

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND BULLETIN 33 • 2015

Review of Survey activities 2014

Edited by

Ole Bennike, Adam A. Garde and W. Stuart Watt

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE, ENERGY AND BUILDING

Geological Survey of Denmark and Greenland Bulletin 33

Keywords

Geological Survey of Denmark and Greenland, survey organisations, current research, Denmark, Greenland.

Cover photographs from left to right

- 1 Fractured granite on the island of Bornholm. Photograph: Merete Binderup.
- 2 The Swedish ice-breaker *Oden* in the Arctic Ocean. Photograph: Martin Jakobssen.
- 3 A geologist enjoying the magnificent view over the landscape in South-East Greenland. Photograph: Jakob Lautrup.
- 4 A geologist crossing a local ice cap on Nuussuaq peninsula in West Greenland. Photograph: Jason Briner.

Frontispiece: facing page

Ice conditions in the area north of Greenland during the GEUS LOMROG 2012 cruise with the Swedish ice-breaker *Oden*. See paper by C. Marcussen *et al.* in this issue. Photograph: Thomas Funck.

Chief editor of this series: Adam A. Garde

Editorial board of this series: John A. Korstgård, Department of Geoscience, Aarhus University; Minik Rosing, Geological Museum, University of Copenhagen; Finn Surlyk, Department of Geosciences and Natural Resource Management, University of Copenhagen

Scientific editors: Ole Bennike, Adam A. Garde and W. Stuart Watt

Editorial secretary: Jane Holst

Referees (numbers refer to first page of reviewed article): Anonymous (17, 33); Leon Bagas, AU (49); Liz Bagshaw, UK (69); Niels Balling, DK (21); Sean Brennan, USA (85); Hilmar Bungum, NO (21); David Burgess, CA (61); Valeria Caironi, IT (53); Mikael Calner, SE (9); Jakob Qvortrup Christensen, DK (33); Ida Lykke Fabricius, DK (13); Xavier Fettweis, BE (65); Peter Gerling, DE (85); Henning Haack, DK (25); Maths Halstensen, NO (13); Douglas R. Hardy, USA (69); Jens Havskov, NO (25); Martin Heinesen, FO (41); Julie Hollis, GL (53); Niels Tvis Knudsen, DK (57); John Korstgård, DK (17, 37); Jeppe Malmros, CH (57); Ruth Mottram, DK (65); Asger Ken Pedersen, DK (45); Minik Rosing, DK (49); Mark Simoni, NO (37); Henrik Stendal, GL (77, 81); Svend Stouge, DK (9); Max Strunck, SE (73); Phil Symonds, AU (41); Leif Theilgaard, DK (29); Henrik Vedel, DK (29); Tod E. Waight, DK (45); Jacob Clement Yde, NO (61, 73).

Illustrations: Benny M. Schark, Jette Halskov, Stefan Sølberg, Willy L. Weng, Susanne Rømer and Frants v. Platen-Hallermund

Layout and graphic production: Kristian A. Rasmussen

Printer: Rosendahls-Schultz Grafisk A/S, Albertslund, Denmark

Manuscripts received: 8 December 2014 – 12 May 2015

Final versions approved: 27 January 2015 – 21 May 2015

Printed: 7 July 2015

ISSN (print) 1604-8156

ISSN (online) 1904-4666

ISBN (print) 978-87-7871-404-6

ISBN (online) 978-87-8771-405-3

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.* 33, 88 pp.

Available from

Geological Survey of Denmark and Greenland (GEUS)

Øster Voldgade 10, DK-1350 Copenhagen K, Denmark

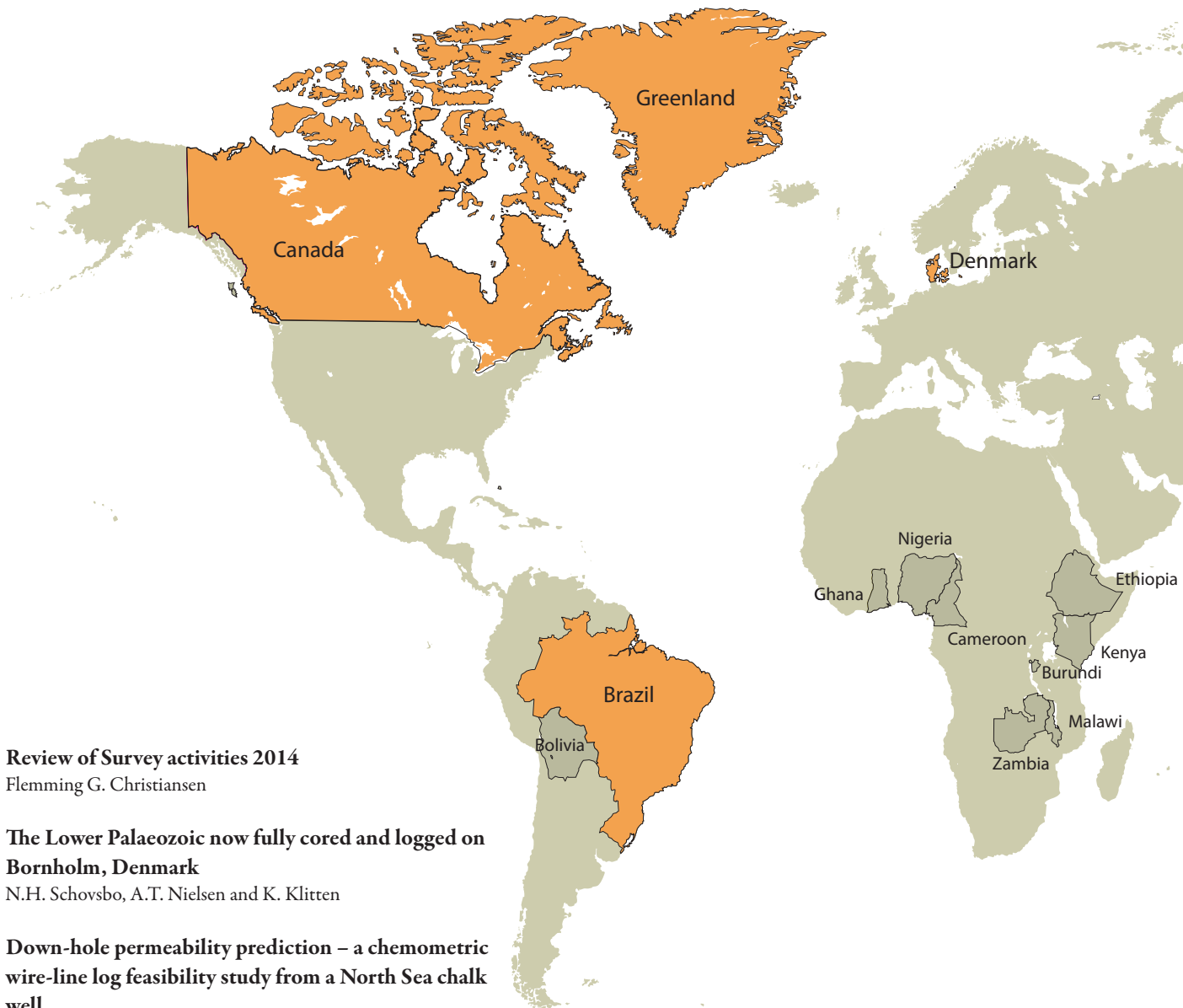
Phone: +45 38 14 20 00, fax: +45 38 14 20 50, e-mail: geus@geus.dk

and at www.geus.dk/publications/bull

© De Nationale Geologiske Undersøgelser for Danmark og Grønland (GEUS), 2015

For the full text of the GEUS copyright clause, please refer to www.geus.dk/publications/bull





7 Review of Survey activities 2014

Flemming G. Christiansen

9 The Lower Palaeozoic now fully cored and logged on Bornholm, Denmark

N.H. Schovsbo, A.T. Nielsen and K. Klitten

13 Down-hole permeability prediction – a chemometric wire-line log feasibility study from a North Sea chalk well

K.H. Esbensen, N.H. Schovsbo and L. Kristensen

17 Thrust-fault architecture of glaciotectonic complexes in Denmark

S.A.S. Pedersen and L.O. Boldreel

21 Consistency of postglacial geodynamics for the Kattegat region, southern Scandinavia, based on seismological, geological and geodetic data

S. Gregersen and P.H. Voss

25 Acoustic events on a small seismological network – shock waves from thunder and fireballs

P.H. Voss, T. Dahl-Jensen and T.B. Larsen

29 A hydrological early warning system for Denmark based on the national model

H.J. Henriksen, S. Stisen, X. He and M.B. Wiese

33 Relationship between groundwater chemistry and the Precambrian basement rocks on eastern Bornholm, Denmark

P. Gravesen, R. Jakobsen and B. Nilsson

37 Assessment of the mineral raw material potential in Denmark – methods and major findings

J.K. Keiding, P. Kalvig, C. Ditlefsen, S. Lomholt and P.R. Jakobsen

41 The Continental Shelf Project of the Kingdom of Denmark – status and issues

C. Marcussen, F. Mørk, T. Funck, W.L. Weng and M. Pedersen

45 Magma mixing, mingling and hybridisation at different crustal levels: snapshots from 1.9 billion years of magmatism in south-eastern Greenland

T.F. Kokfelt, S.M. Weatherley, J.K. Keiding and T.B. Ártíng



Grey indicates countries where GEUS had projects in 2014
Orange indicates countries with GEUS projects described in this volume.

49 A quartz-wolframite-molybdenite vein and scheelite in amphibolite horizons from Thrudvang peninsula, Skjoldungen, SE Greenland

D. Rosa and T. Ulrich

53 Follow-up on Ujarassiorit mineral hunt finds and outreach activities, South-East Greenland

M.D. Poulsen, H. Paulick, D. Rosa, V.J. van Hinsberg, J. Petersen and L.L. Thomsen

57 Greenland ice sheet melt area from MODIS (2000–2014)

R.S. Fausto, D. van As, J.A. Antoft, J.E. Box, W. Colgan and the PROMICE project team

61 Unique applied glaciology challenges of proglacial mining

W. Colgan, H.H. Thomsen and M. Citterio

65 Observed melt-season snowpack evolution on the Greenland ice sheet

C. Charalampidis and D. van As

69 Automatic weather stations for basic and applied glaciological research

M. Citterio, D.v. As, A.P. Ahlstrøm, M.L. Langer, S.B. Andersen, J. E. Box, C. Charalampidis, W.T. Colgan, R.S. Fausto, S. Nielsen and M. Veicherts

73 Digital models based on images taken with handheld cameras – examples on land, from the sea and on ice

E.V. Sørensen, M. Bjerager and M. Citterio

77 Investigations of detrital zircon, rutile and titanite from present-day Labrador drainage basins: fingerprinting the Grenvillean front

T.B. Thomsen, C. Knudsen and A.M. Hinchey

81 Composition of ilmenite and provenance of zircon in northern Brazil

C. Knudsen, T.B. Thomsen, F. Kalsbeek, J.A. Kristensen, H. Vital and R.K. McLimans

85 Reserves and resources for CO₂ storage in Europe: the CO₂StoP project

N. Poulsen, A. Bocin-Dumitriu, S. Holloway, K. Kirk, F. Neele and N. Smith

Review of Survey activities 2014

Flemming G. Christiansen

Deputy Director

Over the past decades the Geological Survey of Denmark and Greenland (GEUS) has gradually changed from an organisation that focussed on basic mapping and research to one that provides knowledge for discussions and decisions within society and the political system in Denmark and Greenland. Knowing the importance – and in some cases controversy – of many of these decisions, it is of the utmost importance that such input is based on high-quality and well-documented research that is objective, transparent and easily accessible.

Such input to important public and political discussion is also reflected in this issue of the Review of Survey activities that contains a total of 20 four-page papers, eight on Denmark, eighth on Greenland and four on broader themes.

In addition to many classical research summary papers, there are also examples of activities giving input to important political decisions on energy such as shale gas and carbon capture and storage technology, use of and exploration for mineral resources in Denmark and Greenland, climate (monitoring of the Greenland ice sheet) and foreign policy (international boundaries).

Activities in Denmark

The activities and research in Denmark of GEUS cover a wide range of topics within our main programme areas: data, water, energy, mineral resources as well as nature and climate.

The island of Bornholm has a different geological history from the rest of Denmark; a dominance of outcropping basement rocks and Palaeozoic sedimentary rocks gives special research possibilities. One paper summarises information on the Lower Palaeozoic from scientific wells. This succession is now fully cored and logged, thereby providing important data for correlation to other regions for assessing resources in Denmark and Scandinavia and for local use of water supplies.

Chalk is a very important rock type for Denmark as it hosts more than 90% of the Danish petroleum reserves in the North Sea. One paper discusses one of the main challenges, namely prediction of permeability, which is a very critical parameter for production performance.

GEUS is involved in many studies of Quaternary and recent geological processes. One paper describes thrust-fault architecture of glacio-tectonic complexes using 3D geological models based on integrated photo-data from cliff sections with high resolution seismic data.

GEUS records seismological events at many locations in Denmark and Greenland, data that are useful for many different purposes. One paper applies seismological, geological and geodetic data to discuss the consistency of postglacial geodynamics (especially uplift) in the Kattegat region. Another paper provides examples of shock waves from thunder and fireballs that have been detected on seismograms.

The use of groundwater is very important for the Danish society, and GEUS carries out many studies on water resources and possible future scenarios due to changes in climate and use. One paper uses the comprehensive and constantly updated DK-model in the process of developing a hydrological early-warning system for Denmark that can be important for water plans for emergency managers. Another paper describes the relationship between groundwater chemistry and the weathering of Precambrian basement rocks on eastern Bornholm.

The Center for Minerals and Materials (MiMa) at GEUS was established to identify and study important raw material chains from source to use, with the goal of enhancing our knowledge of the risk of resource scarcity and the ensuing vulnerability of the Danish society. One paper gives an assessment of the mineral resource potential of the on- and offshore areas in Denmark with focus on methods and the main results. Denmark has a high potential for aggregates, various clays, chalk and lime, salt and granite – but there are also many conflicting interests on the use of land and seabed where detailed planning and regulations are required.

Activities in Greenland

Once again there was a high level of activity in and concerning Greenland in 2014. Many large and small projects were carried out, studies that are important for evaluating and marketing the resource potential in Greenland. The level of activity in both oil and mineral exploration is rather low at present, but it is very important to prepare for a future when

prices of the most important commodities will rise again. Monitoring of ice and predicting climate changes are also important GEUS activities.

The work on the Continental Shelf Project reached a new culmination point, when the 5th submission concerning a very large area north of Greenland, with great international media coverage, was sent jointly to the Commission on the Limits of the Continental Shelf by the Government of the Kingdom of Denmark and the Government of Greenland in December 2014. One paper gives a status for the recent work on the project and mentions some of the issues for the coming years where data and results will be presented and used in negotiations, maintenance and hopefully supplemented by additional scientific data.

Several papers focus on mapping and evaluation of the mineral potential in Greenland. One paper gives snapshots of the magmatic history in south-eastern Greenland with examples of magma mixing, mingling and hybridisation at different crustal levels. A second paper gives details of mineralisation in the Skjoldungen area, South-East Greenland, where tungsten- and molybdenum-bearing minerals have been discovered within veins in amphibolites. A third paper follows up on the annual Ujarassiorit public mineral hunt in South-East Greenland where a number of interesting samples have been found by local stone collectors (e.g. corundum, precious and base metals), and where considerable time during field work was used for outreach activities in several small settlements.

Studies and monitoring of the Greenland ice sheet and local glaciers provide a significant contribution to models for global sea-level rise. The important monitoring programme of the Greenland Ice Sheet (PROMICE) that was initiated in 2007 continuously supplies crucial data that are used in a

number of subsequent projects and in key publications. Three papers in this issue use such data from PROMICE. One discusses the ice-sheet melt area, where data from MODIS (NASA's Moderate-resolution Imaging Spectroradiometer) are validated against PROMICE data. A second is on the observed melt-season snowpack evolution of the Greenland ice sheet. A third paper gives a technical description of the automatic weather stations that have been developed for basic and applied research. A fourth paper addresses applied glaciological challenges of proglacial mining, which may be important in Greenland where several potential mining sites are located very close to the margin of the ice sheet.

Broader thematic activities

Internationally GEUS also works in many different countries with a variety of projects and is involved in broader thematic studies. The first of these thematic papers describes how digital outcrop models can be made based on images from a handheld camera, with examples from land, sea and ice. A second paper gives details of a so-called provenance study in Labrador, Canada, using detailed analytical data on zircon, rutile and titanite that can be applied to map out boundaries between major orogenic terrains. Another provenance study of heavy minerals from northern Brazil is also presented, in this case with focus on titanium placer deposits.

The challenge of climate change demands reduction in global CO₂ emissions. One of the most promising technical solutions is to use carbon dioxide capture and storage (CCS). The final paper is a summary of the CO₂StoP project, which has designed a database on storage capacity in 27 European countries and identified important gaps in our knowledge.