The Geology of Svalbard

To Svalbard Colleagues
View of Ny-Ålesund settlement seen from the west with three mountain peaks, Tre Kroner, in the distance. The peaks are capped by Carboniferous strata unconformably resting on Early Devonian rocks. They are 30 km distant from the buildings, being foreshortened by the telephoto lens. The glacier from which they emerge as nunataks extends about 15 km nearer. The remaining 15 km just visible is the eastern, inner part of Kongsfjorden. To the right in the foreground is a raised, insulated and heated utiliduct supplying water from a small lake. Photo M. J. Hambrey, CSE 1962 (SP.941e).

View WSW from the old road quay at Ny Ålesund, with Scheteligfjellet in the centre right formed mainly of Carboniferous and Permian strata. Typical low cloud is creeping half way up the mountain from the right. The middle foreshortened low tundra with snow is characteristic raised beach or strandflat topography. The cliffs in the foreground usually about 5–10 m high form the coastline of the shallow bay, Thiisbukta, where in somewhat deeper water motorboats have a sheltered anchorage. The ice in the foreground is ‘bay ice’, which forms each winter and melts in the early summer. After a hard winter (probably in June) this bay ice is grounded in shallow water at low tide. In a few days it would disintegrate and drift away with tide. Photo M. J. Hambrey (SP631).
The Geology of Svalbard

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Preface

I think that we shall have to get accustomed to the idea that we must not look upon science as a “body of knowledge”, but rather as a system of hypotheses; that is to say, as a system of guesses or anticipations which in principle cannot be justified, but with which we work as long as they stand up to tests, and of which we are never justified in saying that we know they are “true” or “more or less certain” or even “probable”.

Karl A. Popper (From a paper that Popper read in 1934 when his Logik des Forschung was in proof. It was published in English in the new appendixes of his Logic of Scientific Discovery 1959, p. 317).

This work attempts to present the geology of Svalbard in some detail, arranged systematically as a definitive study and so reflecting the present conjuncture of research. It may thus meet the needs of specialists with information on related fields or of any geoscientist wanting an indication of what is known about this key region.

Svalbard (peaked mountains), the name earlier referred to the whole archipelago. It is now replaced by the name Svalbard (cold coasts), within which Spitsbergen is the principal landmass. Spitsbergen alone is about the size of Switzerland and the whole archipelago a little less than the area of Scotland. Geologically it has the wealth in variety and complexity in stratigraphy and structure no less than these classic areas. Moreover with an international history and present treaty status many nations have participated in research so the geological literature currently comprising far more than 3000 publications is widely scattered and rapidly increasing. There are indeed excellent published geological outlines, but no comprehensive work.

Part 1 of this work is introductory, setting the stage. Chapter 3 in particular presents the principal geological conventions used throughout and outlines the main geological features and tectonic hypotheses. Part 2 divides Svalbard into eight somewhat arbitrary regions/sectors which are described with minimal interpretation. The rock successions are described briefly from the top down as illustrated. Part 3 interprets historical events and environments which are described with minimal interpretation.

My interest in the project stems from about 50 years of research in many aspects of Svalbard geology with some 50 colleagues and collaborators listed below. However this book purports to be an objective study of contributions from international sources. Where there are differences of opinion alternative views are presented. Obviously, however, no single person could comprehend the whole literature nor avoid some personal bias when making a coherent synthesis that has been thought through. These objectives would take more than a lifetime to fulfill. This work is presented as a contemporary statement in the spirit of the quotation at the head of this preface. By venturing conjectures and exposing them freely in graphic form as well as in the text it is intended that they shall be subject to critical assessment. Lack of appropriate evidence does not vitiate an hypothesis nor can abundant supporting evidence establish it. Only contradictory evidence provides effective criticism. This work presents a challenge and a platform for further research and will be superseded in the normal course of science.

The philosophy behind this study is that all geological data may be integrated in time and space, that is stratigraphy in the broad sense. This regional synthesis is offered as a contribution to Earth history. It is a two way interaction. Understanding of process enables and demands the interpretation of historical data and the attempt to understand history leads to further modifications in the theory of the Earth. For example: the attempt to make sense of the field data led to early hypotheses of continental drift; of cooling and heating of the mantle with regional subsidence and uplift; of compression leading to lateral escape, transpression and transtension; of large scale paleo-strike-slip of former provinces and allochthonous terranes; and of global Vendian glaciation.

This is a personal synthesis at the conclusion of work epitomizing a journey that began for me in Spitsbergen on graduation in 1938. I have been privileged as a student and teaching officer in a great University and as a member and Fellow of an ancient Cambridge College. These positions require specified duties in teaching and administration, but with freedom to pursue investigations whenever and wherever they may lead, provided the necessary resources can be found.

I came into a culture where the older generation worked out their own research as individuals with little or no organized cooperation.

After two abortive research lines I decided in 1948 both to attempt to tie up some unfinished work in Spitsbergen and at the same time to try out a pattern of cooperative research with our students. All I have learned about research was gained through such interaction and that is why I dedicate this work to those colleagues. Some, hardly junior, have long achieved distinction. About 400 persons have in diverse ways contributed to our joint enterprises. I draw attention to the early decades when fieldwork involved long boat journeys to Spitsbergen and then transport by small open boats, manhauled sledges and always much pack-carrying to the study area. Equipment was primitive and conditions often harsh. We thought ourselves fortunate indeed to share the experience of our predecessors in Svalbard exploration. I mention only two colleagues. Colin B. Wilson worked with me in Ny Friesland contributing greatly to the work in Chapter 7. His contribution, first in our systematic survey of Ny Friesland and later on his private solo excursions by small boat with outboard, carrying sledges and supplies from Longyearbyen round the northwest to Ny Friesland where he recorded exemplary observations across enormous distances. His motivation was the shear joy of discovery and only with difficulty was he persuaded to prepare work for publication. His death in 1959, not in Spitsbergen, but by an accident in Cambridge, deprived us of a remarkable investigator. C. John B. Kirton a brilliant first year student was killed in 1958 by a flying stone while holding a fossil at a new locality on a mountain later named after him. A service was held in 1959 at his remote grave and memorial cairns were built nearby and by the shoreside base. He represents the best in our university tradition.

Our research group was never an official university project and we paid our way as best we could in the early days, contributing personally. The need for independence led to the formation of Cambridge Spitsbergen Expeditions, (later Cambridge Svalbard Exploration). This then led to the formation of the Cambridge Arctic Shelf Programme to give more security of employment and to spread our interests so as not to compete for limited funds in Britain or Norway.

Finally I acknowledge one colleague, my wife Elisabeth, who in the early years looked after our family taking domestic responsibilities single handed. In the middle years she assisted in Svalbard on 13 field seasons and has latterly given invaluable support to my writing of this work for which I alone must bear full responsibility.

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July 1997

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Two kinds of acknowledgement relate to the research and to this publication.

First paying tribute to those to whom the book is dedicated the research has benefited from the participation of many colleagues during 45 field seasons as well as in Cambridge. They contributed greatly to my education and determination to write this book. It may be of interest to other Svalbard geologists to note who have published from this experience. In list A those names with asterisks worked on Svalbard material for their research degrees, others participated, some over one period.

It would, however, be wrong to think only of the geologists whose reward was in their work. We depended throughout on logistic support. Of the hundred or more who supported the work in this way list C names those who took responsibility for more than one season, for example captaining boats.

More than a hundred geology undergraduates joined as assistants and many have gone on to distinguish themselves. They often asked the most penetrating questions, made unlikely observations and were rewarding companions.

Whereas the above thanks are for my own personal indebtedness to those who have shared in the work I gladly acknowledge the immense debt due to the larger scientific community whose published work is the basis of this book as may be noted from the list of publications cited. At the same time I should declare that by no means have the extensive files of CSE and CASP unpublished work been abstracted here. I remembered only what seemed relevant.

The lexicon of stratigraphic names begun in the fifties was abbreviated and checked recently in co-operation with W. K. Dallmann (Norsk Polarinstittut Geologist and Chairman of the SKS).

The more comprehensive bibliography (the basis of the reference list here) has a long history beginning with the earliest research. Managed for many years as a card index by K. N. Herod it was in due course computerised initially by R. A. Scott (CASP) and subsequently updated at regular intervals with the continuing help of D. Manasrah (CASP), and E. L. Lesk, Information Officer in CASP, who scanned new literature for me through this work. Publications were listed as met in the work and not sought out for a comprehensive bibliography.

Unless otherwise stated in the captions, the figures were devised and sketched by me and then executed on disc by those who have initialled the diagrams, mainly L. M. Anderson, C. F. Stephens, S. R. A. Kelly, D. Manasrah and P. A. Doubleday.

Whereas I drafted most of the text and sketched most of the figures others contributed of their expertise as indicated in the chapter headings. The late Dr A. Challinor gave permission to include the serial cross sections of the West Spitsbergen Orogen from his dissertation and later CSE reports (Section 20.6).

D. I. M. Macdonald, Chief Geologist of CASP, supported this work throughout and seconded CASP staff at different times to this project. I. Geddes helped with the proofs. The place name list was compiled by Mr L. M. Anderson.

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* H. J. Campbell
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* C. Croxton
* J. L. Cutbill
* M. Dettmann
* J. A. D. Dickson
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(B) Some of those who contributed to the field work and later in other ways

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Conventions

Geological conventions employed throughout the work are treated in Chapter 3. These include the international time scale, principles for lithostratigraphic nomenclatures, the uses of some technical terms and the descriptive names for Svalbard structures. Place names are explained in Chapter 1 and listed in Part 4.

Acronyms in common use

CASP: Cambridge Arctic Shelf Programme.
GSSP: Global stratotype section and point.
IKU: Continental Shelf Institute, Trondheim.
NP: Norsk Polarinstitutt.
SKS: Stratigrafisk Komite for Svalbard.

Authority

It is intended that any positive statement be supported by a reference at the end of the paragraph or subsection. If none it may be assumed either that the statement is common knowledge or that it is the original contribution (opinion) of this work. The names of up to three authors may be cited in the text and ‘et al.’ generally refers to four or more.

Use of contemporary nomenclature and compass orientation

In recording earlier work, unless original wording is quoted (in quotes), the present usage (for example of place and stratigraphic names) is generally substituted. Original names may be added in parentheses. Compass directions for earlier geological ages are expressed in the present orientation without implication as to what was the ancient orientation.

Transliteration

The Norwegian alphabet places symbols ø and å at the end whereas they are placed here as though unmodified in the English language alphabetical order.

For Chinese: Pinyin

For Cyrillic: The system used was jointly recommended by the Permanent Committee on Geographical Names (PCGN) for British Official use and the United States Board on Geographical Names (USBGN), as revised in 1970 and 1972. It is used in the Times Atlas of the World, the Scott Polar Research Institute and the Geographical Names Division of the US Army Topographic Command, which has published perhaps the most comprehensive gazetteer of the FSU. The ISO system has advantages but requires the addition to normal type of accurate diacritical symbols unfamiliar in the west.

Use of stratigraphic nomenclature (as explained in Section 3)

The problem of divergent stratigraphic nomenclature and classification has been met by a discussion arriving at a conclusion generally early in each historical chapter. That discussion, often seemingly of miniscule interest, may then be confined to that particular section. The conclusions may be applied in the rest of the work both in earlier or later parts. Therefore, the reader who finds a different scheme employed and is possibly irritated thereby, should find the reasoning behind such a choice in a section in each of the historical chapters. The Stratigraphic Glossary may help.