

# Volume estimation of the Rissa clay slide in Norway - Using Structure-from-motion photogrammetry

Johannes Hardeng Department of Earth Science  
johannes.hardeng@uib.no University of Bergen

## Abstract

In this study, the volume of Norway's biggest clay slide of the twentieth century is reconstructed by applying structure-from-motion photogrammetry to old aerial imagery. Digital elevation models (DEMs), showing the pre- and post-slide topography was reconstructed in Agisoft Metashape Pro from imagery from 1965 and 1978 respectively. The DEMs were then processed in Esri ArcMap 10.6 to visualize the 1965 and 1978 landscapes, and to calculate slide volume. The study suggests a slide area of 362,678 m<sup>2</sup>, with an estimated volume of displaced sediment of 2,782,037 m<sup>3</sup>.

## Background

April 29, 1978 a large quick clay slide was triggered in Rissa, Norway. The slide was the biggest in Norway during the twentieth century, and hit a farming community at the south end of lake Botn (fig 1). The slide was triggered after 700 m<sup>3</sup> of mass was placed in a landfill down by the shore of the lake. The initial slide was relatively small, but several much larger slides quickly followed in the retrogressive slide pit. In total, 7 farms and 5 houses were taken by the slide, as well as roads and other infrastructure. Of the 40 people present in the slide area, only one person was killed, as eye witnesses were quick to evacuate the area after the initial slide.

The Norwegian Geotechnical Institute has reconstructed the different stages of the slides, and discussed the modes of failure. The reported slide area is 330 000 m<sup>2</sup>, and the estimated volume of slide-debris is in the order of 5-6 million m<sup>3</sup> (Gregersen, 1981).

The purpose of this study is to attempt to give more accurate estimations of the slide area and volume, by applying structure-from-motion (SfM) photogrammetry to two sets of aerial imagery from 1965 and 1978.

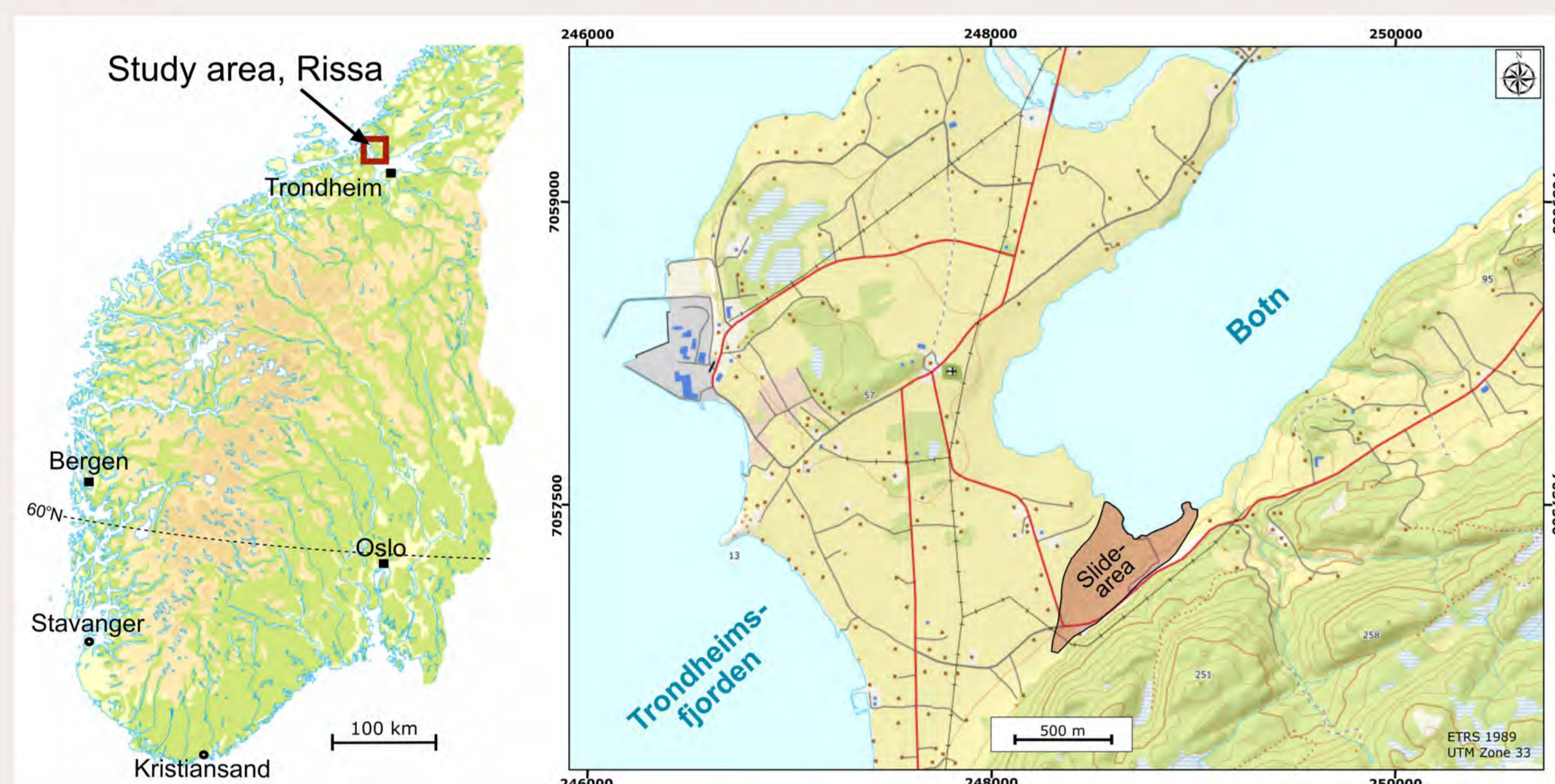


Fig. 1: The study area, Rissa, is situated north of Trondheim. The slide was initiated near the shore of lake Botn, and gradually retrograded south-westward. Maps from norgeskart.no.

## Data & methods

Pre- and post-slide topography was reconstructed using SfM-photogrammetry on two sets of aerial images from 1965 and 1978 respectively (table 1). The DEMs were constructed using Agisoft Metashape Pro, and then processed in Esri ArcMap 10.6 to visualize the landscapes and to calculate elevation change between 1965 and 1978 as specified in the workflow below (fig. 2).

Table 1: Information about the sets of aerial images used in this study.

	Number of images	Resolution	Image date
Dataset 1	11	17797 x 17294	7/18-1965
Dataset 2	6	19514 x 20555	5/22-1978

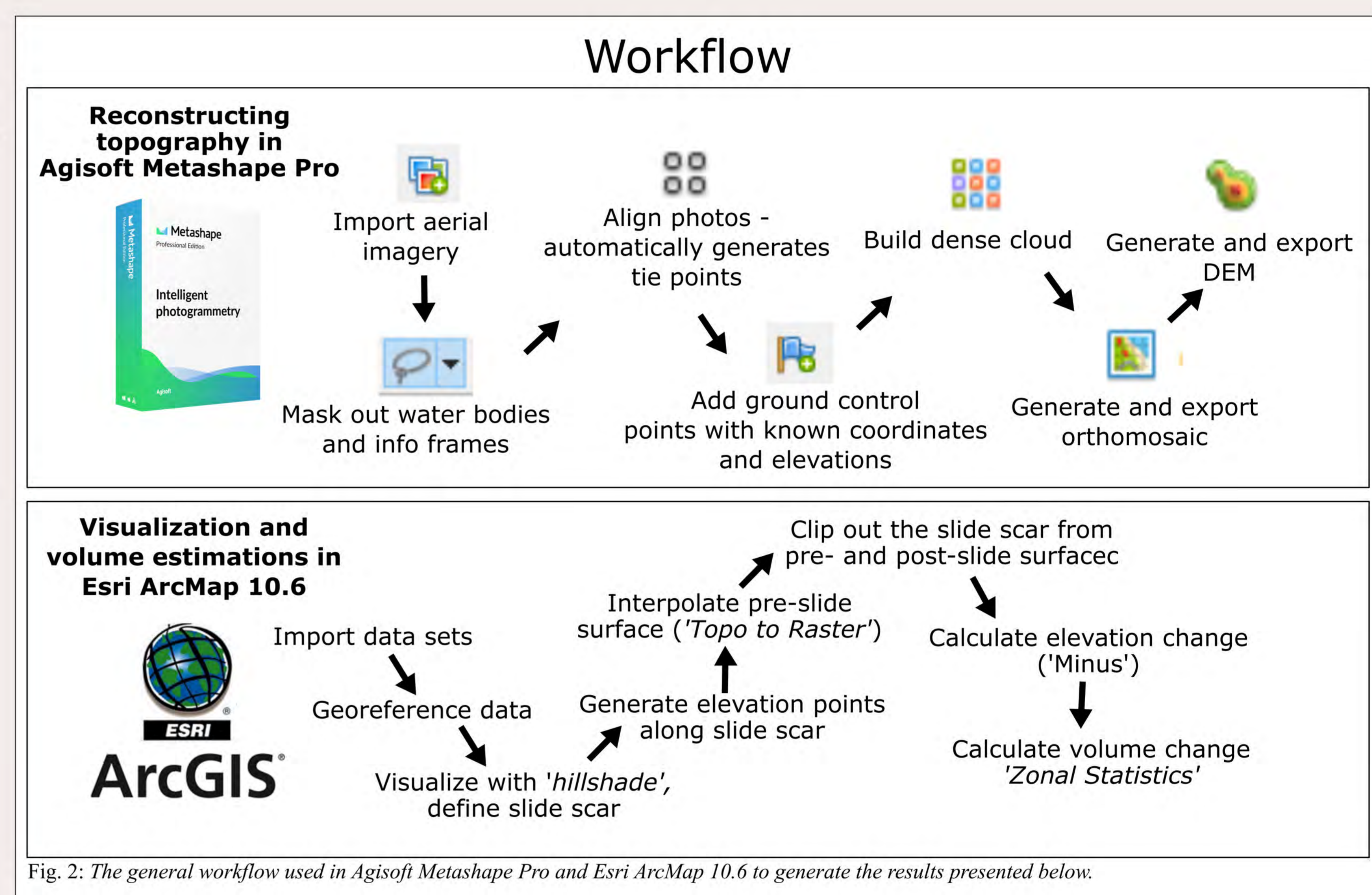


Fig. 2: The general workflow used in Agisoft Metashape Pro and Esri ArcMap 10.6 to generate the results presented below.

## Results

Table 2: The data sets that were produced in Agisoft Metashape and used for visualization and volume estimates in ArcMap 10.6.

	Resolution (cell size)	DEM elevation range (m)
Orthomosaic (1965)	0,213769	-
Orthomosaic (1978)	0,0741799	-
DEM (1965)	0,427532	-14,97 - 183,12
DEM (1978)	0,148359	0,17 - 133,74

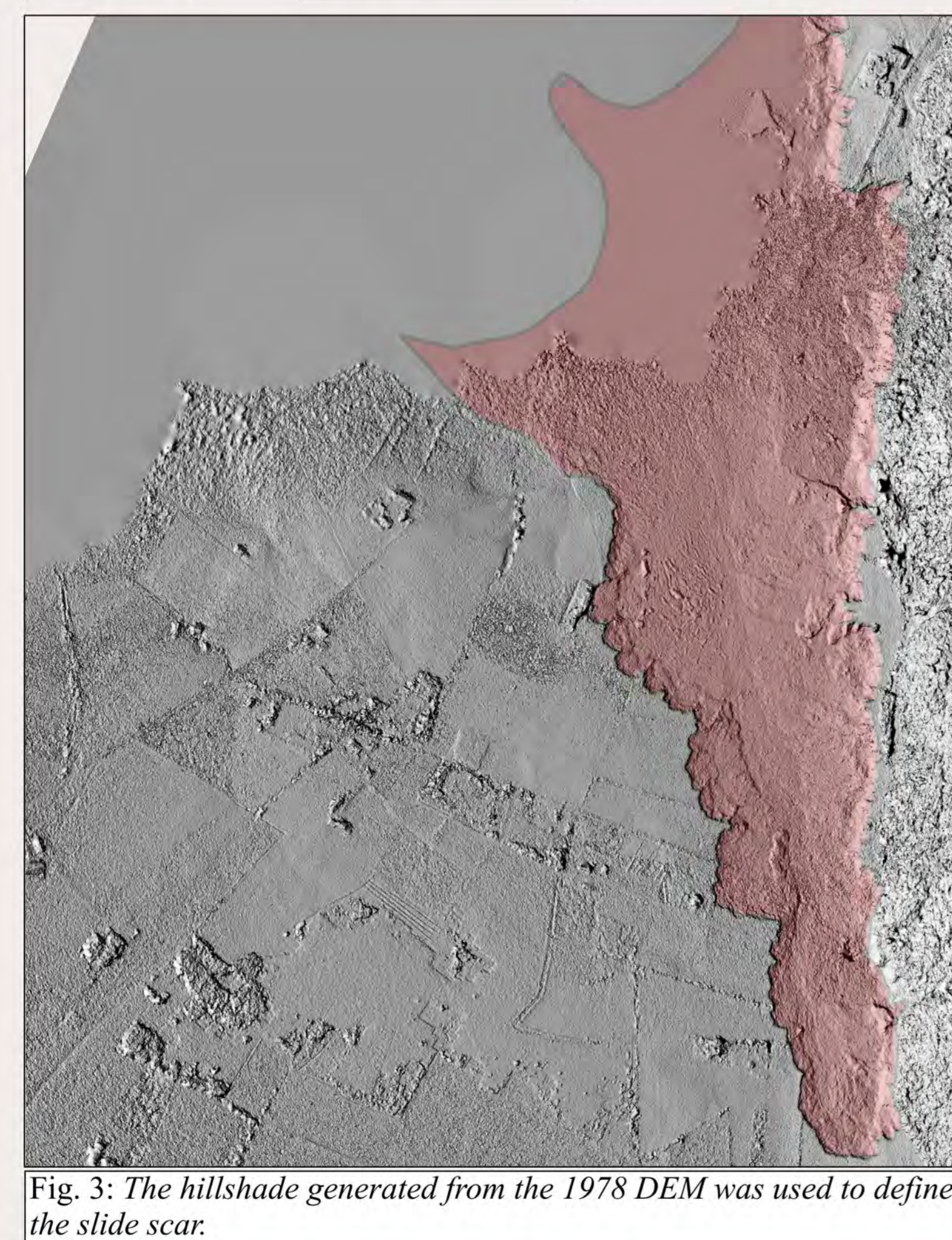


Fig. 3: The hillshade generated from the 1978 DEM was used to define the slide scar.

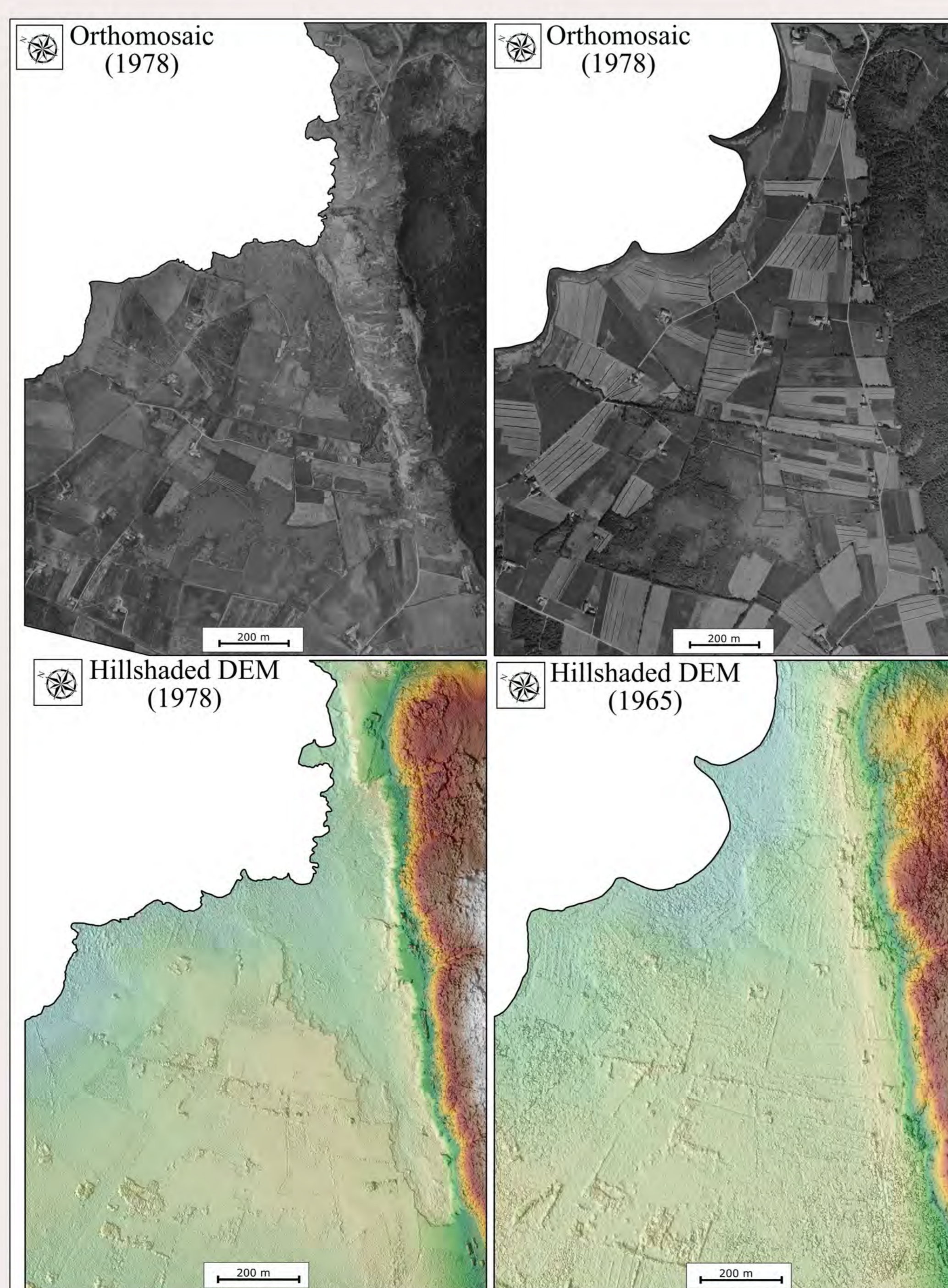


Fig. 4: Top: Orthomosaics showing the landscape in 1978 and 1965. Bottom: Hillshaded DEM's, visualizing the reconstructed topography in 1978 and 1965

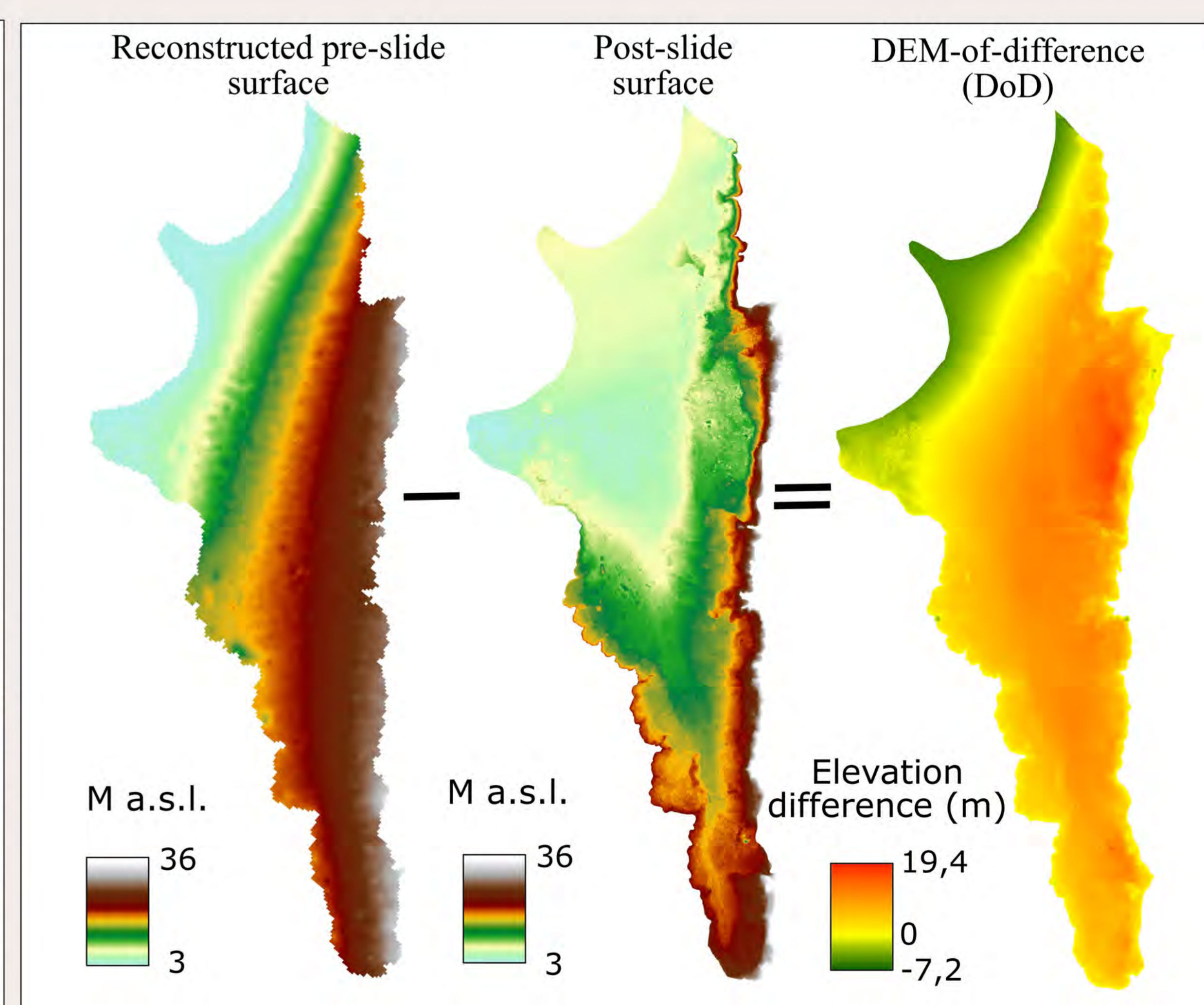


Fig. 3: DEMs showing the pre-slide surface interpolated using the 'Topo to Raster'-tool, the post-slide surface from the 1978-DEM and the DEM-of-difference (DoD), displaying the elevations changes. Note that negative values (green) indicate sediment and positive (red) indicate sediment loss.

Table 3: The main findings from this study.

	Max elevation change (m)	Area (m <sup>2</sup> )	Volume (m <sup>3</sup> )
Sediment loss	19,4	319,229	2,709,729
Sediment gain	7,2	43,449	72,308
Total (displaced sediment)		<b>362,678</b>	<b>2,782,037</b>

## AKNOWLEDGEMENTS

Thanks to Benjamin Aubrey Robson for providing the aerial photographs and for introducing me to SfM-photogrammetry

## REFERENCES

Gregersen, O. (1981) *The Quick Clay Landslide in Rissa, Norway*. Norwegian Geotechnical Institute, Publication No. 135, Oslo 1981.

UNIVERSITY OF BERGEN

