

Aeromagnetic survey in south-eastern Greenland: project Aeromag 2013

Peter Riisager and Thorkild M. Rasmussen

Aeromagnetic surveys are nowadays used at a wide range of scales and purposes. In frontier and under-explored areas, where data are otherwise sparse or non-existent, aeromagnetic acquisition remains the cheapest and easiest way to obtain or refine a picture of the structural setting. Aeromagnetic data are also useful for strategic planning of geological mapping campaigns and detailed geophysical data acquisition. Moreover, aeromagnetic data are of importance for prospecting, helping to define prospects. Large aeromagnetic surveys can be carried out efficiently and safely almost everywhere, in a short period of time and at reasonable cost.

In the following we present the newly released *Aeromag 2013* aeromagnetic survey that covers a remote and relatively under-explored coastal region in south-eastern Greenland, stretching from 64°45'N and northward to 67°30'N (Fig. 1). The survey represents a total of 65 492 line km, and covers an area of 30 100 km², adding a significant new dataset to the already existing database of government-financed geophysical surveys in Greenland. With the completion of the *Aeromag 2013* project, the database presently contains a total of *c.* 633 500 line km of high-resolution aeromagnetic data and *c.* 75 000 line km of multi-parameter data (electromagnetic, magnetic and partly radiometric data). Further details on previous surveys on Greenland and the database of available aeromagnetic data are summarised in Rasmussen *et al.* (2013; see also Fig. 1).

Details of the Aeromag 2013 survey

EON Geosciences Inc. flew the *Aeromag 2013* survey between 13 June and 2 September 2013, using two Piper Navajo PA-31 aircraft equipped with geophysical instruments (detailed below), and operating out of the airport at Kulusuk. The magnetic base stations used for correction of diurnal magnetic variations were installed at two different locations in Kulusuk.

The survey was carried out by flying along a gently draped surface 300 m above the ground or sea level. Due to the severe topography ranging from sea level to *c.* 2450 m, the gentle drape resulted in an average height above ground of 711 m. The survey lines were NE–SW-oriented, parallel to the coastline with a separation of 500 m while orthogonal

tie-lines were flown with a separation of 5000 m. Total magnetic field data were recorded with a sampling interval of 0.1 sec. which corresponds to a sample distance of *c.* 7 m. The magnetic field at the base station was recorded with a 1 sec. sampling interval. Aircraft positional data from differential GPS measurements were recorded with a 1 sec. sampling interval, and aircraft altitude measurements obtained from barometric altimeter and radar were recorded with a sampling interval of 0.1 sec. A continuous digital video recording of the terrain passing below was also produced. Further details on the survey operation and equipment can be found in a report by EON Geosciences Inc. (2013), which is available at the online DODEX database at the Geological Survey of Denmark and Greenland (Riisager *et al.* 2011).

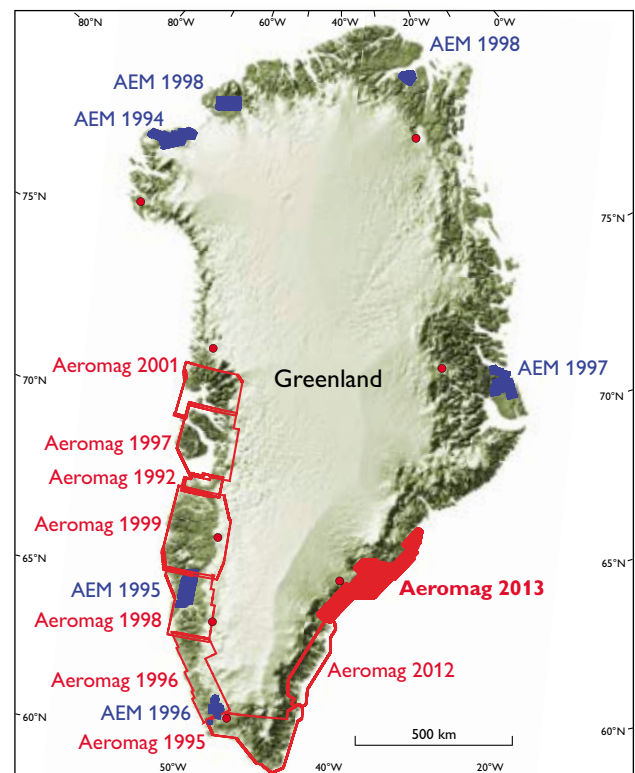


Fig. 1. Map of Greenland showing the location of government-financed high-resolution airborne geophysical surveys conducted from 1992 to 2014. Red: aeromagnetic surveys (Aeromag). Blue: combined electromagnetic and magnetic surveys (AEM).

Results and products

The *Aeromag 2013* survey dataset can be obtained as line data in the format of a Geosoft database. In addition two map sheets at scales of 1:250 000 and 35 map sheets at scales of 1:50 000 have been produced from interpolation and gridding of the data. The map sheets are available as both grid-files and pdf-files. Each of the map sheets shows the total magnetic field intensity and first and second vertical derivatives. Figure 2 shows the gridded total magnetic field intensity data for the entire survey area. The International Geomagnetic Reference Field corresponding to the date and location of the measurement has been subtracted from the data leaving the magnetic anomalies caused by the variation of magnetisation in the uppermost crust. Superimposed on the magnetic anomaly data in Fig. 2 is a shaded relief modelled by using a light-source illumination inclination of 45° and a declination of 45° (i.e. a light-source from the north-west).

Release of data

The completion of the *Aeromag 2013* project was marked by the release of the data on 3 March 2014. The data can be

obtained for free from the Ministry of Industry and Mineral Resources in Greenland by submitting a form available at the Greenland Mineral Resources portal (<http://www.greenmin.gl/>).

Magnetic anomaly maps and geological implications

The surface geology of the surveyed region is shown on the map in Fig. 3. The survey covers the eastern part of the Nagssugtoqidian orogen that mainly consists of reworked Archaean gneisses with minor supracrustal rocks and several Palaeoproterozoic intrusives (Bridgwater *et al.* 1990; Kolb in press). Palaeogene intrusions and coast-parallel dykes are found in the northern part of the survey area (Tegner *et al.* 1998).

The magnetic anomalies mapped in the *Aeromag 2013* survey area range in amplitudes between -1318 nT and +3270 nT, with both the most negative and positive values relating to mapped intrusions (Figs 2, 3). In the southern part of the survey area, several NNE-SSW-trending subparallel linear and positive anomalies (marked I in Fig. 2) are clearly discernible, and most likely represent large dykes. The anomalies can be traced in the survey area over more than

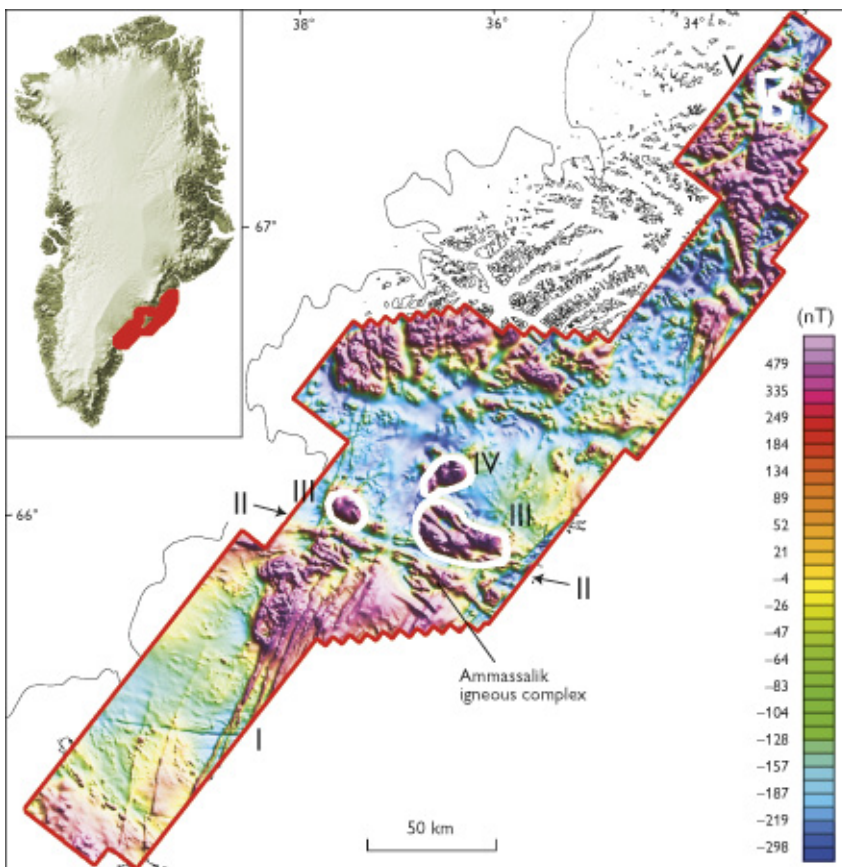
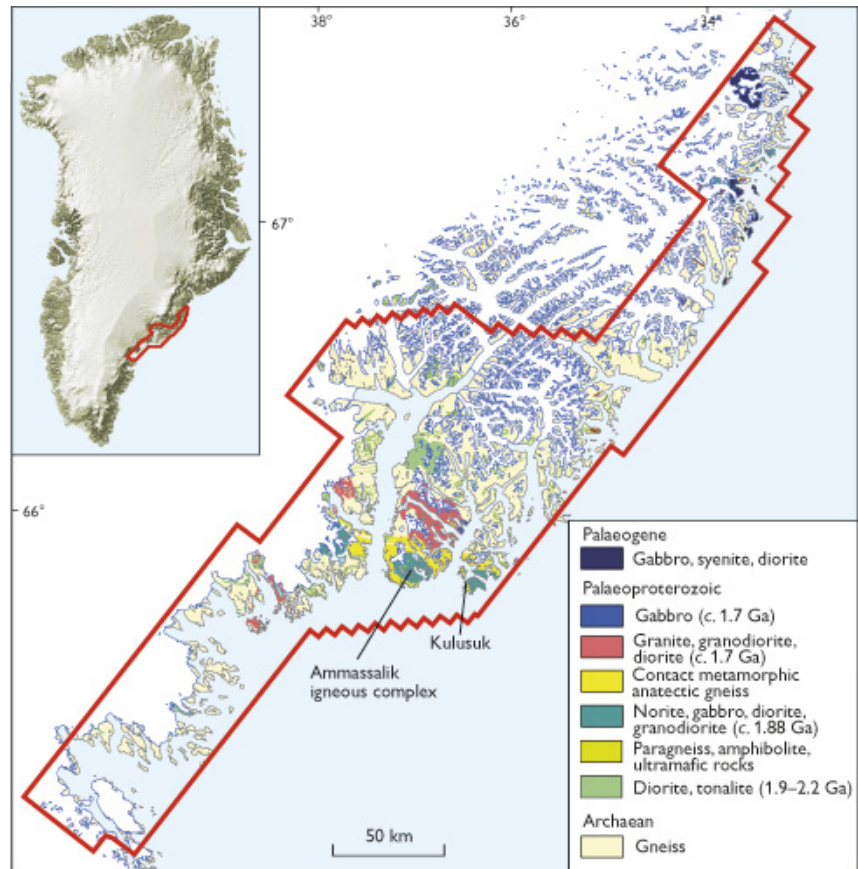


Fig. 2. Aeromagnetic anomaly map of the survey area in south-eastern Greenland covered during the *Aeromag 2013* project. I-V: magnetic anomalies discussed in the text. I: Possible large dykes NNE-SSW. II: Magnetic E-W low. III: Ammassalik igneous complex. IV: 1.9-2.2 Ga diorite intrusion. V: Kruse Fjord gabbro complex.

Fig. 3. Geological map of the survey area in south-eastern Greenland (modified from Escher 1990). Red: the Aeromag 2013 survey area. I–V: magnetic anomalies discussed in the text.



120 km and presumably extend offshore. To the north, several of these anomalies appear to be truncated by a magnetic low (II; Fig. 2) just north of the Ammassalik igneous complex. The magnetic anomalies measure 1–2 km across and have amplitudes in the order of 300 nT, with a magnetisation direction enhancing the present geomagnetic field suggesting a magnetisation dominated by induced magnetisation or a remanent magnetisation with a direction in the same general direction as the present geomagnetic field or both. The linear magnetic anomalies, which are mainly found offshore, are both much larger, and have a different orientation than the ENE–WSW-striking mafic dykes mapped in the area (Bridgwater *et al.* 1990). In order to estimate the depth of the source of the magnetic anomalies, Euler deconvolution (Reid *et al.* 1990) was carried out using the Standard Euler 3D method of the Geosoft package software v. 8.1. The method is based on Euler’s homogeneity equation that relates the magnetic field and its gradient components to the location of the source. The system uses a least squares method to solve Euler’s equation simultaneously for each grid position within a window and then determines the anomaly position, depth, and base level for a specific magnetic source. The most critical parameter in the Euler deconvolution is the structural index, which enters as an exponential factor corresponding to the

rate at which the field falls off with distance, for a source of a given geometry. For our analysis we used a structural index value of 1, which is suitable for a dyke, and a window size of 2 km. The resulting depth estimates for the top of the dykes are generally below 400 m. Given the uncertainty of the depth estimates, and the up to 200 m water depth in the offshore area (Becker *et al.* 2009) where the magnetic anomalies are best defined, it is possible that the dykes are exposed near the coast. Finally, we note that the Kangâmiut dykes found in West Greenland, in a similar location on the North Atlantic craton (south of the central part of the Nagssugtoqidian orogen in West Greenland) are much less prominent magnetically (Rasmussen & van Gool 2000; Korstgård *et al.* 2006) than the linear magnetic anomalies seen in the *Aeromag 2013* survey area. We tentatively interpret the linear magnetic anomalies as massive dykes.

The E–W-trending magnetic low just north of the Ammassalik igneous complex marked II in Fig. 2 coincides with a suggested suture zone of the Nagssugtoqidian orogen, where the Rae craton to the north-east in an oblique WSW-directed subduction collided with the North Atlantic craton south of the suture zone at *c.* 1870–1885 Ma (Kolb in press). The suggested location of the suture zone is also supported by the apparent abrupt termination of several of the positive

NNE–SSW-trending anomalies marked I on Fig. 2 and discussed above.

North of the Ammassalik igneous complex the *c.* 1.7 Ga post-orogenic granodiorite intrusion marked III in Fig. 2 is clearly defined by positive magnetic anomalies with amplitudes up to almost 2000 nT. Similarly, the older 1.9–2.2 Ga diorite intrusion farther north marked IV in Fig. 2 is associated with a strong (*c.* 2500 nT) positive magnetic anomaly. The strongest magnetic anomalies in the Aeromag 2013 survey area are found in the northern part of the survey area and can be related to the Palaeogene intrusions in the area. The Kruuse Fjord gabbro complex marked V in Fig. 2 is related to a negative anomaly, hence having a magnetisation dominated by reversely magnetised remanent magnetisation, which is in excellent accordance with an Ar–Ar isochron age of 48.0 ± 1.2 Ma, and emplacement of the intrusive complex during the reverse C21R chron (Cande & Kent 1995).

Conclusions

In this paper we present the newly released *Aeromag 2013* survey that adds new and exciting data to the already extensive database of Greenland aeromagnetic data. The paper focuses on magnetic anomalies of regional extent, including sub-parallel linear and positive anomalies trending NNE–SSW (marked I on Fig. 2) that we suggest stem from hitherto undiscovered very large dykes. The suggested location of the suture zone of the Nagsugtoqidian just north of the Ammassalik igneous complex (II; Fig. 2) is supported by the aeromagnetic data. Finally, we note a general good correspondence between the mapped surface geology of the region and the aeromagnetic data; in particular, the intrusions which are clearly discernible. The magnetic data provide a basis for further analysis and modelling of the 3D geometry of the igneous intrusions. Many more local anomalies can be identified in the *Aeromag 2013* dataset but interpretations require further analyses.

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Authors' address

Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark. E-mail: pri@geus.dk.