

# Photo Flying in North East Greenland 2017

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DANISH MINISTRY OF ENERGY, UTILITIES AND CLIMATE

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## **Abstract**

A photo flying task was undertaken by the Geological Survey of Denmark and Greenland (GEUS) and The Ministry of Mineral Resources in Greenland (MMR) one week in July 2017 in North East Greenland. Space in base camp, Daneborg, and helicopter time was keenly provided by another GEUS drilling campaign in the area, providing base camp facilities and helicopter. The expenditure of the helicopter hours was funded by MMR and the originally proposed lines for photo flying in the area was estimated by GEUS to take 30 helicopter-hours to photograph. The time in the field allowed unfortunately only three days of photo flying, producing almost 9,500 photographs, and spending nearly 15 hours. Additionally, a field team from the GEUS drilling campaign, added 1,500 photographs and spent 3 and a half hours. At the end nearly 11,000 photographs were collected from the area and 18 helicopter hours were used.

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# 1. Introduction

In the summer of 2017 the Geological Survey of Denmark and Greenland (GEUS) undertook a test drilling programme, in Wollaston Forland and Store Koldewey, North East Greenland. In the same area The Ministry of Mineral Resources (MMR) planned to launch a Photo flying programme. By joining forces North East Greenland Photo Flying project was conducted on conditions of available space in GEUS base camp and possible helicopter hours. MMR and GEUS agreed on a preliminary 2,500 line km of photo-shooting, estimated to take c. 30 hours of flying and MMR would cover the helicopter cost.

The photo flying programme was undertaken as preparation for compilations of new 1:100,000 scale geological maps in North East Greenland in relation to oil and gas prospectivity off-shore North-East Greenland. Available geological maps of the area come in 1:1,000,000 (Henriksen & Higgins, 2008); 1:500,000 (Henriksen, 1984; Bengaard & Henriksen, 1986; Henriksen, 1997; Jepsen, 2000; Escher, 2001); 1:250,000 (Koch & Haller, 1971) scales and no 1:100,000 scale maps exist in the project area at present.

The scope of the project aimed for acquiring as many as possible photographs (perhaps up to 30,000) over 2,500 km, based on estimated 30 helicopter hours, in the pre-defined area in North-East Greenland.

## 2. Equipment

The setup of the field work was to take oblique photographs through an open window of a helicopter (Eurocopter AS 350). A NIKON D800E DSLR (digital single lens reflex) camera equipped with a 35mm ZEISS lens was used. To obtain coordinates two separate GPS systems were utilized, Solmenta GPS system and North Surveying differential GPS system. The Solmenta GPS system writes coordinates into the image file attributes created in the camera while the North Surveying system records raw GPS data into a micro SD card for more precise post processing positioning. The second system from North Surveying, consisted of a customized rover-GPS setup and a base station GPS to be located on ground. The GPS base station was moved to various locations during the project to minimize the baseline between rover and base station to a maximum radius of 100 km (distance flown from GPS base station was up to 75 km).

During the image acquisition an experiment to achieve better GPS signal reception and from practical issues (limited space), the customized GPS system from North Surveying was separated from the Nikon camera and placed in front of the helicopter window.

Later a CANON EOS 5D MARK 2 DSLR camera equipped with a CanonEF35mm f/1.4L USM lens, was taken in use by a field team that photographed after 22nd July. This camera acquired almost 1,500 photographs.

### 3. Field work

The Field work was conducted by two persons, one from GEUS and one from MMR. Time in the field in North-East Greenland was from 18th to 26th of July 2017. Three days were spent in the helicopter; 14 hours and 46 minutes were registered as flight time. The number of captured image these three days was 9,456.

Weather conditions, GEUS onshore drilling project and pilot ground time affected the photo flying time. Even though weather condition on ground base for the most part was very good the conditions in the narrow fjords was affected by fog and adiabatic winds from the inland ice, preventing helicopter flight.



**Figure 1.** Location of base camp. Image from Styrelsen for Dataforsyning og Effektivisering (date: 20170831, URL: <https://valdemar.kortforsyningen.dk/FikspunktFrontend/gron.php>).

Due to unforeseen issues related to the GEUS onshore drilling project, the predefined flight plans had to be altered, affecting the allocated helicopter time and hence reduced the photo sessions. Fortunately an onsite field team (H. Vosgerau and M. Bjerager, both from GEUS) from the onshore drilling project was able and eager to acquire images from some of the remaining areas. This field team spent 4 hours and 12 minutes, and captured 1,478 additional photos.

Base camp was Daneborg on Wollaston Forland. A fixpoint named '51012' located at 161 m, height drilled into the solid rock (close to coordinates 74.327143°N, -20.232617°W), see Figure 2. This point is also printed on the Kock & Haller (1971) map of Wollaston Forland and

has the same altitude, indicating that this altitude was measured in the 1930's. This fixpoint and the shoreline was measured daily with the barometric altimeter, and can be used as a reference for calibrating the daily altimetry due to the change in air pressure and humidity.



**Figure 2.** Photographs of fixpoint '51012' above and Daneborg below.



## 4. Flight days

The weather conditions for photo-flying in North-East Greenland were good for the period, though some conditions affected the flight. Fog often prevented flying in the morning hours, at noon the fog often disappeared and the weather conditions changed into clear sky. Afternoon fog, from the seaside, also cut short one flight day.

First day of the photo-flying was Wednesday 19<sup>th</sup>, and the area around Wollaston Forland and Kuhn Ø was flown, see Figure 3.

Second day was Thursday 20<sup>th</sup>, where the flown area was around Clavering Ø and Hold with Hope along with a crossline on Wollaston Forland, see Figure 4.

Friday, was rainy, and the helicopter pilot had to have some resting hours. These two fitted nicely together, meaning that the third day was used to plan the following day's route and setting up the gear and allowing photo-flying for two following days.

Third day of flying was Saturday 22<sup>nd</sup>, and we approached Hold with Hope and Gauss Halvø. However, due to strong wind conditions the planned flying lines in the fjords were omitted (see Appendix Figure A1). After refuelling, the Pendulum Øer were paid a visit, see Figure 5.

**Table 1.** *Days of flight and captured photographs*

<b>Day</b>	<b>Date (YYYYMMDD)</b>	<b>Captured photographs</b>
<b>Wednesday</b>	20170719	4,040
<b>Thursday</b>	20170720	3,398
<b>Saturday</b>	20170722	1,907
<b>Tuesday</b>	20170801	977
<b>Monday</b>	20170807	501
<b>Total</b>		10,823

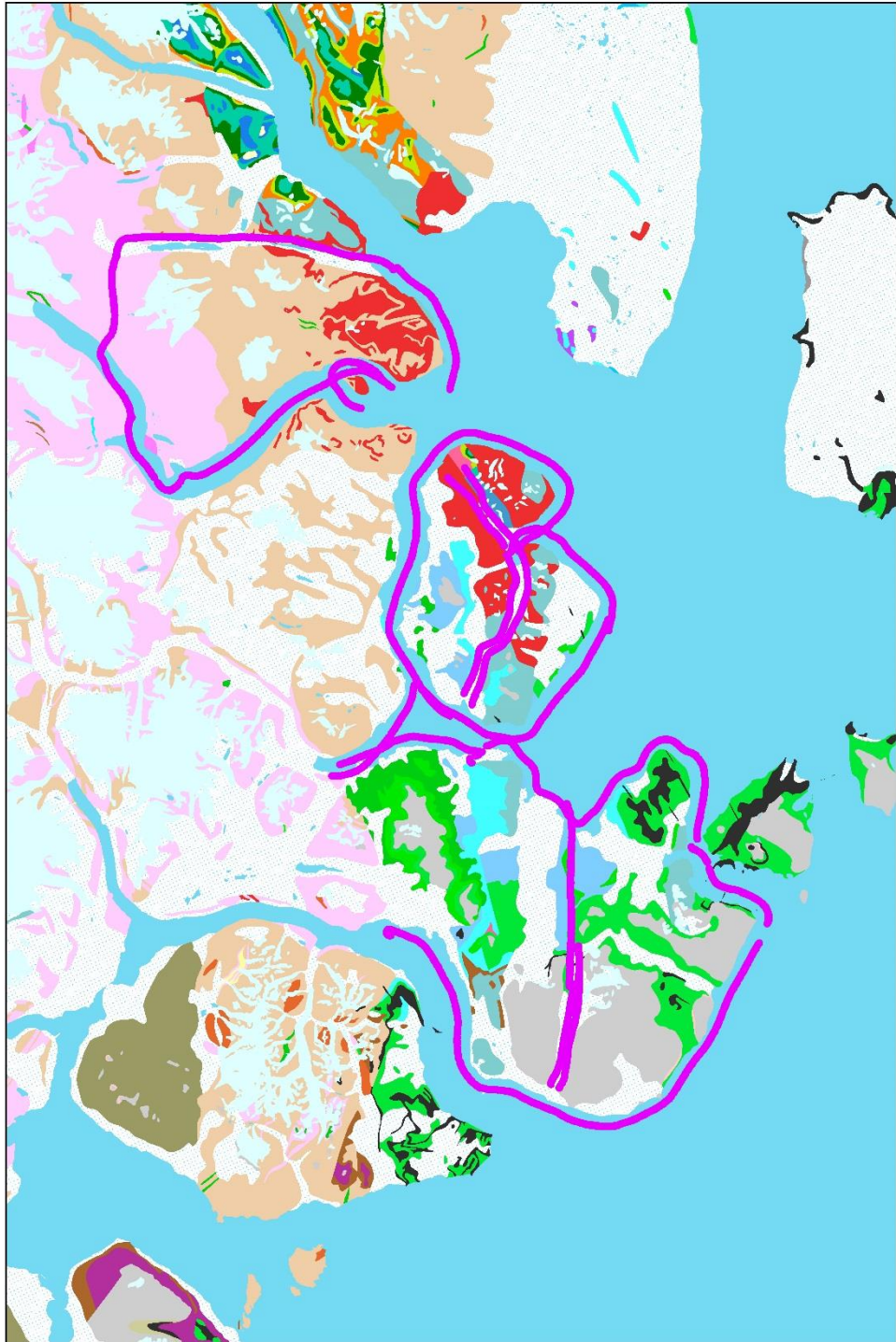
## 5. Acquired images and data

The number of acquired photographs totals 10,823 during this field campaign (Table 1). Roughly estimated the photographed lines measure 2,205 km (Table 2) the first three days of photo flying. Adding the following days of coverage totals the covered distance to 2,935 km of flown distance. The original flight lines were 2,624 km and were estimated to take 30 hours to photo shoot. This estimate does not include taxi-flying to and from distant areas, which would substantially increase the real flight.

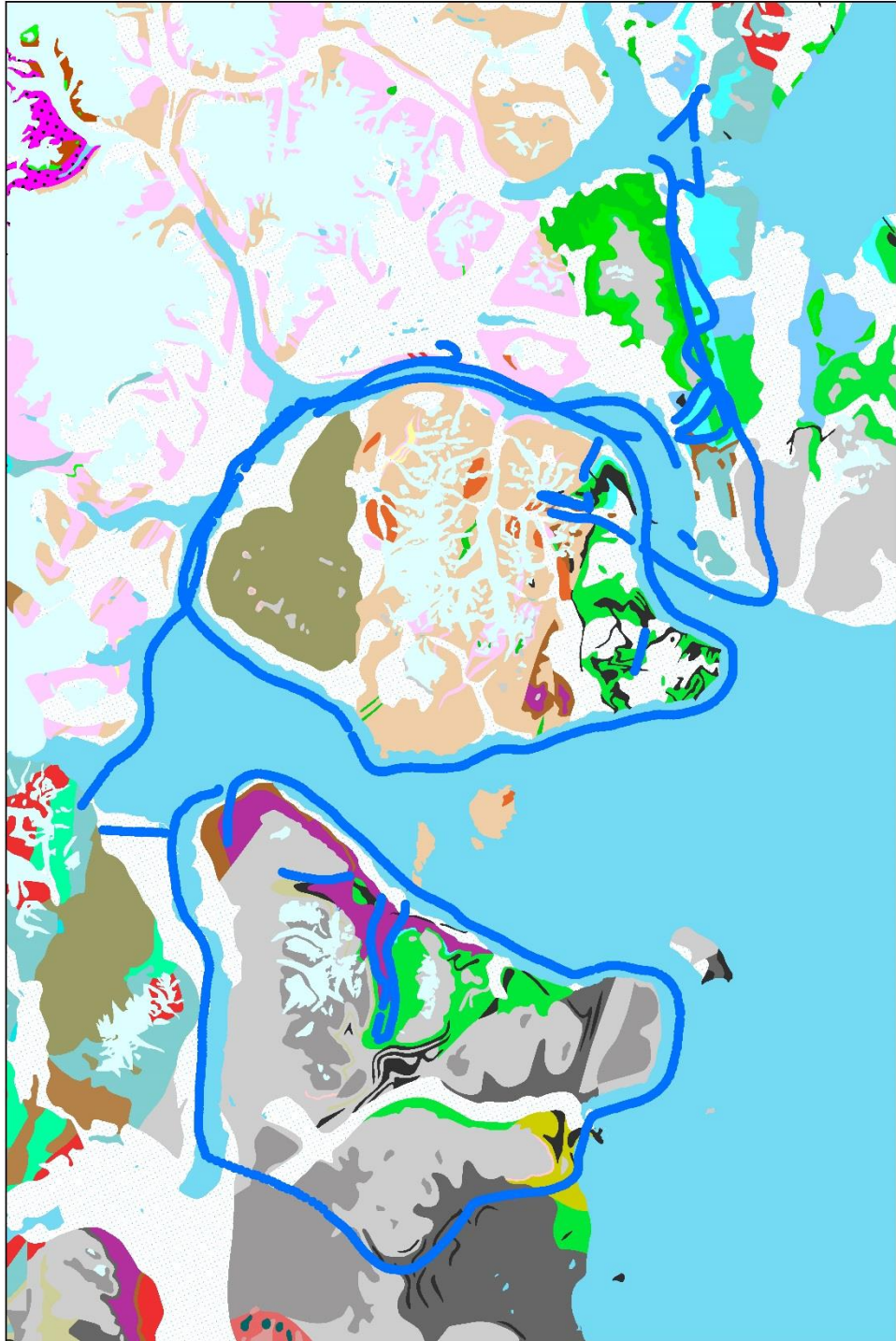
**Table 2.** *Flight dates, captured images and flown distance*

<b>Flight date</b>	<b>Captured images</b>	<b>Flight lines km</b>
<b>20170719</b>	4,040	795
<b>20170720</b>	3,398	850
<b>20170722</b>	1,907	560
<b>20170801</b>	977	580
<b>20170807</b>	501	150
<b>Total</b>	<b>10,823</b>	<b>2,935</b>

The distance has been measured from the obtained coordinates from the photographs. Some of the photographs may not have too much relevance to the overall photo flying and drawing of new map(s), but they are the only tracks that exist of the covered flight routs and distance. Figures 3 to 6 show the location of captured images; Figure 3, shows 19<sup>th</sup> July, Figure 4, 20<sup>th</sup>, Figure 5 22<sup>nd</sup> and Figure 6 location of photographs captured by the step in field team, these were captured from 23<sup>rd</sup> July to August 7<sup>th</sup>. Figure 7 has all locations of the photographs.



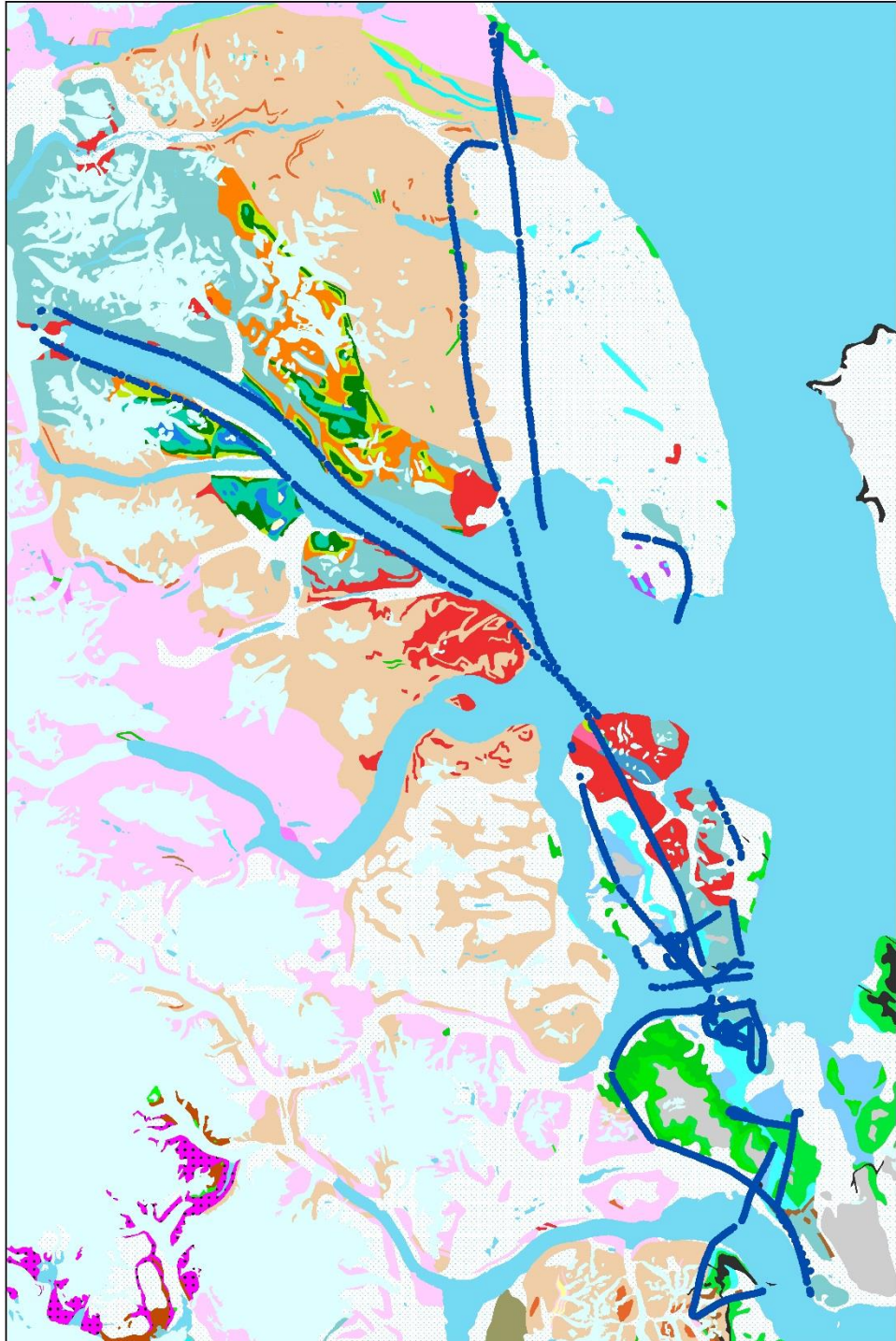
**Figure 3.** Coverage of first day of flight 19<sup>th</sup> July. Each photograph has a coordinate. The images are so close that the points appear as lines.



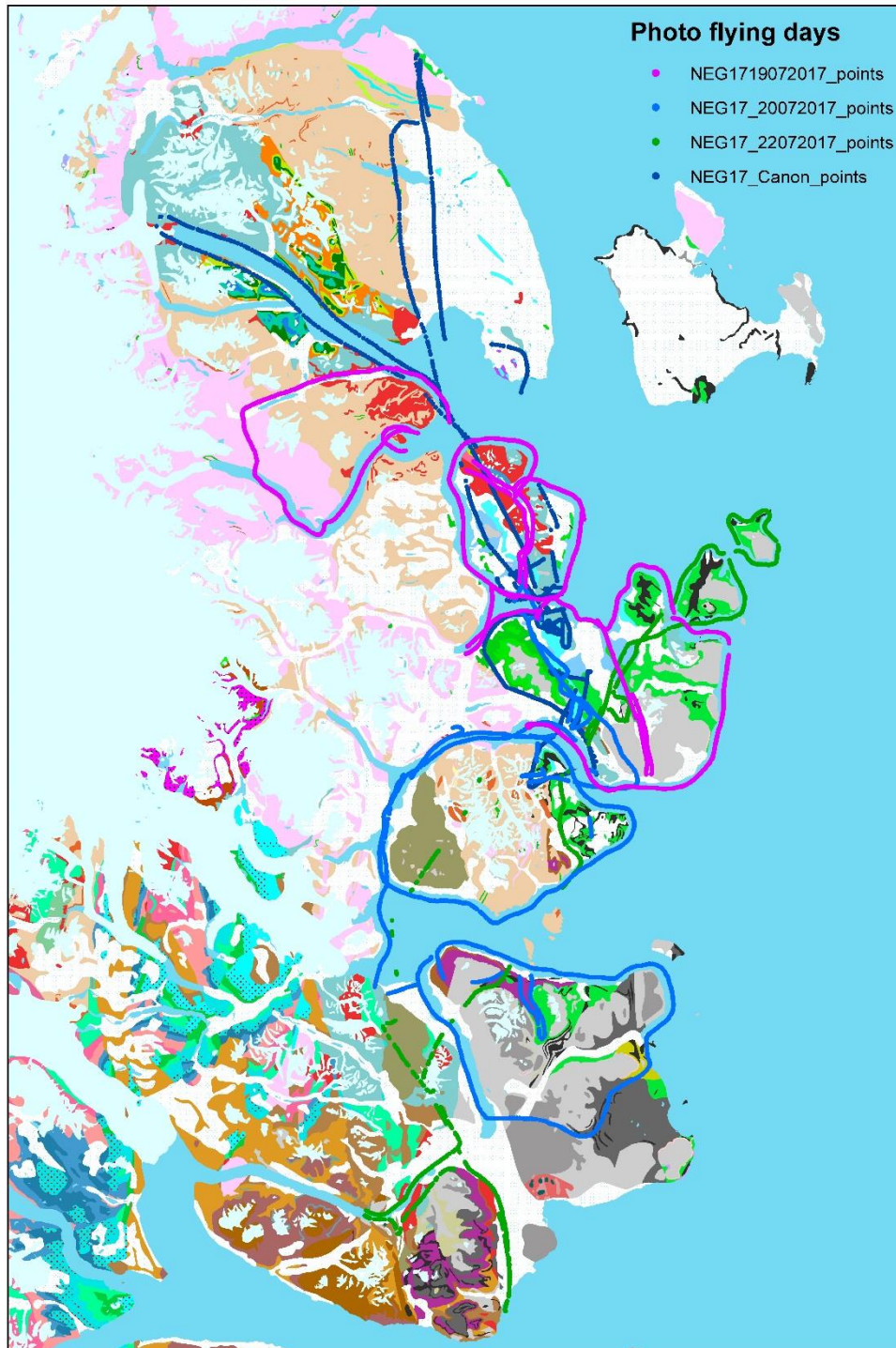
**Figure 4.** Second day of flight, 20<sup>th</sup> July.



**Figure 5.** Third day of flight, 22<sup>th</sup> July.



**Figure 6.** The additional days of flight, covered by the field team, that stepped in.



**Figure 7.** All flight days and the coverage of images that were captured during this field work.

## 6. Discussion

Considering the circumstances for the outset of the field work and the conditions the field work was conducted under, the number of captured oblique photos along with the time spent in the field and associated helicopter time, the flying hours are ineffective and cost for the images high. However, setting up a similar project in North-East Greenland, without an already established base camp, the task could not have been accomplished, for economic reasons. Nevertheless, there are some amendments that can be mentioned and could act as guidelines for similar tasks in the future.

The requested helicopter for photo flying should have side windows that can be opened in both sides, port and starboard. Before, the helicopter is booked, it could be mentioned that photo flying is one of the tasks to be fulfilled, and a window that can be opened on both sides of the helicopter (passenger seats). This would allow the photo shooting to be undertaken on both sides of the helicopter. Not necessarily at the same time, but possibly. It would decrease transport flying time. Also it would give the photographer the option to select which side to photograph from. The question of a camera fastened on the bottom of the helicopter that automatically captures all flights could also be of importance. The helicopter contractor, however, would in that case charge the project for a paramount cost, and the option for that reason is turned down.

Captured images should be readable in the field computer, so that planning and the exposure of the images becomes immediately apparent. Going through the photographs through the cameras display is good, but not to get an overview. This means that the field computer should have software from both CANON and NIKON to read RAW format images.



## 6. Further work

GEUS' photo laboratory, will prepare acquired photographs for stereoscopic viewing and interpretation.

## 7. Conclusion

This photo flying project was undertaken in conjunction with another nearby GEUS project having the same basecamp and depended on available helicopter timeslot hours. It is fair to state the field work was successful even though the plan was more ambitious, than the result. However, the number of planned photo lines acquired the first 3 days (14 hours and 46 minutes helicopter time) was quite a success compared to the pre-estimated 30 hours for the entire area, and covered 2,205 km. Adding the extra flight hours increases the flight lines to almost 3,000 km, in 18 hours and 13 minutes. The weather conditions were good, though some days, especially the morning hours, fog delayed take-of and reduced available flying hours, and thus prevented some photo flying. The captured number of photographs and the varying number of coordinates of the images requires some additional work for setting up the stereo images that cannot be setup automatically.

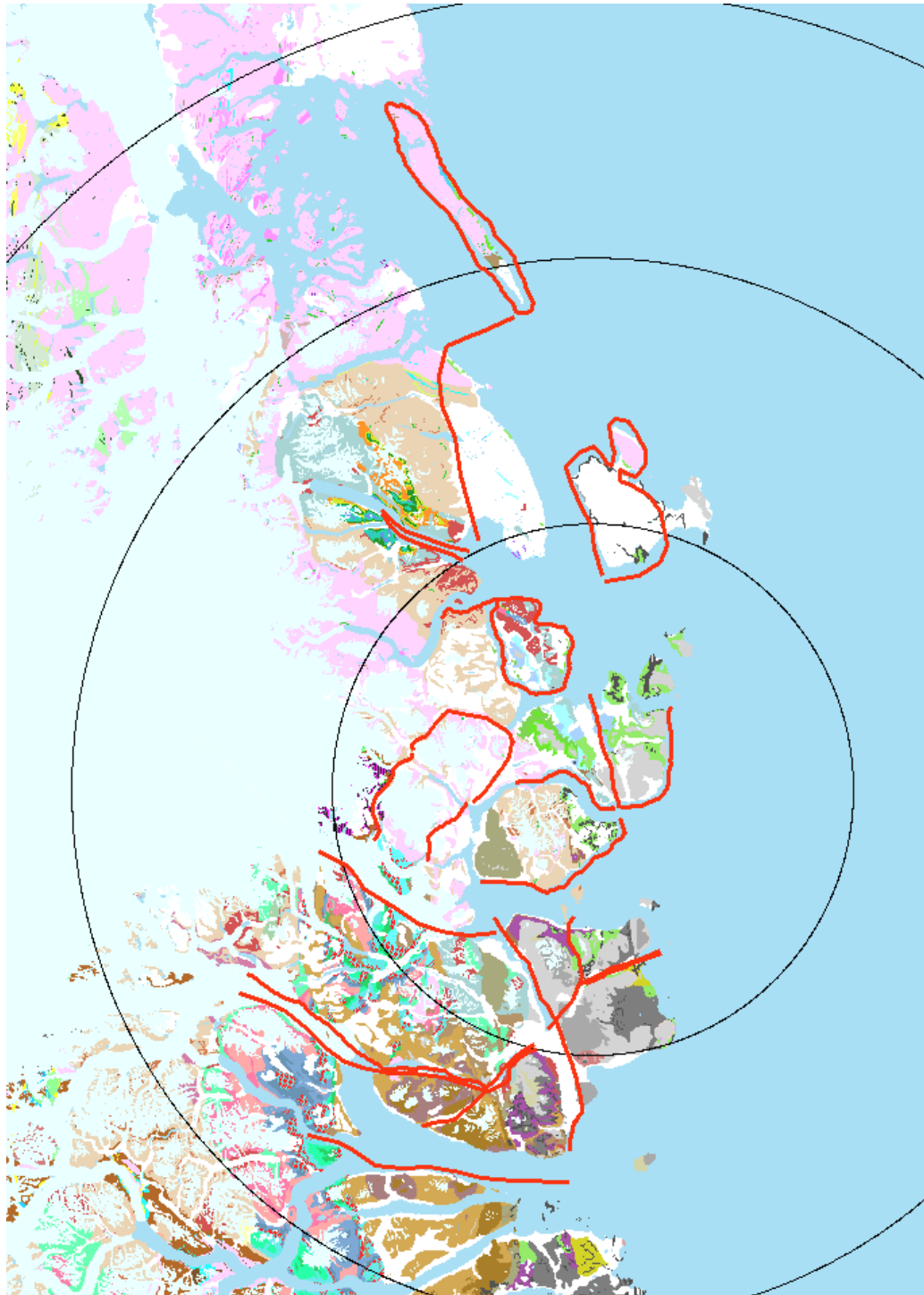
It would have been optimal not to be dependent on other projects in order to undertake the planned photo flying – and have the helicopter available for approximately a week ideally. However, as mentioned previously this is a difficult balance due to the very high costs associated with such a project, as a stand-alone.

The 9,345 captured images in 14 hours and 46 minutes of flying time, plus the additional step-in by the field team, filling up some of the missing areas is fortunate and increases the total number of captured photographs to 10,823 and spending 18 hours and 13 minutes. The combined number of total photographs and the lines acquired in the project is quite satisfying based on the total hours flown and will provide important information for planning of future field work and geological mapping in North East Greenland.

## 8. References

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## Appendix



**Figure A1.** Original field-plan from a modified draft dated from December 2016, and modified in early 2017. Circles are 100, 200 and 300 km radii from Daneborg; red line is proposed flight, totalling 2,645 km.