

Airborne geophysical surveys in Greenland – 1996 update

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Two major airborne geophysical surveys were carried out in 1996, the third year of a planned five-year electromagnetic and magnetic survey programme (project AEM Greenland 1994–1998) financed by the Government of Greenland, and the second year of an aeromagnetic survey programme (project Aeromag) jointly financed by the governments of Denmark and Greenland; both projects are managed by the Geological Survey of Denmark and Greenland (GEUS). The two 1996 surveys were:

- 1) Project Aeromag 1996 in South-West and southern West Greenland;
- 2) Project AEM Greenland 1996 in South-West Greenland.

All areas surveyed and planned for future surveys as of March 1997 are shown in Figure 1. Results of both the 1996 surveys were released in March 1997, as a continuation of a major effort to make high quality airborne geophysical data available for both mineral exploration and geological mapping purposes. The data acquired are included in geoscientific databases at GEUS for public use; digital data and maps may be purchased from the Survey. The main results from the 1996 surveys are described in Thorning & Stemp (1997) and Stemp (1997). Two further new airborne surveys have already been approved for data acquisition during the 1997 field season, with subsequent data release in March 1998.

A summary of all surveys completed, in progress or planned since the formal inception of project AEM Greenland 1994–1998 is given in Table 1. The programme was expanded to include a separate regional aeromagnetic survey in 1995, provisionally for 1995–1996, with extension subject to annual confirmation and funding.

Project Aeromag 1996: South-West and southern West Greenland

This project was a continuation of the highly successful regional aeromagnetic mapping programme initi-



Fig. 1. Airborne geophysical surveys in Greenland 1992–1997. Project AEM Greenland surveys outlined in green, Project Aeromag in red.

Table I. Surveys completed and planned under project AEM Greenland and project Aeromag

<p>(a) AEM Greenland 1994: fixed-wing electromagnetic (GEOTEM) and magnetic survey (Stemp & Thorning, 1995) Inglefield Land, North-West Greenland 17 340 line km 400 x 4000 m grid 120 m terrain clearance (drape) flown by Geoterrex Ltd financed by the Government of Greenland data released 1995</p>
<p>(b) AEM Greenland 1995: fixed-wing electromagnetic (GEOTEM) and magnetic survey (Stemp, 1996a) Maniitsoq–Nuuk area, central West Greenland 20 446 line km 200 x 4000 m and 400 x 4000 m grid 120 m terrain clearance (drape) flown by Geoterrex Ltd financed by the Government of Greenland and Cominco Ltd data released 1996</p>
<p>(c) Aeromag 1995: fixed-wing magnetic survey (Thorning & Stemp, 1997) South Greenland 89 755 line km 500 x 5000 m grid 300 m terrain clearance (drape) flown by Sander Geophysics Ltd financed by the governments of Denmark and Greenland data released 1996</p>
<p>(d) Aeromag 1996: fixed-wing magnetic survey (Thorning & Stemp, 1997) South-West and southern West Greenland 67 277 line km 500 x 5000 m grid 300 m terrain clearance (drape) flown by Geoterrex Ltd financed by the governments of Denmark and Greenland data released 1 March 1997</p>
<p>(e) AEM Greenland 1996: helicopter electromagnetic, magnetic, radiometric and VLF-EM survey (Stemp, 1997) five areas in South-West Greenland 8756 line km 200 x 2000 m grid 60 m terrain clearance flown by Aerodat Inc. financed by the Government of Greenland data released 1 March 1997</p>
<p>(f) AEM Greenland 1997: fixed-wing electromagnetic and magnetic survey central East Greenland financed by the Government of Greenland to be flown by Geoterrex Ltd. data to be released March 1998</p>
<p>(g) Aeromag 1997: fixed-wing magnetic survey Disko Bugt area, central West Greenland financed by the Government of Greenland to be flown by Sander Geophysics Ltd. data to be released March 1998</p>
<p>(h) AEM Greenland 1998: financed by the Government of Greenland in planning stage</p>

ated in 1995 in South Greenland (Thorning & Stemp, 1996, 1997) and extends coverage northwards along the west coast of Greenland to latitude 63°45'N (Fig. 1). This high sensitivity airborne magnetic survey is designed to map regional geological structures throughout the area, including beneath the Inland Ice, in order to gain a better understanding of the complex geology of the region.

The survey was flown by Geoterrex Ltd between 4 June and 14 September 1996, using a geophysically equipped Cessna Titan 404 aircraft operating out of the airports at Nuuk and Narsarsuaq. A total of 67 277 line km of data were acquired based on 500 metre spaced flight lines and 5000 metre spaced tie lines. Despite the fact that 50 % of available days were lost due to inclement weather, good production was achieved by the employment of 'double crews' to take advantage of the long daylight hours available during the Greenland summer. Other positive production factors included long survey lines, a choice of two airstrips for refuelling (as well as safety considerations), and the use of a long range aircraft, with only three days lost due to unserviceable equipment.

The 'highs' and 'lows' experienced in conducting airborne geophysical surveys in Greenland can best be illustrated by the following two examples:

1) A good survey day - 17 July 1996:

Flight 45	6.5 hours	1295 line km
Flight 46	7.6 hours	1643 line km
Total	14.1 hours	2938 line km

2) A poor survey month - August 1996:

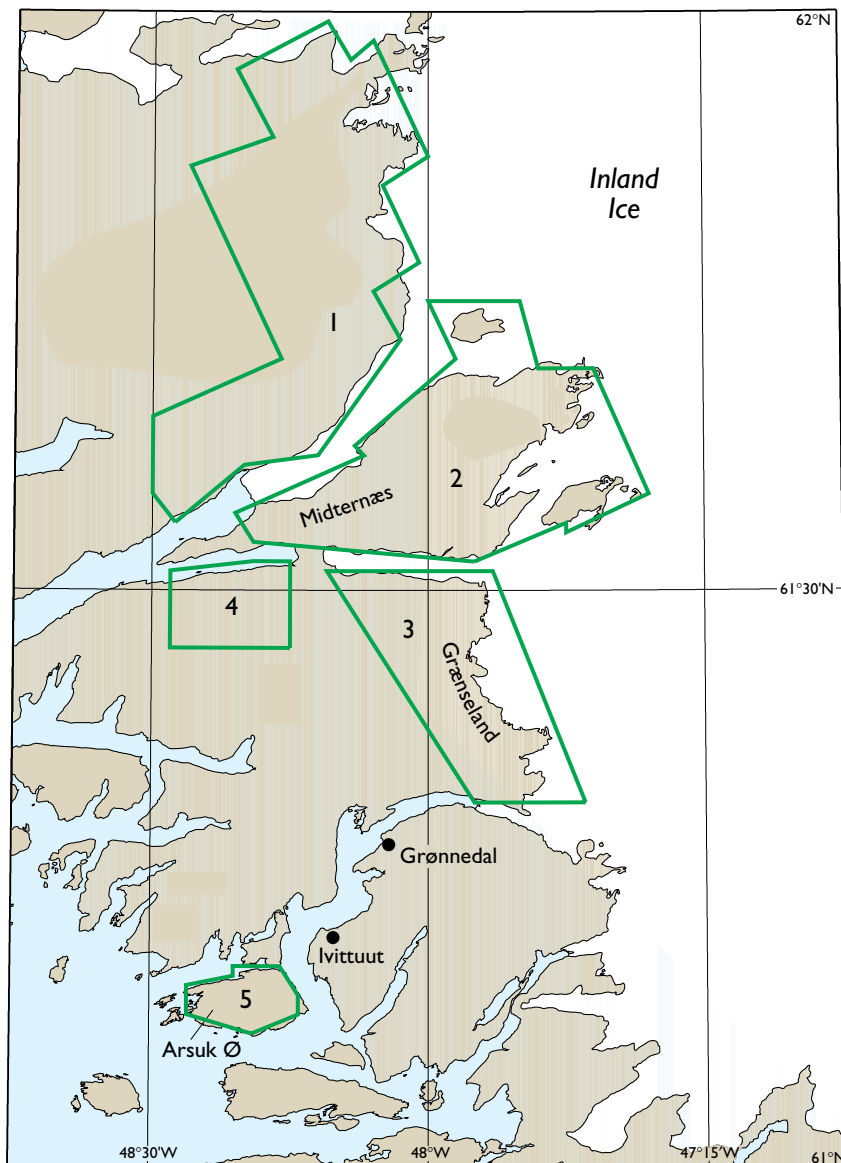
Total survey hours:	53.2
Total line km:	8672

Two important changes were introduced in 1996 based on experience gained from project Aeromag 1995 (Thorning & Stemp, 1996). The first was to reduce the size of the survey from approximately 90 000 line km to no more than 70 000 line km. The second was to begin the tendering process earlier so that an early June mobilisation date by the successful contractor was feasible. The objective was to adjust the size and timing of the field work to the weather window in Greenland. There is no doubt that these adjustments were successful in 1996.

One of the secondary benefits derived from this continuing airborne survey programme is the statistical database developing with respect to survey operations

Fig. 2. Location of the five survey areas of project AEM Greenland 1996.

- 1: Tartoq Group areas north of Midternæs;
- 2: Midternæs, mainly Ketilidian supra-crustal rocks;
- 3: Grænseland, mainly Ketilidian supra-crustal rocks;
- 4: Tartoq Group areas south-west of Midternæs;
- 5: Arsuk Ø, Ketilidian supracrustal rocks.



in Greenland, i.e. when is flying possible? What is the best month in a particular region?

Results of Aeromag 1996 were released on 1 March 1997 in digital format, as well as in the form of map sheet sets at scales of 1: 50 000 and 1: 250 000.

Project AEM Greenland 1996: South-West Greenland

For the first time since the inception of the AEM programme in Greenland, a helicopter was used to conduct a geophysical survey. A total of 8756 line kilometres of geophysical data were collected between 30 May and 23 October 1996, by the Canadian contractor

Aerodat Inc. The helicopter was based at Grønnedal in southern West Greenland, a Danish naval base south of the main survey areas (Fig. 2). Five separate blocks were surveyed, the primary objectives being supra-crustal rocks of both Early Proterozoic (Ketilidian) and Late Archaean (Tartoq Group) age.

In addition to the standard multi-frequency EM and magnetic measurements, radiometric and VLF-EM measurements were made for the first time. The helicopter survey system employed is illustrated in Figure 3. An ASTAR (AS-350B2) helicopter owned and operated by Greenlandair A/S served as a suitable survey platform for the geophysical package, which consisted of the following:



Fig. 3. The Greenlandair helicopter taking off from Grønnedal with the Aerodat bird assembly. Magnetometer and VLF sensor in midair, with electromagnetic transmitter/receiver system on ground.

- 1) a five frequency EM system employing both vertical co-axial and horizontal co-planar coil pairs housed in the lower bird;
- 2) a high sensitivity magnetometer housed in the upper bird;
- 3) a dual channel VLF-EM system also housed in the upper bird;
- 4) a 256 channel gamma ray spectrometer utilising a detector crystal volume of approximately 17 litres, mounted on the floor of the helicopter.

Despite an early and successful start to the project, it was plagued by operational problems resulting in lengthy delays. Twice the complete bird assembly was released from the cargo hook of the helicopter for, as yet, undetermined reasons. On the first occasion the helicopter was surveying on line, and the release resulted

in non-repairable damage to the bird assembly. The second incident took place when the helicopter was ferrying to the survey area, and the equipment dropped into a fjord and sank. Bird damage (repairable) occurred on a third occasion during an emergency landing as a result of a hydraulic failure of the helicopter. The perseverance of both Aerodat and Greenlandair personnel finally resulted in the successful completion of all aspects of the programme in late October.

Each survey block was flown with a mean helicopter terrain clearance of 60 m with flight lines spaced at 200 m intervals, resulting in very high resolution data from multiple geophysical sensors. These data were released on 1 March 1997 at which time both digital data and maps (scales of 1:20 000 and 1:100 000) were made available for viewing or purchase.

Mineral exploration prospects for direct ground follow-up that companies and geoscientists familiar with the use of these geophysical results may be seeking, may include the following (some of which were reviewed by Stemp, 1997):

- 1) massive sulphide zones related to specific EM anomalies;
- 2) uranium concentrations mapped by the radiometric survey;
- 3) 'magnetite' mapping by both EM and magnetic surveys for indirect detection of associated minerals;
- 4) alteration zones mapped by the radiometric survey (potassium channel);
- 5) kimberlite pipe detection, i.e. circular structures on magnetic, radiometric or EM maps (Stemp, 1996b).

Financing of project AEM Greenland 1996 by the government of Greenland included funds allocated for a Ph.D. study programme. This funding will continue for three years and is a co-operative venture between GEUS and Aarhus University. Lene Poulsen, the Ph.D. candidate, will conduct quantitative, electromagnetic interpretation studies on the multi-frequency HEM data from one of the survey blocks.

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References

- Stemp, R. W. 1996a: Airborne electromagnetic and magnetic survey of the Maniitsoq–Nuuk area, southern West Greenland. Results from project AEM Greenland 1995. *Danmarks og Grønlands Geologiske Undersøgelse Rapport* **1996/11**, 34 pp.
- Stemp, R. W. 1996b: Airborne geophysical surveys applied to diamond exploration in Greenland. Some results from Project AEM Greenland 1995. *Danmarks og Grønlands Geologiske Undersøgelse Rapport* **1996/84**, 21 pp.
- Stemp, R. W. 1997: Helicopter-borne geophysical surveys in the Grønnedal region, South-West Greenland. Results from Project AEM Greenland 1996. *Danmarks og Grønlands Geologiske Undersøgelse Rapport* **1997/12**, 66 pp., including 40 maps.
- Stemp, R. W. & Thorning, L. 1995: Airborne electromagnetic and magnetic survey of Inglefield Land, North-West Greenland. Results from project AEM Greenland 1994. *Open File Series Grønlands Geologiske Undersøgelse* **95/1**, 45 pp.
- Thorning, L. & Stemp, R. W. 1996: Airborne geophysical surveys in 1995. *Bulletin Grønlands Geologiske Undersøgelse* **172**, 71-73.
- Thorning, L. & Stemp, R. W. 1997: Projects Aeromag 1995 and Aeromag 1996. Results from aeromagnetic surveys over South Greenland (1995) and South-West and southern West Greenland (1996). *Danmarks og Grønlands Geologiske Undersøgelse Rapport* **1997/11**, 44 pp.

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