvestija AN SSSR, ser. geol., 10,* 62-69.

Klubov, B.A. 1965: Geologičeskij očerk ostrova Edž. (Geological review of Edgeøya.) In: *Materialy po geologii Špicbergena.* NIIGA, Leningrad. 71-82.

Korjakin, V.S. 1975: Položenie i morfologija lednikov. (Position and morphology of glaciers.) In: *Oledenenie Špicbergena.* NAUKA, M. 7-39.

Krasil'ščikov, A.A. 1970: Shema stratigrafii dokembrija - nižnego paleozoja arhipelaga Špicbergen. (Precambrian to Lower Paleozoic stratigraphic scheme of Spitsbergen.) *Akademii NAUK SSSR, doklady 194 (5).*

Krasil'ščikov, A.A. 1973: Stratigrafija i paleotektonika dokembrija - rannego paleozoja Špicbergena. (Precambrian to Early Paleozoic stratigraphy and paleotectonics of Spitsbergen.) *Tr. NIIGA, Vol. 172*, Leningrad. 1-120.

Krasil'ščikov, A.A. & Kovaleva, G.A. 1976*: Dokembrijskie litologo-stratigrafičeskie kompleksy zapadnogo poberež'ja Špicbergena. (Precambrian lithostratigraphical complexes of the west coast of Spitsbergen.) In Sokolov, V.N.: *Geologija Sval'barda.* NIIGA, Leningrad. 63-70.

Krasil'ščikov, A.A., Krylov, A.Ja. & Aljapyšev, O.A. 1964: O vozraste nekotoryh granitoidnyh porod i gnejsov severnoj časti arhipelaga Špicbergen. (On the age of some granitoids and gneisses from the northern part of the archipelago of Svalbard.) *Akademii NAUK SSSR, doklady 159 (4)*, 796-798.

Krasil'ščikov, A.A. & Livšic, Ju.Ja. 1974: Tektonika ostrova Medvežij. (Tectonics of Bjørnøya.) *Geotektonika, 4*, 39-51.

Krasil'ščikov, A.A. & Mil'štejn, V.E. 1975: O vozraste "Serii Drevnih Dolomitov" ostrova Medvežij (Barencevo more). (On the age of the "Series of Ancient Dolomites" on Bjørnøya). *Akademii NAUK SSSR, doklady 225 (1),* 161-163.

Kulling, O. 1934: The Hecla Hoek Formation around Hinlopenstretet. *Geografiska Annaler Årg. XVI (4)*, 161-254.

Kuznecov, Ju.A. 1964: Glavnye tipy magmatičeskih formacij. (Main types of magmatic formations). *Nedra, Moskva. 1*-387.

Livšic, Ju.Ja. 1965: Paleogenovye otloženija Zemli Nordenšel'da (Zap. Špicbergen). (Paleogene deposits of Nordenskiöld Land, Vestspitsbergen.) Pp. 193-215 in Sokolov, V.N. (ed.): *Materialy po geologii Špicbergena.* [English translation in Harland, W.B. et al.(ed.): *Geology of Spitsbergen.* National Lending Library of Science and Technology, Boston Spa., Yorkshire 1970.]

Livšic, Ju.Ja. 1967: Tretičnye otloženija zapadnoj časti arhipelaga Špicbergen. (Tertiary deposits in the western part of the Archipelago of Svalbard.) Pp. 185-204 in Sokolov, V.N. (ed.): *Materialy po stratigrafii Špicbergena.* (English translation, The British Library, Lending Division, 1977, 235-259.)

Livšic, Ju.Ja. 1973: Paleogenovye otloženija i platformennaja struktura Špicbergen. (Paleogene deposits and platform structure of Spitsbergen.) *NIIGA, tr. 174.* 1-159.

Livšic, Ju.Ja. 1974: Paleogene deposits and the platform structure of Svalbard. *Norsk Polarinstitutt Skrifter 159*, 1-50.

Major, H. &. Nagy, J. 1972: Geology of the Adventdalen map area. *Norsk Polarinstitutt Skrifter 138*, 1-58. (with map, published in 1964)

Major, H. & Winsnes, T. 1955: Cambrian and Ordovician fossils from Sørkapp Land, Spitsbergen. *Norsk Polarinstitutt Skrifter 106*, 1-47.

Murašov, L.G. & Mokin, Ju.I. 1976*: Stratigrafičeskoe rasčlelenie devonskih otloženij o. Špicbergen. (Stratigraphic subdivision of Devonian deposits of the island of Spitsbergen.) Pp. 78-91 in Sokolov, V.N. (ed.): *Geologija Sval'barda.* NIIGA, Leningrad.

Nagy, J. 1970: Ammonite faunas and stratigraphy of Lower Cretaceous (Albian) rocks in southern Spitsbergen. *Norsk Polarinstitutt Skrifter 152*, 1-58.

Nathorst, A.G. 1910: Beiträge zur Geologie der Bäreninsel, Spitzbergens und des König-Karl-Landes. *Bulletin Geologiska Institutionen Universitetet i Uppsala 10 (1910-1911)*, 261-416.

Örvig, T. 1969: Vertebrates from the Wood Bay Group and the position of the Emsian - Eifelian boundary in the Devonian of Vestspitsbergen. *Lethaia 2 (3-4)*, 273-328.

Parker, J.R. 1967: The Jurassic and Cretaceous sequence in Spitsbergen. *Geological Magazine 104*, 487-505.

Pčelina, T.M. 1972: Triassovye otloženija ostrova Medvežij. (Triassic deposits of Bjørnøya). In: *Mezozoiskie otloženija Sval'barda.* NIIGA, Leningrad. 5-20.

Playford, G. 1962: Lower Carboniferous microfloras of Spitsbergen. *Palaeontology 5 (3 & 4)*, 550-678.
Różycki, S.Z. 1959: Geology of the north-west part of Torell Land, Vestspitsbergen. *Studia Geologica Polonica 2*, 1-98.
Sandford, K.S. 1956: The stratigraphy and structure of the Hecla Hoek Formation and its relationship to a subjacent metamorphic complex in North-East Land (Spitsbergen). *Geological Society of London, Quarterly Journal 112*, 339-362.
Smith, D.G., Harland, W.B. & Hughes, N.F. 1975: The geology of Hopen, Svalbard. *Geological Magazine 112 (1)*, 1-23.
Smith, D.G., Harland, W.B., Hughes, N.F. & Pickton, C.A.G. 1976: The geology of Kong Karls Land, Svalbard, *Geological Magazine 113 (5)*, 193-304.
Talimaa, V.N. 1978: Telodonity silura i devona SSSR i Špicbergena. (Silurian and Devonian Thelodontes of the USSR and Spitsbergen). *Mokslas*, Vil'nius, 1-276.
Teben'kov, A.M., Ohta, Y., Balašov, Ju.A. & Sirotkin, A.N. 1996: Newtontoppen granitoid rocks; their geology, chemistry and Rb-Sr age. *Polar Research 15 (1).*
Ustrickij, V.I. 1967: Osnovnye čerty stratigrafii i paleogeografii verhnego paleozoja Špicbergena. (Main stratigraphical and paleogeographical features of the Upper Paleozoic of Spitsbergen.) Pp. 71-93 in V.N. Sokolov (ed.): *Materialy po stratigrafii Špicbergena.* NIIGA, Leningrad.
Vogt, T. 1938: The stratigraphy and tectonics of the Old Red Formation of Spitsbergen. *Proced./Abstr. Geol. Soc. London 1343*, 1-88.
Worsley, D. 1973: The Wilhelmøya Formation - a new lithostratigraphic unit from the Mesozoic of Eastern Svalbard. *Norsk Polarinstitutt Årbok 1971*, 7-16.
Worsley, D. & Edwards, M.B. 1976: The Upper Paleozoic succession of Bjørnøya. *Norsk Polarinstitutt Årbok 1974*, 17-34.

Papers marked * are also published in English:

Burov, Ju.P., Krasil'ščikov, A.A., Firsov, L.V. & Klubov, B.A. 1977: The age of Spitsbergen dolerites. *Norsk Polarinstitutt Årbok 1975*, 101-108.
Burov, Ju.P. & Semevskij, D.V. 1979: The tectonic structure of the Devonian Geraben (Spitsbergen). *Norsk Polarinstitutt Skrifter 167*, 239-248.
Dallmann, W.K. & Mørk, A. (eds.) 1991: Stratigraphical dictionary of Svalbard. Translation from the Russian title: Stratigrafičeskij slovar' Špicbergena (Gramberg, I.S., Krasil'ščikov, A.A. & Semevskij, D.V., eds., 1990). *Norsk Polarinstitutt Rapportserie 74.* 1-189.
Krasil'ščikov, A.A. & Kovaleva, G.A. 1979: Precambrian rock-stratigraphic units of the west coast of Spitsbergen. *Norsk Polarinstitutt Skrifter 167*, 81-88.
Murašov, L.G. & Mokin, Ju.I. 1979: Stratigraphic subdivision of Devonian deposits of Spitsbergen. *Norsk Polarinstitutt Skrifter 167*; 249-261. (Author's name is misspelt "Murašcov" in publication.)

Unpublished reports of PMGRÈ cited, but not included in this volume:

Bro, E.G. & Švarc, V.L. 1983: *Otčët po obrabotke materialov burenija skvažiny Raddedalen-1, o. Edž. (Report on the data processing of the Raddedalen-1 drill-hole, Edgeøya.)* 1-61.
Bro, E.G., Pčelina, T.M., Preobraženskaja, E.N. & Desjatkov, V.M. 1990: *Otčët po obrabotke materialov burenija parametričeskih skvažin Vassdalen-2 i -3 [Špicbergen]. (Report on the data processing of the Vassdalen-2 and 3 parametric drill-holes [Spitsbergen].)* 1-147.
Miloslavskij, M.Ju., Karnoušenko, E.P. & Sirotkin, A.N. 1993: *Geologičeskoe stroenie Central'nogo i Vostočnogo rajonov Špicbergena. (Geological structure of Central and Eastern regions of Spitsbergen.)* 1-261.
Škola, J.V., Burov, Ju.P. & Deč, V.N. 1977: *Otčët po obrabotke materialov burenija Grumantskoj parametričeskoj skvažiny na o. Zapadnyj Špicbergen. (Report on the data processing of the Grumant parametric drill-hole on western Spitsbergen.)* 1-434.