GEOLOGICAL SURVEY OF DENMARK AND GREENLAND BULLETIN 11 · 2006

Precambrian crustal evolution and Cretaceous–Palaeogene faulting in West Greenland

Edited by
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GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF THE ENVIRONMENT

Geological Survey of Denmark and Greenland Bulletin 11

Keywords
Archaean, Cretaceous–Palaeogene, deformation, faulting, geochronology, Kangâmiut dykes, Nagssugtoqidian, Rinkian, West Greenland

Cover
Flat-lying, grey Archaean orthogneisses cut by Palaeoproterozoic dolerite dykes (black), which have been deformed and rotated into near-parallellism with their host rocks during the Nagssugtoqidian orogenesis. The whole succession is cut by late- to postkinematic Nagssugtoqidian pegmatites (pink). South coast of island 11 km east of Aasiaat in the northern Nagssugtoqidian orogen. The Nagssugtoqidian deformation of Archaean rocks in this region is the main subject of Mazur *et al.* (this volume) and van Gool & Piazolo (this volume). Photo: Adam A. Garde.

Frontispiece: facing page
Archaean, syn- to postkinematic granitic sheets cutting grey orthogneiss and variably folded with their host. Coastal exposure on the north coast of Saqqarput 30 km south-east of Kangaatsiaq, within an Archaean block in the northern Nagssugtoqidian orogen that has largely escaped Palaeoproterozoic deformation. Compare with the cover photograph displaying an example of Palaeoproterozoic deformation, and see articles by Mazur *et al*. and Thrane & Connelly (this volume). Photo: Adam A. Garde.

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Digital photographic work: Benny M. Schark
Graphic production: Knud Gr@phic Consult, Odense, Denmark
Printers: Schultz Grafisk, Albertslund, Denmark
Receipt/acceptance dates of manuscripts: see end of individual articles
Printed: 5 December 2006

ISSN 1604-8156
ISBN-10: 87-7871-188-6
ISBN-13: 978-87-7871-188-5

Geological Survey of Denmark and Greenland Bulletin
The series *Geological Survey of Denmark and Greenland Bulletin* replaces *Geology of Denmark Survey Bulletin* and *Geology of Greenland Survey Bulletin*.

Citation of the name of this series
It is recommended that the name of this series is cited in full, viz. *Geological Survey of Denmark and Greenland Bulletin*.
If abbreviation of this volume is necessary, the following form is suggested: *Geol. Surv. Den. Green. Bull*. 11, 204 pp.

Available from
Geological Survey of Denmark and Greenland (GEUS)
Øster Voldgade 10, DK-1350 Copenhagen K, Denmark
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or
Geografforlaget ApS
Rugårdsvej 55, DK-5000 Odense C, Denmark
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Preface

The present volume marks the completion of a large research project by the Geological Survey of Denmark and Greenland (GEUS), focused on the northern part of the Palaeoproterozoic Nagssugtoqidian orogen of central West Greenland, and carried out by a team of Danish and international participants. The project comprised geological mapping as well as structural, geochronological, geochemical and economic geological studies. This volume contains reports on both Archaean and Palaeoproterozoic geology as well as a study of neotectonic brittle structures. The field work was carried out in 2000–2003 in the region between Nordre Strømfjord and Jakobshavn Isfjord (see e.g. van Gool & Piazolo 2006, this volume, fig. 1). The project had two immediate purposes, namely to establish an overview of the mineral resource potential of supracrustal rocks in the region between 66° and 70°15′N, and produce four new geological sheets in the Survey's 1:100 000 map series.

The first collection of papers about the Nagssugtoqidian orogen, published by the Geological Survey of Greenland (GGU, now part of GEUS), dates back to 1979 (Korstgård 1979). The investigations in this period were mainly based on field descriptions and structural analysis of coastal areas in the southern and central parts of the orogen, combined with limited petrographical, palaeomagnetic and geochronological studies; the results also comprised the first 1:100 000 geological map from within the Nagssugtoqidian orogen (Olesen 1984). The Proterozoic age of the orogen had been established, but it was believed that most, if not all of the quartzofeldspathic basement gneisses were of Archaean origin.

Subsequent work in the Nagssugtoqidian orogen by GGU in the 1980s showed that besides Archaean orthogneisses and supracrustal rocks, the central part of the orogen also comprises the root zone of a Palaeoproterozoic magmatic arc and associated panels of Palaeoproterozoic volcanic and metasedimentary rocks (Kalsbeek *et al.* 1987). These results were confirmed during further investigations by the Danish Lithosphere Centre (DLC) in 1994–1999, and the plate-tectonic collisional history of the southern and central Nagssugtoqidian orogen was described in detail (van Gool *et al.* 2002). However, these studies added little to previous knowledge of the northern parts of the orogen in the Kangaatsiaq–Aasiaat–Qasigiannguit region, knowledge that was largely based on coastal reconnaissance by Henderson (1969) at the time when the entire orogen was still believed to consist of Archaean rocks.

Another project preceding the present work was carried out by GGU in 1988–1991 immediately north of the Nagssugtoqidian orogen, in the southernmost part of the likewise Palaeoproterozoic Rinkian fold belt (Disko Bugt project, Kalsbeek 1999). It was shown that also the latter region comprises Palaeoproterozoic (meta)sedimentary rocks, and that most of the Archaean basement is strongly overprinted by Palaeoproterozoic structures that were formed during overall W- or NW-directed lateral tectonic transport. Although these structures might be related to similar structures in the Nagssugtoqidian orogen, the relationship between the Nagssugtoqidian orogen and the Rinkian fold belt remained speculative.

The only previous economic geological study of regional extent in central West Greenland was an airborne reconnaissance study supplemented by local field work, which was carried out in the early 1960s by Kryolitselskabet Øresund A/S. This work resulted in the discovery of a massive sulphide deposit at Naternaq (Lersletten), which was studied again in some detail in 2001 by the Survey (Østergaard *et al.* 2002) but not reported on in the present volume.

The present volume comprises 12 papers with topics ranging geochronologically from mid-Archaean to Palaeogene, and geographically from the southern Nagssugtoqidian foreland to the central part of the Rinkian fold belt. Many of the papers deal with the northern part of the Nagssugtoqidian orogen and are related to the recent field work in that region, while a few contributions are rooted in DLC- or other projects. The papers have been arranged in approximate chronological order and are grouped in terms of their main subjects.

The two first papers, by Hollis *et al.* and Moyen & Watt, deal with Archaean supra- and infracrustal rocks in the northern Nagssugtoqidian orogen: their origin, ages, and structural and metamorphic evolution. These papers provide insight into the age and origin of the continental crustal orthogneisses and granites that underlie most of the region, and discuss the relationships between the supracrustal and plutonic components, using zircon U-Pb age determinations and major and trace element geochemical characteristics. Also the question of Palaeoproterozoic tectonic overprint is discussed, with the conclusion from both study areas that most of the observed structures are Archaean.

The third paper with focus on Archaean geology, by Stendal *et al.*, describes a small gold prospect at Attu likewise in the northern Nagssugtoqidian orogen, and discusses the age of the prospect and its host rocks using Pb-Pb geochronology of magnetite. It is concluded that the host rocks at Attu may be as old as 3162 ± 43 Ma, and that the gold prospect itself is around 2650 Ma in age.

The fourth paper, by Mayborn & Lesher, is a thorough review of the Kangâmiut dyke swarm in the southern Nagssugtoqidian orogen and its foreland. It includes new whole-rock and mineral chemical data, and a list of sampling sites and corresponding field data. The emplacement mechanism and depth of the dyke swarm are discussed in detail, and it is concluded that the dykes were emplaced during the initial rifting prior to the Nagssugtoqidian collision and that they are unrelated to subduction processes (contrary to the belief by some previous authors).

The next three papers provide geochronological constraints on the ages of supra- and infracrustal rocks and the deformation and metamorphism in the northern Nagssugtoqidian orogen, and on late orogenic uplift in the central Rinkian fold belt. In the first of these papers Thrane & Connelly employ zircon U-Pb age determinations (mainly using the laser ICP-MS method), and for the first time provide unequivocal documentation that the Naternaq supracrustal belt is of Palaeoproterozoic age. Other zircon age data from a synkinematic granite southeast of Kangaatsiaq show that the large fold structures in this region are of Archaean age. The subsequent paper by Stendal *et al.* presents Pb-Pb ages and isotopic signatures of magnetite in amphibolites; the obtained ages are younger than 1800 Ma and are related to cooling of the orogen. Stepwise leaching Pb-Pb ages of monazite and allanite in pegmatites fall in the range of 1750–1800 Ma, and are interpreted to date the emplacement of these rocks. The third paper in this group, by Sidgren *et al.*, deals with new $^{40}Ar/^{39}Ar$ ages of around 1790 Ma (hornblende) and 1680 Ma (muscovite) from Archaean and Palaeoproterozoic rocks in the central Rinkian fold belt, which are interpreted as orogenic cooling ages. The hornblende ages are significantly older than such hornblende ages previously obtained from the central and northern Nagssugtoqidian orogen, pointing to different uplift histories in the two regions. This may in turn suggest that the Rinkian continental collision preceded that in the Nagssugtoqidian orogen.

Four of the remaining five papers deal with the Nagssugtoqidian structural evolution. In the first of these, van Gool & Piazolo present a new method of structural analysis, where a geographical information system (GIS) is used as a framework for visualisation and analysis of large amounts of structural data. The paper graphically presents an overview of thousands of data points within an area of approximately 160 × 180 km in the central and northern parts of the Nagssugtoqidian orogen. This interesting data set points directly towards the two next papers, where crustal-scale structures in the same region and their origin are discussed: Sørensen *et al.* address the prominent Nordre Strømfjord shear zone just south of this block, and describes the structural and metasomatic transition into the shear zone by means of aeromagnetic and lithological map patterns and geochemical data. Another paper, by Mazur *et al.*, addresses a prominent break in the structural pattern within the Kangaatsiaq–Aasiaat area, where the southern part acted as a rigid block during the Nagssugtoqidian orogeny and thus preserved its Archaean structure. The fourth paper in this group, by Korstgård *et al.*, combines rock and aeromagnetic data to discuss the relationship between structure, metamorphic facies and total magnetic field intensity anomalies in the southern Nagssugtoqidian orogen. The authors show that static metamorphic boundaries are gradual, whereas boundaries along deformation zones are abrupt.

The last paper, by Wilson *et al.*, is a novel remote sensing and field geological analysis of onshore brittle structures related to the complex Ungava fault zone in the Davis Strait, which developed during the Cretaceous–Palaeogene opening of the Labrador Sea – Davis Strait – Baffin Bay seaway. The study area is located in the central Nagssugtoqidian orogen, and the authors carefully establish a distinction between old Nagssugtoqidian and younger structures in the basement rocks and identify five main sets of young lineaments. They conclude that the onshore fault patterns are predominantly of strike-slip nature, and that they reflect the stress fields that governed the opening of the seaway.

Acknowledgements

The editors are grateful to the 14 external reviewers, each of whom reviewed one or more of the individual papers, for their thorough and constructive work.

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