DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2018/6

Digital elevation models and orthophotos from Booth Sound North-West Greenland: processing and technical description

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DANISH MINISTRY OF ENERGY, UTILITIES AND CLIMATE

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Introduction

The Geological Survey of Denmark and Greenland (GEUS) was contracted by Alba mineral Resources to process oblique stereo-images collected during fieldwork (Figure 1) conducted in the Thule area (License MEL 2017/29), North-West Greenland by Alba Mineral Resources.

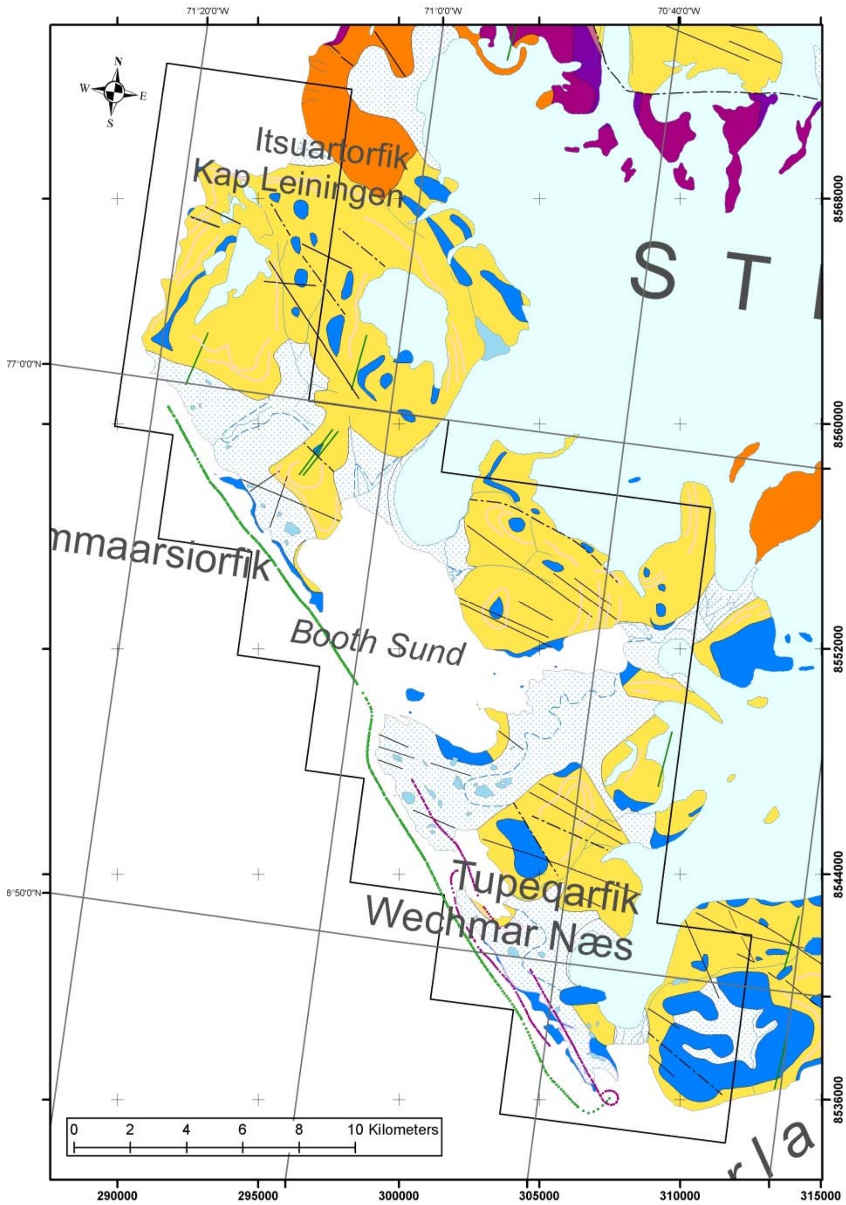

Figure 1. *Geological map showing the camera positions of the stereo-images collected in 2017. Green dots are the location of the oblique overview images and purple dots are the camera locations of the more nadir looking images acquired in the southern part of the license area MEL 2017/29. Black polygon outlines the MEL 2017/29 license area.*

The stereo-images were collected with a hand-held digital camera system rented from GEUS with the purpose of digital terrain model generation and orthophoto production. The camera system consists of a Canon EOS 5D Mark II digital camera equipped with a Canon 35 mm lens (Table 1) and a customized differential GNSS (Global Navigation Satellite System) receiver. The camera system was calibrated prior to field work using a theodolite surveyed steel frame located at the Technical University of Denmark (DTU). The result of the calibration is given in Table 1 and the accuracy of the calibration is estimated to be around 1/3 a pixel or c. 2 µm. The images were acquired from a B212 helicopter pointing the hand-held camera obliquely downwards during data acquisition (Figure 2). The images were collected over two days (Figure 1). Oblique overview images (c. 350-400 m above ground) were collected on the first day, while on the second day more nadir-looking images (c. 600 m above ground) were collected from the southern part of the license block.

Camera	Lens	Calibrated focal length (36 mm width)	Principle point offset		Principle point symmetry offset		Symmetrical lens distortion (odd order polygonal coefficients)			
			X	Y	X	Y	K0	K1	K2	K3
Canon EOS 5D Mark II	EF 35mm f/1.4L USM	34.346 mm	-0.026 mm	-0.026 mm	-0.026 mm	-0.026 mm	0	-8,27E-05	-1,00E-07	0,00E+00

Table 1. Summary of calibrated cameras parameters used during data acquisition.

Preparation of the images

The preparation of the images essentially consists of two steps. Firstly, a relative model is constructed by identifying common points (tie-points) between overlapping images. Secondly, this model is transformed into absolute coordinates by combining camera location data and control source data through a rigorous photogrammetric bundle adjustment process.

Tie points were measured automatically using the Agisoft Photoscan Professional software. The raw tie point matches were subsequently imported into 3D Stereo Blend as input into the photogrammetric bundle adjustment. Tie-points were thinned during import using an area-based approach to ensure an even distribution of the tie-points. For absolute positioning of the overview flight a combination of stereoscopically measured planar surface points (sea-level) and control points (pass points) measured in monochrome aerial photographs (1:150.000) covering the area as well as post-processed camera position GNSS data. The monochrome aerial photographs are oriented using the 2006 aero triangulation by the Agency for Data Supply and Efficiency (previously Geodectic Institute, then Cadastre and Survey of Denmark and Danish Geodata Agency). All provided control information is weighted according to an a priori estimated error. The root mean square (RMS) error on the bundle adjustment for the overview flight, which is essentially an estimation of how well the newly acquired stereo-images align to the orientation of the monochrome aerial photographs, amounts to c. 1.5 m (x and y) and 2.1 m in elevation.

For absolute positioning of the more nadir images a combination of stereoscopically measured planar surface points (sea-level) and control points (pass points) measured in the oriented overview flights collected by Alba Mineral Resources as well as post-processed camera position GNSS data was used. All provided control information was as for the overview flights weighted according to an a priori estimated error. The root mean square (RMS) error on the bundle adjustment for the close-up flights, which is essentially an estimation of how well the close-up flights aligns to the overview flights, amounts to c. 0.1-0.3 m (x and y) and 0.3 m in elevation.

The photogrammetric or geometric accuracy (relative accuracy) in the image plan is determined by the camera to outcrop distance, camera focal length and how accurate a point can be determined in the stereoscopic model which is a function of the accuracy of the triangulation, the camera calibration and on how well a given point can be defined in the stereoscopic model. The photogrammetric accuracy in depth on the other hand also depends on the ratio between the camera to object distance and the distance between camera stations (camera baseline).

Typical values for point determination is around one pixel which leads to an accuracy of c. 0.07 - 0.1 m in the image plane, while the accuracy in depth is c. 0.18 - 0.3 m when having a 60% overlap, a camera to object distance between 400-600 m, 1/3 of a pixel accuracy for the camera calibration and triangulation and a typical 1/3 of pixel point determination accuracy in the later digital elevation model generation. For the oblique overview images it is important to note that there is a large change in scale when moving into the background which will results in decreasing relative accuracy. In addition, because of the oblique image configuration, the relative accuracy in the image plane is actually probably better expressed by the accuracy in depth.

The result of the bundle adjustment from 3D Stereo Blend was subsequently exported back into Photoscan where the calculated camera orientation was used in the following digital elevation model and orthophoto extraction.

Figure 2. *Image showing how oblique stereo-images were collected from an Air Greenland Helicopter B212 using a handheld camera from an altitude of c. 600 above ground.*

Resulting products

Digital Elevation Model

The digital elevation models (Figure 3 and 4) were generated in Photoscan (UTM 20N) and delivered as a 1x1 m gridded Geotiff files in UTM zone 19N. Two digital elevation models were produced from the oblique overview images. One covers the area north of Booth Sound (Figure 1) and the other the area south of Booth Sound. In addition, three digital terrain models were generated from the more nadir-looking images.

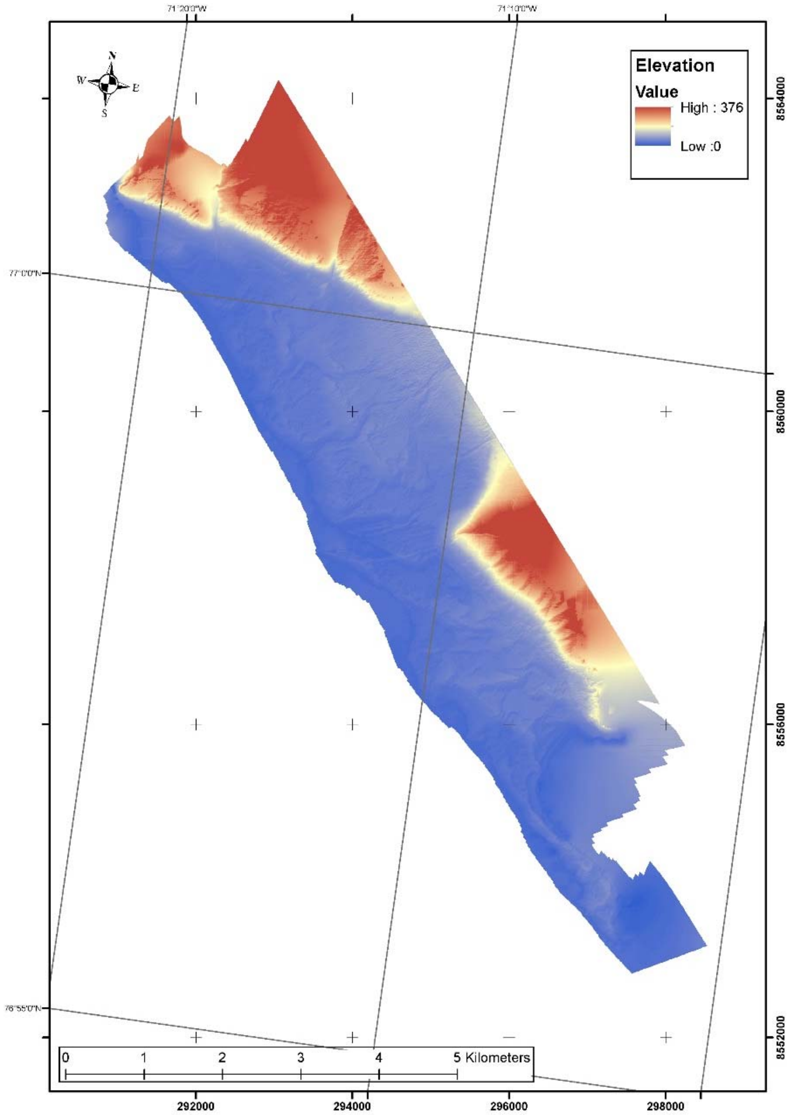

Figure 3. Example of the digital elevation model generated from the oblique overview images north of Booth Sound.

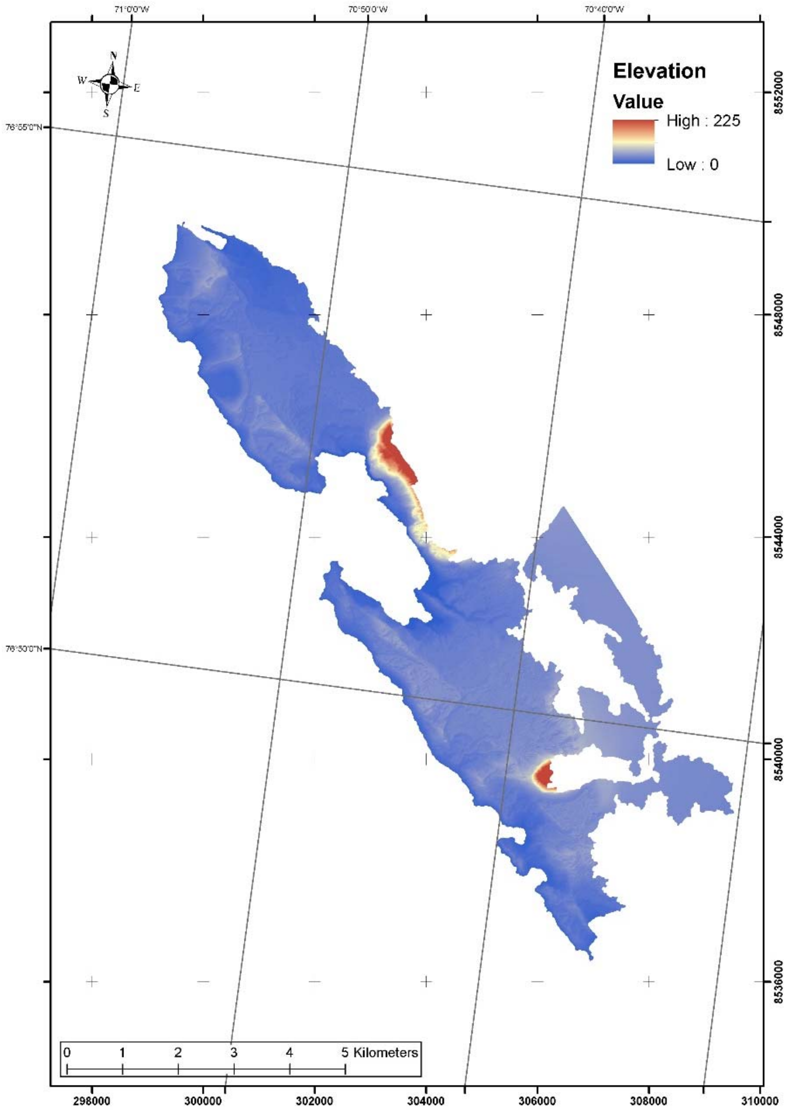

Figure 4. *Example of the digital elevation model generated from the oblique overview images south of Booth Sound.*

Orthophoto

The orthophotos (Figure 5-9) were also produced using Agisoft Photoscan (UTM 20N) and were delivered as orthophotos with 20 cm resolution in a Geotiff format (UTM 19N). As for the digital terrain models, two orthophotos were produced from the oblique overview images. One covers the area north of Booth Sound (Figure 1) and the other the area south of Booth Sound. In addition, three orthophotos were generated from the more nadir-looking images.

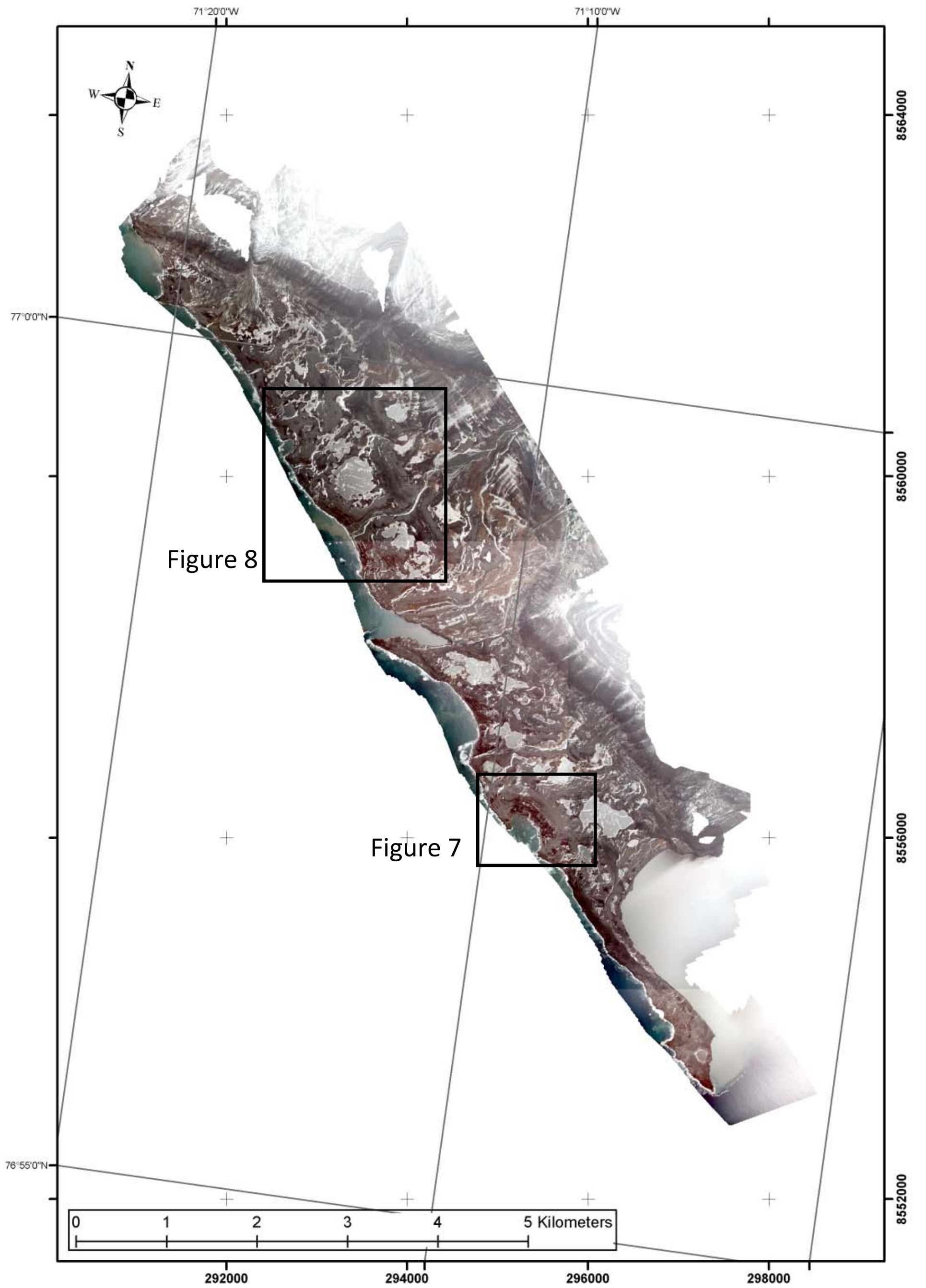

Figure 5. *Example of the orthophoto generated from the oblique overview images north of Booth Sound. Inset boxes gives the position of figure 7 and 8.*

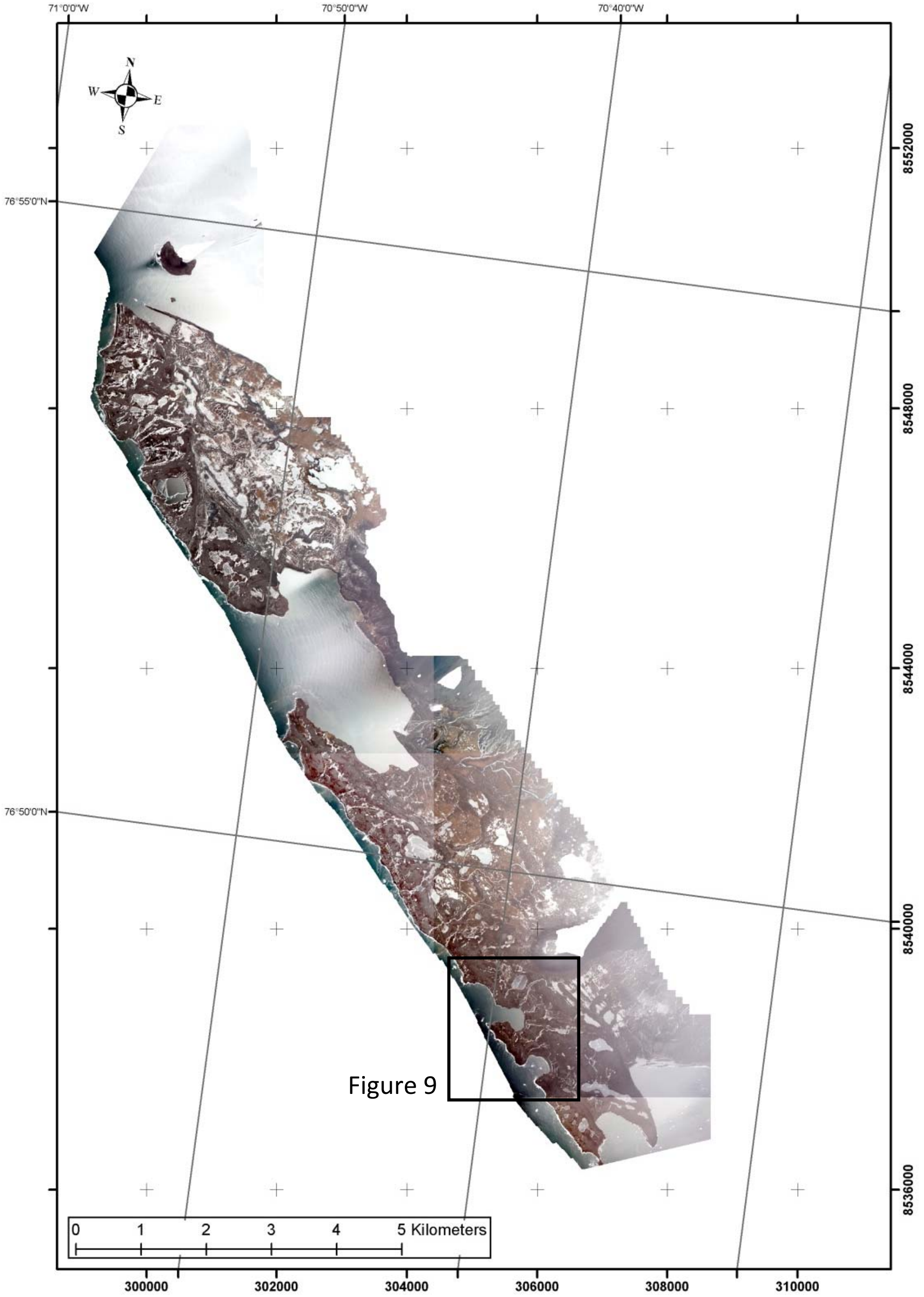

Figure 6. *Example of the orthophoto generated from the oblique overview images south of Booth Sound. Inset box gives the position of figure 9.*

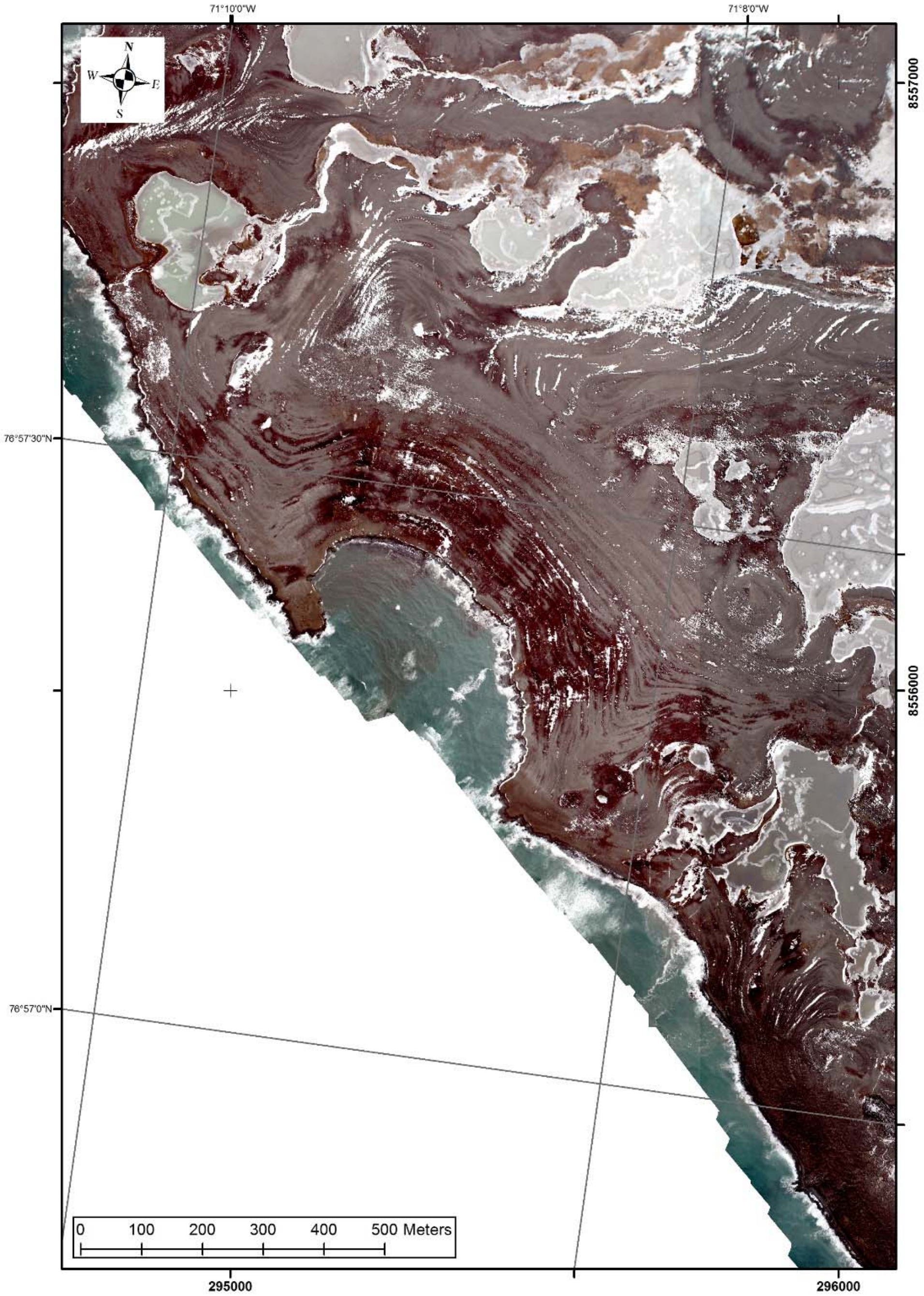

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Figure 7. *Close-up example of the generated orthophotos.*

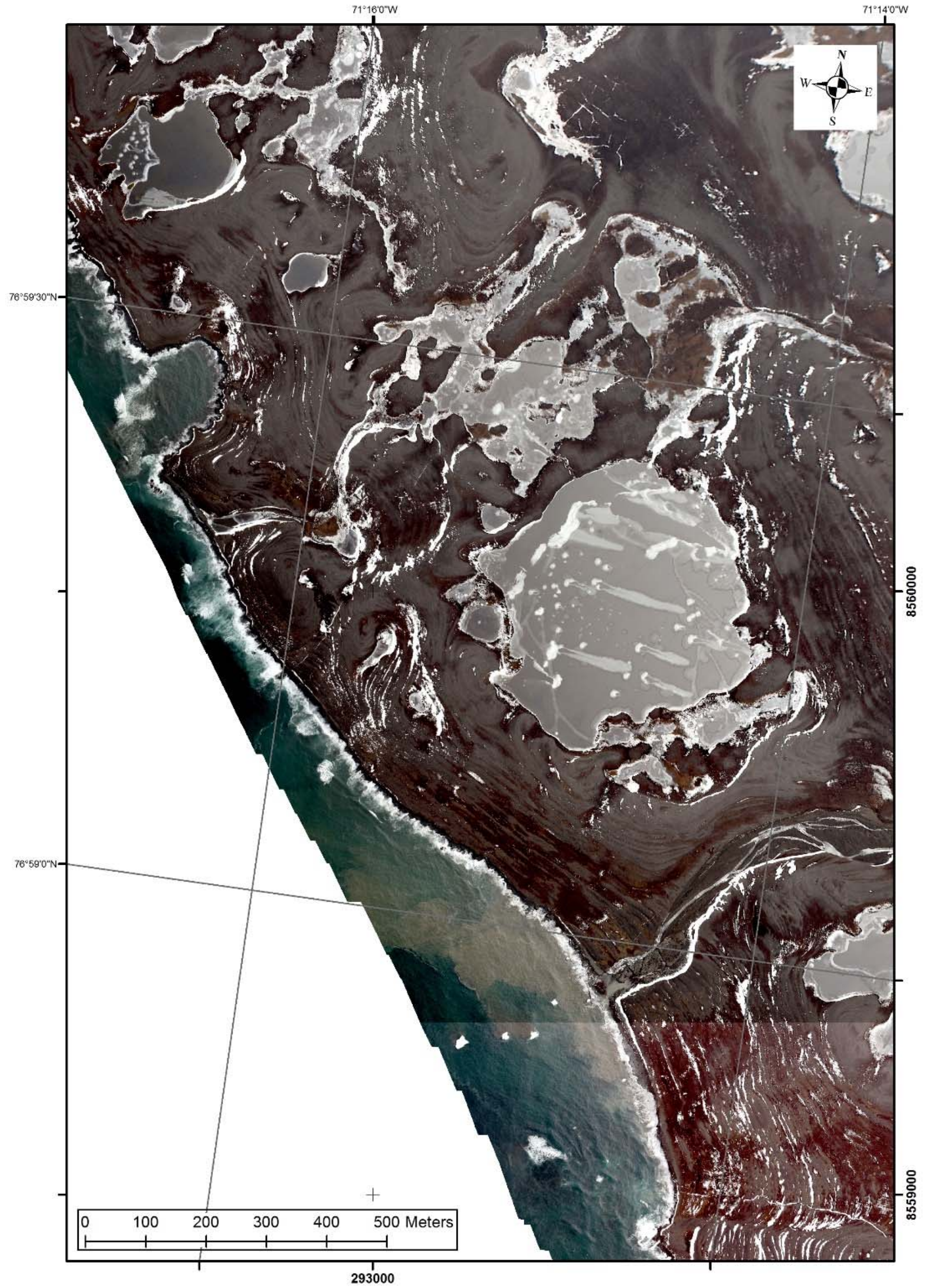

Figure 8. *Close-up example of the generated orthophotos.*

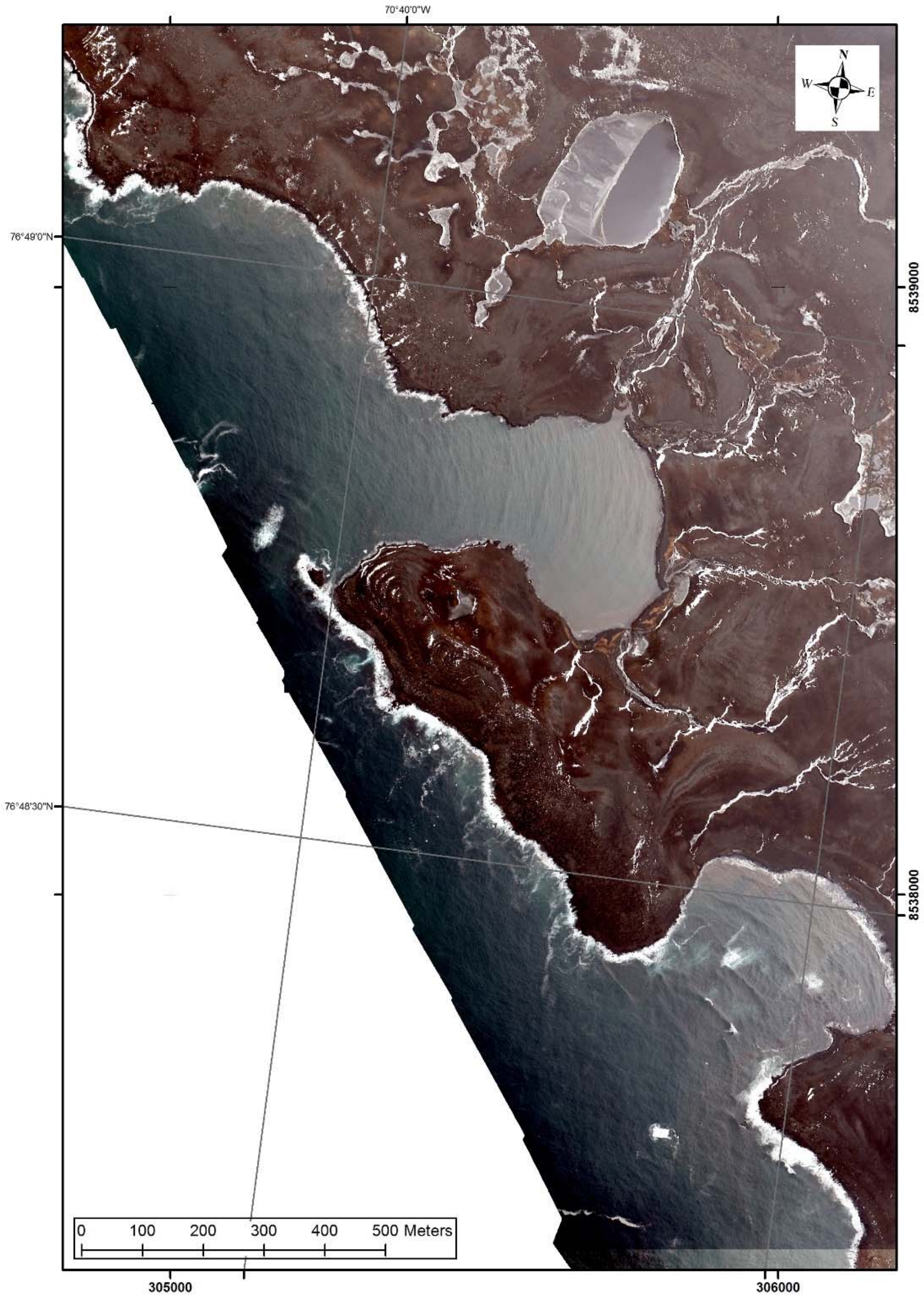

Figure 9. *Close-up example of the generated orthophotos.*

Data delivery

The digital surface model and the orthophoto was delivered to Alba Mineral Resources in digital format and is archived at GEUS.