Airborne geophysical surveys in central West Greenland and central East Greenland in 1997

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In order to stimulate mining exploration activity in Greenland the Government of Greenland decided in 1993 to finance a five-year programme of airborne electromagnetic surveys over selected regions of Greenland, Project AEM Greenland 1994–1998. By the end of 1996 three surveys had been undertaken in various parts of Greenland (Stemp & Thorning 1995a, b; Stemp 1996a, b; Stemp 1997a, b). In 1992 the Danish Government financed a small aeromagnetic survey (Project Aeromag 1992; Thorning 1993). Regional aeromagnetic surveying was taken up again when the governments of Denmark and Greenland jointly financed two aeromagnetic surveys in 1995 and 1996 – the projects Aeromag 1995 and Aeromag 1996 (Thorning & Stemp 1997).

To this suite of airborne geophysical surveys of selected regions in Greenland were added two surveys in 1997, both financed by the Government of Greenland. The fourth year of Project AEM Greenland 1994–1998 encompassed a transient electromagnetic (GEOTEM) and magnetic survey over northern Jameson Land, central East Greenland, while Project Aeromag 97 added a regional aeromagnetic survey over Disko Bugt – Nuussuaq, central West Greenland. As in previous years, commercial geophysical contractors carried out the survey operations in Greenland according to an agreement with the Geological Survey of Denmark and Greenland (GEUS) entered into after international tendering following rules of the European Union. GEUS manages the projects and organises the distribution and use of the results. The new maps and digital data from the two 1997 surveys, a total of 85 252 line kilometres of data covering 51 414 km^2, were released to the public on 1 March 1998.

This note provides some introductory information about the two surveys. Further information can be found in reports by Stemp (1998) and Thorning (in press); both include a number of full-page colour anomaly maps from the survey areas.

The airborne geophysical programme will continue in 1998, and the areas to be surveyed have already been selected. The final year of Project AEM Greenland 1994–1998 will include combined GEOTEM and magnetic surveys over two regions in North Greenland: Washington Land in western North Greenland, where operations are expected to start in May 1998 operating out of Alert in Canada, and later in the season over J.C. Christensen Land in central North Greenland operating out of Station Nord in eastern North Greenland. Project Aeromag 1998 will continue the regional aeromagnetic survey programme in West Greenland, extending the coverage by including most of the region from 63°45′N to 66°N in southern West Greenland. This project will be based at Nuuk and start in March 1998. The Government of Greenland will finance all surveys in 1998.

Figure 1 shows all survey areas for the electromagnetic and magnetic surveys of Project AEM Greenland 1994–1998 and the aeromagnetic survey areas of Project Aeromag 1992, 1995, 1996, 1997 and 1998.

Project Aeromag 1997: central West Greenland

The regional aeromagnetic survey over the Disko–Nuussuaq region of central West Greenland (Fig. 1) includes onshore and offshore areas where there is ongoing exploration for both minerals and oil. While previous Aeromag surveys in 1992, 1995 and 1996 mainly covered onshore areas of interest for mineral exploration, the results obtained in 1997 will also be of major interest to petroleum exploration activities in the area.

Sander Geophysics Ltd. of Ottawa, Canada, carried out the survey operations. A total of 70 630 line km of high-resolution aeromagnetic data were acquired. The easternmost part of the survey area, mainly onshore Precambrian terrain, was flown with a line spacing of 500 m, while the westernmost part of the survey area, including off-

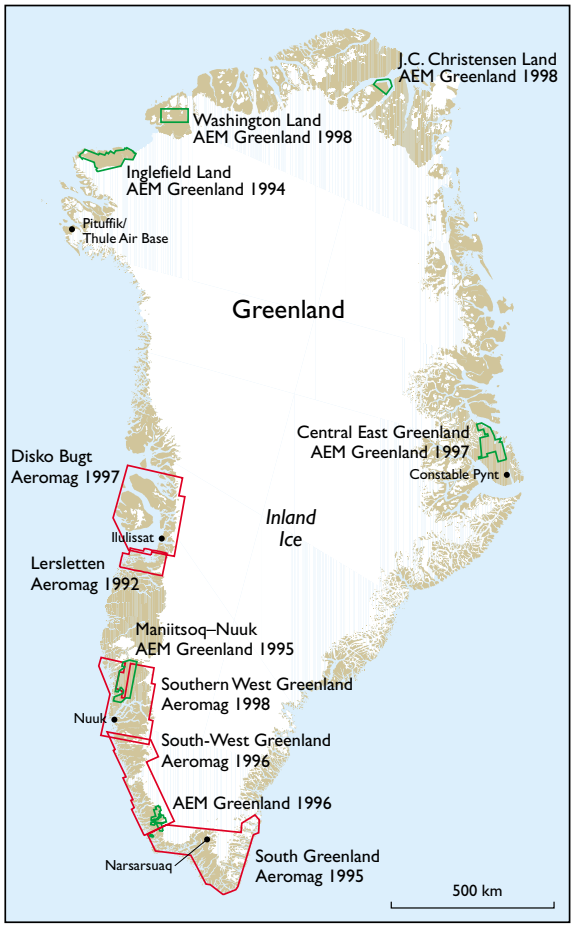

Fig. 1. Airborne geophysical surveys financed by the governments of Denmark and Greenland in the period 1992–1998.

shore areas and the basalt areas of Disko and Nuussuaq, was flown with a line spacing of 1000 m. The main line direction was north–south with control lines east–west at a spacing of 5000 m over the entire survey area. The survey altitude was kept as close to 300 m as possible by flying in a gentle drape defined by a digital terrain model and aircraft performance. The survey operations took place from 12 May 1997 to 25 July 1997 and were based at Ilulissat, the only airport in the area, using two aircraft for part of the time. For the first time in Greenland, the aircraft used were of the type Cessna 208B Grand Caravan (C-GSGY and C-GSGZ) which performed excellently. The principle instrument was a high sensitivity, caesium vapour magnetometer. During the 75-day field season 84 flights were required to collect the 70 630 line kilometres covering an area of approximately 46 187 km^2. Thus average production was 841 km per flight or 942 km per operational day. These excellent production figures reflect the limited problems with weather and equipment encountered during this survey.

The following parameters were measured digitally:

1. Airborne total magnetic field;
2. Aircraft altitude from barometric altimeter;
3. Terrain clearance from radar altimeter;
4. Airborne GPS data (latitude, longitude, height);
5. Ground total magnetic intensity;
6. Ground based GPS data (latitude, longitude, height);
7. Video tape recording of flight path.

Basic compilation scale was 1:50 000. The survey area has been divided into 35 map sheets and for each of these four maps are produced: Flight Line maps, Total Magnetic Intensity anomaly maps in colour, Total Magnetic Intensity as contour maps, and First Vertical Derivative of Total Magnetic Intensity as colour anomaly maps. Overview maps are at a scale of 1:250 000 (two map sheets) and 1:500 000 (one map sheet) include the same range of maps supplemented by shadow anomaly maps of various types. The combination of radar altimeter and differential GPS was used to calculate a model of terrain heights along lines and combine the information into a Digital Terrain Model in the form of a regular grid. This is only displayed at scale 1:500 000. More details about the instrumentation and its calibration, the acquisition of data, and the compilation and presentation of data can be seen in Murphy & Coyle (1997).

The complicated and varied geology of this region in central West Greenland encompasses Precambrian crystalline rocks, Cretaceous sedimentary basins and a major Tertiary basalt province. The new aeromagnetic maps and digital data have added substantial detail and regional coherence to the geophysical expression of the geology. As noted above, the results from Aeromag 1997 will be of considerable interest for the hydrocarbon exploration in the area (see Christiansen *et al.* 1998, this volume). A brief discussion of some of the many interesting features in the magnetic data is included in Thorning (in press).

Project AEM Greenland 1997: central East Greenland

As with project Aeromag 1997, the area selected for the AEM Greenland 1997 survey is theoretically prospective for both minerals and hydrocarbons. The survey

block is located in northern Jameson Land, central East Greenland (Fig. 1). The highly variable topographic relief limited survey coverage in the region to the areas that could be safely flown. Nevertheless, some extremely interesting airborne geophysical results were released to the public on 1 March 1998.

The Jameson Land Basin is a thick sequence of Upper Palaeozoic and Mesozoic continental and marine sediments which have been invaded by a large number and variety of Tertiary intrusions (Henriksen 1986). The area has a mining history, as Nordisk Mineselskab A/S commercially mined the Blyklippen lead-zinc deposit in the period 1956–1962. Known mineral occurrences in the region are well documented by Harpøth *et al.* (1986).

Constable Pynt airport served well as the operational base for the field survey and also for the preliminary compilation and interpretation of the results. The airport was serviced by two regularly scheduled flights per week from Iceland during the survey period. Weather was reasonable by Greenland standards, and fog was not a problem compared to conditions during earlier survey operations in parts of South and West Greenland.

Geoterrex-Dighem Ltd. of Ottawa, Canada operated a Casa aircraft (C-FDKM) equipped for transient electromagnetic (GEOTEM) and magnetic surveying (Fig. 2). A total of 14 622 line kilometres of data were acquired, including two east–west reconnaissance lines flown north of the survey area at approximate latitudes of 72°35′N and 73°15′N.

The main survey covers a 5 227 km^2 large area. Lines were oriented east–west at 400 m intervals with north–south tie lines spaced at four kilometre intervals. Mean terrain clearance of the aircraft was 120 m, subject to flight crew safety in areas of rugged topography. GPS navigation with differential post-flight processing provided the required flight path accuracy.

The airborne geophysical equipment consisted of a GEOTEM time domain (transient) electromagnetic system and a high sensitivity, caesium vapour magnetometer. The latest, three-receiver coil version of GEOTEM was utilised. The aircraft was also equipped with radar and barometric altimeters plus a colour video camera.

Data acquisition was carried out in the period 11 July – 24 August 1997, a total of 45 days including 26 production days, 13 standby days for weather or diurnal disturbances and six unserviceable days. These statistics compare favourably with earlier AEM surveys in Greenland, i.e. 50–60% production days. Average flight duration for the Casa aircraft was 4.1 hours, yielding an average production per flight of approximately 375 km.

Fig. 2. The Geoterrex-Dighem Ltd CASA aircraft being inspected by the Danish Minister of Research, Jytte Hilden (right) and the Greenland Home Rule Government Minister for Research, Marianne Jensen (left), at Constable Pynt airport. This aircraft was used for the AEM Greenland 1997 GEOTEM survey.

Thirteen map sheets at a scale of 1:50 000 cover the survey area as the primary compilation scale. Various maps were also compiled at 1:250 000, 1:500 000 (flight path location only) and 1:900 000 (A4 report size). Multichannel stacked profiles of all parameters were produced for individual flight lines at 1:50 000 scale.

Map presentations include the following:

1. GEOTEM anomalies with flight lines;
2. GEOTEM x-coil channel 12 amplitude;
3. Conductance based on z-coil GEOTEM data;
4. Total magnetic intensity;
5. Magnetic vertical gradient;
6. Grey shadow of total magnetic intensity;
7. Colour shadow of total magnetic intensity;
8. Colour drape of x-coil channel 12 amplitude over shadow relief of total magnetic intensity;
9. Digital terrain model (DTM).

The digital terrain model is an interesting ancillary product of an airborne geophysical survey created using radar altimeter and GPS elevation data.

Comprehensive information on survey equipment, specifications and data processing is available in a report by Geoterrex-Dighem Ltd. (1997) which is provided with each data purchase and is available for viewing at the Survey's offices in Copenhagen.

A survey report (Stemp 1998) provides a detailed list of specific GEOTEM conductors recommended for ground follow-up as well as an insight into both regional and local magnetic variations in the survey block, including the possible discovery of new hidden, probably Tertiary intrusions south of the Werner Bjerge complex.

In summary, year four, of the planned five-year programme, project AEM Greenland 1994–1998, continued the success of earlier years. This was the first airborne electromagnetic survey carried out in East Greenland and also the first such survey over non-Precambrian geology in the area. The growth of the geophysical database is a key ingredient in the future development of exploration in Greenland. In addition to the surveys planned for the final year of Project AEM Greenland 1994–1998, in 1998 GEUS will also carry out limited ground follow-up of interesting anomalies in the AEM Greenland 1997 survey area financed by the Government of Greenland.

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