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GIS compilation of geoscience data: an ArcView GIS version of partly unpublished data from Wegener Halvø, central East Greenland (1 CD-ROM included)

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Contents

Abstract

This report contains a CD-ROM with a digital version of both published and unpublished geodata from the Wegener Halvø area in central East Greenland. The data are made available as an ArcView GIS project. A background topographic and geological map has been digitised from the 1:100 000 Fleming Fjord map sheet (Perch-Nielsen *et al.* 1978–81) using ArcView GIS version 3.0a. The unpublished data comprise geochemistry of stream sediment samples collected during a regional uranium exploration campaign in 1976 as well as geochemistry of rock samples collected during the recently concluded project 'resources of the sedimentary basins of North and East Greenland'.

An airborne geophysical survey was flown in northern Jameson Land in 1997, overlapping with parts of Wegener Halvø. Magnetic and electromagnetic data from this survey are also included in the GIS project.

The printed part of the report contains a short overview of geology and mineralisation, background information of the various themes presented in the GIS project and a short discussion of the data.

This report has been published with financial support from the Bureau of Minerals and Petroleum, Government of Greenland.

Introduction

This report contains a CD-ROM with a digital presentation of partly unpublished geodata from the Wegener Halvø area in central East Greenland. Wegener Halvø has for a long time been known to contain widespread mineral occurrences (Harpøth *et al.* 1986). The Upper Permian shales of the *Ravnefjeld Formation* have recently been subject to ore geological investigations as a part of the project 'resources of the sedimentary basins of North and East Greenland' (Fougt *et al.* 1999), and some of the results from this campaign are included here. Furthermore, geochemical analyses of stream sediment samples collected in 1975 are included as are geophysical maps from the project AEM 1997 (Stemp 1998). Most of the information gathered by early Danish expeditions to the area and by Nordisk Mineselskab A/S until 1985 was summarised by Harpøth *et al.* (1986) and is not included on the CD-ROM.

The topographic and geological background on the CD-ROM has been digitised from the 1:100 000 Fleming Fjord map sheet (Perch-Nielsen *et al.* 1978–81) using ArcView GIS version 3.0a.

The CD-ROM is for users who have an ArcView GIS software licence and a basic knowledge of the ArcView GIS software. The freeware ESRI ArcExplorer (version 1.1.2) is not a suitable viewer for the digital GIS data due to lack of projection facilities in the program.

The directory structure and the content of the CD-ROM follow the overall ideas discussed in Schjøth & Thorning (1998).

Geological overview of the Wegener Halvø area

Stratigraphic framework

Wegener Halvø is situated close to the eastern margin of the post-Caledonian Jameson Land Basin. The oldest rocks in the area are Precambrian metasediments of the Eleonore Bay Supergroup, exposed on the north-eastern tip of the peninsula. Devonian sedimentary and acid volcanic rocks are likewise exposed in the north-eastern part of Wegener Halvø as well as along the coast and in deeper parts of the valleys. These deformed units are in most of the area unconformably overlain by an Upper Permian transgressive sequence called the *Foldvik Creek Group*. Only locally are Carboniferous – Lower Permian clastic sediments found in between the Devonian and Upper Permian sediments. The youngest sedimentary rocks in the area are of Triassic to Lowermost Jurassic age and represent varying marine and continental depositional conditions. A number of Tertiary basaltic dykes are also found in the area, especially along tectonic lineaments. The density of dykes in the area, however, is noticeably smaller than in other parts of the basin, and no dykes are included on the geological map on the CD-ROM.

The *Foldvik Creek Group*

The *Foldvik Creek Group* has been subject to much recent research. It consists of a basal conglomerate (*Huledal Formation*), which is very thin or sporadically absent on Wegener Halvø as compared to other parts of the basin. This is overlain by two carbonate units; the *Karstryggen* and *Wegener Halvø Formations*. The *Karstryggen Formation* was deposited in a hypersaline environment and was later eroded during subaerial exposure (Surlyk *et al.* 1986). The *Wegener Halvø Formation* is on Wegener Halvø dominated by carbonate build-ups which have grown on palaeotopographic highs. A package of time-equivalent bituminous mud stones (*Ravnefjeld Formation*) is found in karstic depressions in the *Karstryggen Formation* and in more basin-ward settings in the north-western part of the area where it also attains greatest thicknesses. The *Schuchert Dal Formation* forms the top of the *Foldvik Creek Group* in the area. It represents a regressive phase within the basin (Surlyk *et al.* 1984) and consists on Wegener Halvø mainly of carbonate-rich sandstones which are locally very rich in shell fragments.

Mineralisation

Mineralisation with lead, zinc, copper, barium, silver, gold and uranium is widespread on Wegener Halvø (Harpøth *et al.* 1986). Vein-type occurrences of base metals, gold and silver with quartz, carbonate, barite and fluorite as gangue minerals are common in the Devonian to Lower Permian part of the stratigraphy, especially on the north-eastern tip of Wegener Halvø and around Tvekegledal (Harpøth *et al.* 1986). Gold has also been reported from the Devonian part of the stratigraphy, and seems to be closely associated with

'stockwerk' veining in feldspar porphyries of rhyodacite-latite composition (Harpøth *et al.* 1986; B. Thomassen pers. com.).

Stratabound occurrences of copper and barite with minor lead, zinc and silver are found in Upper Permian carbonates in large parts of Wegener Halvø. The main ore minerals are chalcopyrite, galena, sphalerite and tennantite-tetrahedrite. The mineralisation is clearly related to fractures in the limestones and is always associated with intense barite veining. On the eastern part of Quensel Bjerg and in the eastern part of Devondal quartz-veining and occasionally drusy quartz is also found. In some localities late fluorite crystals are found in cavities. Mineralisation in the carbonates has been shown to post-date hydrocarbon migration in the area, and an Early Tertiary age has been suggested (Stemmerik 1991)

The shales of the *Ravnefjeld Formation* are found to mineralised inside an almost 50 km^2 area on Wegener Halvø. Mineralisation is in most places confined to the lowermost metre of the shale sequence, immediately above the carbonates of the *Karstryggen Formation*. Only in a narrow (c. 200 metre wide) shale basin lying in the southern extension of the Vimmelskaftet valley is the *Ravnefjeld Formation* found to be mineralised in a significant vertical section. This zone coincides with a tectonic lineament (the Vimmelskaftet lineament), which is believed to have controlled the introduction of mineralising fluids to the shales. This lineament can also be found c. 8 km further towards the south on Quensel Bjerg, where the *Ravnefjeld Formation* is more sandy and unmineralised, but where the surrounding carbonates are found to be pervasively mineralised with barite, copper, lead and zinc.

The main ore minerals found in the *Ravnefjeld Formation* are sphalerite and galena but occasionally pyrite and chalcopyrite are found. Replacement of fossils by ore minerals is widespread, and mineralisation often coincides with layers of resedimented material derived by breakdown of build-ups of the *Wegener Halvø Formation*. Mineralisation of the *Ravnefjeld Formation* is believed to be of early diagenetic origin, mainly because of the occurrence of ore minerals in concretions formed prior to shale compaction (Nielsen & Pedersen 1998).

All Triassic formations have been found to be base metal and silver enriched in large parts of east Jameson Land, and in the area covered by the CD-ROM, especially the south side of Devondal contains widespread Triassic-hosted metal occurrences. A thorough overview of these occurrences was given by Thomassen *et al.* (1982) and Harpøth *et al.* (1986).

Some important general trends for the Triassic-hosted mineralisation are that they are laterally continuos. Furthermore, they are found in all Triassic formations, whereas mineralisation in the overlying Jurassic sediments never has been observed. In general copper is found in all Triassic formations, whereas lead and zinc is absent from the Upper Triassic *Fleming Fjord Formation*. The sulphides are mainly found as fine-grained disseminations and a diagenetic origin has been suggested for the mineralisation (Thomassen *et al.* 1982; Harpøth *et al.* 1986).

Use of the CD-ROM

The CD-ROM contains a geoscientific data set for the Wegener Halvø area for users with an ArcView GIS software licence. The GIS project is made for ArcView GIS version 3.x running on Windows 95/98 or Windows NT 4.0 or newer versions. It can also run on a UNIX workstation. A PC with at least a Pentium processor, 32 Mb RAM and a graphic interface with at least 2 Mb is recommended.

Getting started

To use the CD-ROM, simply insert the CD-ROM into the computer and start ArcView. Open the project ***wegener.apr*** which is located in the *\av_data* directory (see fig. 1 for directory structure) and open a view. The project contains 13 views (Fig. 2) of which 10 cover topography, geology, samples, geochemistry and geophysics. The remaining threee views contain legends for use with the geophysical maps (see later).

- The **Index** view shows the geographic location of Wegener Halvø.
- The **topographic map** view contains coast lines, rivers and place names.
- The **geology** view contains geological units and faults, and has furthermore included a number of photo localities. These are subdivided into general photos, photos of rocks in outcrop and photos of samples in hand specimens and under microscope. To view a picture, activate the **photograph** theme, press the hot link button and select a point (⊠). For the best effect, maximise the picture window.
- The geochemical data sets are presented in two different views, one containing **stream sediment** data and one containing analytical results from **rock samples**. Both views consist of a number of themes (one per element) which – when activated – will result in dot plots for the selected elements. Parameters are given in the legend box. Detection limits are given in Table 1 and 2. It is possible to chose a geological map for background by activating the **geology** theme in the lowermost part of the theme list.

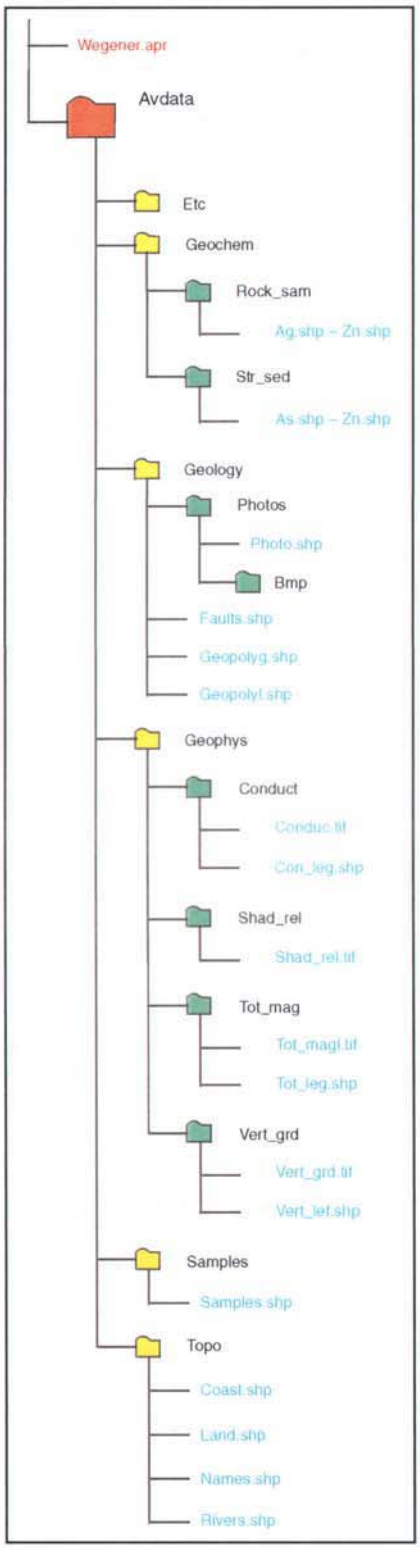

Figure 1. *Overall directory structure showing the location of important files.*

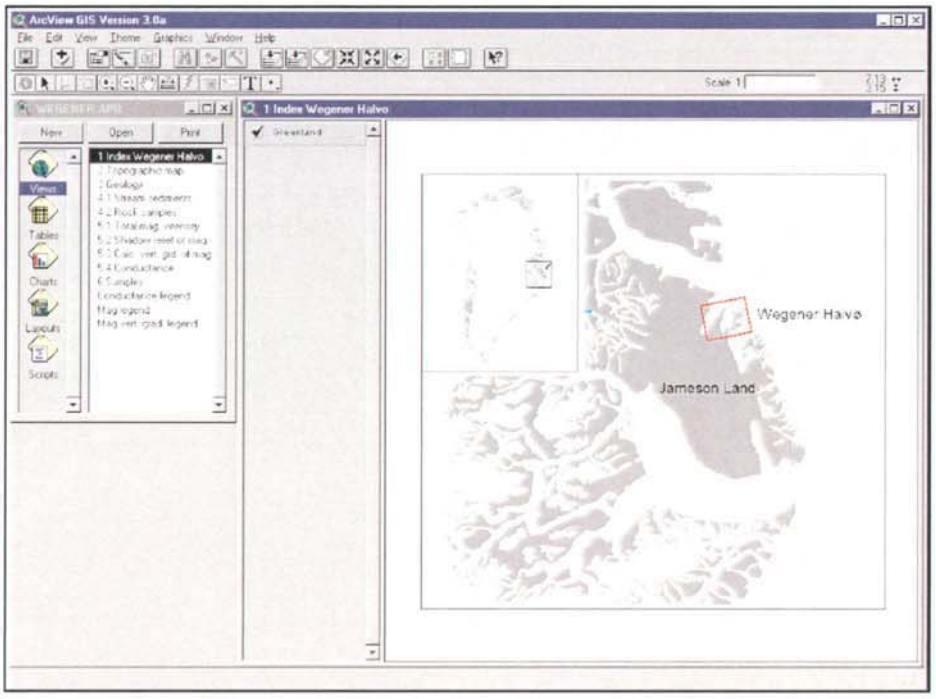

Figure 2. *The project window showing the list of view to the left and the index map to the right.*

- Four geophysical views are included on the CD-ROM comprising **total magnetic intensity** data, **shadow relief of magnetics**, **calculated vertical gradient of magnetics** and **conductance**. These views are all arranged in the same way. Coast lines and geophysical data are by default visible when opening the view. The geophysical features can subsequently be related to geological units by comparing with the **geology outline** theme, which for visual reasons only contain the boundaries between geological units. More information can be deduced by comparing with the geology view. To display colour legends, activate the legend theme, press the hot link button and press the legend symbol.
- The **samples** view contains a simple topographic map of Wegener Halvø with all samples plotted as squares. Information concerning a single sample can be obtained by activating the sample theme, selecting the info tool and clicking on a square. A list of samples can be seen by opening the attribute table ()for the **samples** theme

Other possibilities

Besides using the CD-ROM as described above, the GIS project can be treated by all the usual ArcView tools. That means that it is possible to zoom to specific areas, activate and deactivate themes and combine themes as needed. It is also possible to see actual analytical values for individual samples by activating a geochemical theme and selecting a sample with the info tool (). Furthermore, it is possible to change the category limits on the dot plots by double clicking on the theme and simply change the numbers. To learn more about the possibilities offered by the software, please refer to the ArcView GIS manual.

Data

The projection of the ArcView GIS data is UTM zone 26, datum WGS 84.

Topographic and geological map

The topographic and geological maps were digitised on-screen in ArcView GIS on basis of transparent print originals of the 1:100 000 Fleming Fjord map sheet (Perch-Nielsen *et al.* 1978–81). These originals were initially scanned on an A0 scanner and rectified using ArcInfo. The topographic data are split in various themes including coastline, land/sea, rivers and place names. The geological information is slightly simplified compared to the original Fleming Fjord map sheet. This part includes a **geology** theme (geopolyg.shp) with coloured polygons and a **geology outline** theme (geopolyl) which only includes the outline of geological units for use as overlay on geochemical and geophysical maps.

Geochemistry of whole rock samples

Geochemical data on rock samples includes ICP-ES (inductively coupled plasma emission spectrometry) analyses of samples collected during field work in 1996. This field season focussed on mineralisation in the Upper Permian *Ravnefjeld Formation* and most samples accordingly belong to this geological unit. The samples were analysed at Activation laboratories Ltd., Canada. The lower detection limits are given in table 1.

Element	*Det. limit*
Ag	0.2 ppm
Cd	0.5 ppm
Cu	1 ppm
Mn	2 ppm
Ni	1 ppm
Pb	2 ppm
Zn	1 ppm

Table 1. *Lower detection limits for ICP-ES analyses on whole rock samples.*

Geochemistry of stream sediment samples

Stream sediment samples were collected during a regional uranium exploration programme in northern East Greenland in 1976 (Steenfelt & Kunzendorf 1979). At each sample station c. 500 g of stream sediment was collected in a paper bag. To increase the representativity each stream sediment sample was composed of subsamples from different sites of sand and silt deposits in the stream bed or banks.

The samples were dried and sieved using a sieve aperture of 0.15 mm. The coarse fraction was discarded, and the fine fraction submitted for analysis. The samples were analysed at Risø by delayed neutron counting and radioisotope-excited X-ray fluorescence spectrometry with plutonium source in 1976 (Kunzendorf 1979). In 1992 the samples were further analysed by instrumental neutron activation analysis at Activation Laboratories Ltd. in Canada. For analysis methods and lower detection limits for individual elements see table 2.

Geophysical data

An airborne electromagnetic (GEOTEM) and magnetic survey was carried out in northern Jameson Land in 1997 as part of the project 'AEM Greenland 1994–1998' with the aim of stimulating mineral exploration (Stemp & Thorning 1995). The southern part of Wegener Halvø falls within the survey area and the geophysical data from this area are included in the CD-ROM. Four maps are presented as described in the previous section comprising total magnetic intensity, calculated vertical gradient of magnetics, shadow relief of magnetics and conductance. The shadow relief of magnetics map has been produced from the digital grid data by 'illuminating' from the east at an angle of 45°. The conductance has been calculated from the Z-coil on-time & off-time data and fitted to the thin sheet model by Geoterrex (Smith 1998).

Element	*Analysis method*	*Det. limit*
Ag	Act., INAA	5 ppm
As	Act., INAA	2 ppm
Au	Act., INAA	5 ppb
Ba	Act., INAA	100 ppm
Br	Act., INAA	1 ppm
CaO	Risø, XRF-plu.	
Ce	Act., INAA	3 ppm
Co	Act., INAA	5 ppm
Cr	Act., INAA	10 ppm
Cs	Act., INAA	2 ppm
Cu	Risø, XRF-plu.	10 ppm
Eu	Act., INAA	0.2 ppm
Fe_2O_3	Risø, XRF-plu.	
Ga	Risø, XRF-plu.	10 ppm
Hf	Act., INAA	1 ppm
Hg	Act., INAA	1 ppm
Ir	Act., INAA	5 ppm
K_2O	Risø, XRF-plu.	
La	Act., INAA	1 ppm
Lu	Act., INAA	0.05 ppm
MnO	Risø, XRF-plu.	
Mo	Act., INAA	5 ppm
Na	Act., INAA	0.05 %
Nd	Act., INAA	5 ppm
Ni	Risø, XRF-plu.	10 ppm
Pb	Risø, XRF-plu.	10 ppm
Rb	Act., INAA	30 ppm
Sb	Act., INAA	0.2 ppm
Sc	Act., INAA	0.1 ppm
Se	Act., INAA	5 ppm
Sm	Act., INAA	0.1 ppm
Sn	Act., INAA	100 ppm
Ta	Act., INAA	1 ppm
Tb	Act., INAA	0.5 ppm
Th	Act., INAA	0.5 ppm
TiO_2	Risø, XRF-plu.	
U	Risø, DNC	0.016 ppm
V	Risø, XRF-plu.	50 ppm
W	Act., INAA	4 ppm
Yb	Act., INAA	0.2 ppm
Zn	Risø, XRF-plu.	10 ppm

Table 2. *Analysis methods and lower detection limits for analyses on stream sediment samples. Act. (Activation Laboratories Ltd.); INAA (Instrumental Neutron Activation Analysis); Risø (Risø National Laboratory); XRF-plu (X-ray Fluorescence Spectrometry with plutonium source); DNC (Delayed Neutron Counting).*

Discussion

The geochemical data on shale samples from the Upper Permian *Ravnefjeld Formation* confirm the overall mineralisation pattern as observed in the field and described by Pedersen (1997). The shales are enriched in base metals over a large area, but are especially enriched in a locality SW of the Ravnefjeld mountain. On this locality the shales are cut by the N–S trending Vimmelskaftet lineament, which has been suggested as conduit for the hydrothermal fluids. The base metal enrichment decreases gradually away from the Vimmelskaftet lineament, but rather high values are found all along the western flank of the valley of Vimmelskaftet.

The stream sediments from the valley of Vimmelskaftet are relatively enriched in Zn in accordance with the previously described mineralisation pattern. However, Pb, Cu and Ba are not particularly enriched in these samples, which can be a result of dilution caused by the thick sequence of Devonian rocks which are also drained by the stream in this valley. Ba is most enriched in the Jameson Elv due to the vicinity of Quensel Bjerg, where the Upper Permian carbonates are very rich in barite. For the same reason Cu, Pb and Zn are enriched in the same samples. It is noticeable that the single sample taken in Devondal is depleted in base metals and barite even though it drains an area where the carbonates are mineralised.

The stream sediments from the north-eastern tip of Wegener Halvø are enriched in a number of elements including Pb, Zn, As, Br, Co, Cr, Cs, Fe_2O_3, Hf, Ni, Rb, Sb, Sc, Th, U and REE. This enrichment may partly be due to the presence of sulphide-bearing quartz veins in the Devonian units (Harpøth *et al.* 1986). The pronounced enrichment in REE, U and Th, however, more likely relates to phosphatic sandstone layers as described in relation to U occurrences in central Wegener Halvø (Harpøth *et al.* 1986).

The magnetic maps show a NE–SW running zone of high magnetism to coincide with the Wegener Halvø peninsula and its south-western continuation. This could be caused by the presence of a relative shallow crystalline basement – possibly a horst – separated by a set of NE–SW trending faults underlying Fleming Fjord and Nathorst Fjord. Alternatively, it could be spectulated wheather the high-magnetic trend stems from a row of granitic intrusions, perhaps associated with the Devonian rhyolites, which are present in the area.

The magnetic maps show the existence of a number of N–S trending lineaments. The Vimmelskaftet lineament shows as a negative magnetic feature which can be traced from Devondal to the north coast of Wegener Halvø. This extent of the lineament seen in the magnetic maps confirms the field observations of Pedersen (1997), who suggested a N–S extent of at least 12 km based on obervations of shale troughs at several localities along strike.

The conductance map show no anomalies in the area covered by the CD-ROM. The zones of highest conductance correspond to the topographic highs, which also correspond to areas with exposed Upper Permian and Triassic carbonaceous units. A combination of these factors probably accounts for most of the variations in conductance shown on the map.

Conclusion

Partly unpublished geochemical and geophysical information from Wegener Halvø, central East Greenland has been presented in a digital format as an ArcView GIS project.

The geochemical data on samples of black shales from the Upper Permian Ravnefjeld Formation show the presence of a base metal-enriched zone centerred around the Vimmelskaftet lineament, and thus supports previous field observations. Stream sediment geochemistry only to a limited extent reflect base metal mineralisation in the Upper Permian part of the stratigraphy, but indicate the presence of a multi-element enriched zone on the northeastern tip of the peninsula.

Useful structural information can be deduced from the total magnetic intensity map, as this reveals the location of important N-S trending lineaments.

Acknowledgement

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