Management Plan

for Antarctic Specially Protected Area No. YYY Parts of WESTERN SØR RONDANE MOUNTAINS, DRONNING MAUD LAND, EAST ANTARCTICA

Introduction

The primary reason for the designation of several sites of the Western Sør Rondane Mountains as parts of an Antarctic Specially Protected Area (ASPA) is to protect the **unique terrestrial biodiversity and ecosystem features** of the area. These are also subjects **of scientific research** on the biodiversity, evolution and function of the biological communities, including their (micro)organisms, and the impact of climate change on these values. The selected sites are representative of the natural terrestrial biological communities typical for inland Antarctic mountainous regions. Thus, this ASPA increases the representation of mountainous habitats in the Antarctic protected areas system. In addition to its environmental and scientific values, this protected Area also contributes to the preservation of **aesthetic** and **wilderness** values.

The **Sør Rondane Mountains** (SRM) are located approximately 200 km inland (71°–72° S/20°–30° E), in the Eastern part of Dronning Maud Land, East Antarctica, and form a typical coastal margin mountainous area, composed of a series of nunataks. They form a 220 km long east-west trending inland mountain range, part of a larger chain of mountains from the Bourg Massif in Western Dronning Maud Land to the Yamato Mountains in Eastern Dronning Maud Land (Mackintosh *et al*. 2014). The highest point is at about 3000 m a.s.l. Late Proterozoic to Paleozoic metamorphic and plutonic rocks (gneiss, granite and amphibolite) dominate the geological features (Matsuoka *et al*. 2006).

The proposed multi-site Antarctic Specially Protected Area (ASPA) in parts of the Western Sør Rondane Mountains (71°50′-72°S; 22°50′-23°50′E) includes **6 ice-free areas**: Tanngarden Nunatak and Ridge (A), Petrellnuten Nunatak (B), range of seven Pingvinane Nunataks (C), two Nunataks of the Perlebandet range (D), a small part of the Teltet Nunatak (E), and the Yuboku Valley (F). The ice sheets and glaciers separating the 6 ice-free areas are not included in the proposed ASPA.

Based on the **Environmental Domains Analysis**, the ASPA belongs to type 7: Inland continental geologic (Morgan *et al*. 2007). It is included in the **ACBR6** (Terauds *et al*. 2012). There is no Antarctic Important Bird Area (IBA) in the ASPA, but further analysis of the petrel colonies is ongoing.

Life in the harsh terrestrial environments of Antarctica, including the Sør Rondane Mountains is dominated by microorganisms. Foodwebs are strongly truncated, with few metazoans consuming organic matter and microbial biomass. Inland nunataks, like in the SRM, are far less studied than those in more coastal locations and in the McMurdo Dry Valleys. Since the first biological survey led by Dr Damien Ernst (Royal Botanical Garden of Belgium) in 2007, before the construction of the Princess Elisabeth station (PES), research has been carried out on the biodiversity of the terrestrial communities (lichens, mosses, invertebrates, prokaryotic and eukaryotic microorganisms). The proposed ASPA sites in SRM are valuable because they hold a biodiversity that is representative of harsh Antarctic mountain ecosystems, at the limits of the physico-chemical conditions that enable life to occur. Moreover, it is probable that exposed rock formations have acted as potential refugia for the (micro)organisms during the last glacial maximum and thus played an important role in these organisms' evolution and biogeography and that they are still hotspots of unique biodiversity today (Altmaier *et al*. 2010, Czechowski *et al*. 2012). A better understanding of the processes shaping biodiversity patterns can also help to predict their shifts in case of climate modifications.

The projects ANTAR-IMPACT, BELDIVA and MICROBIAN, funded by the Belgian Science Policy Office (BELSPO), have involved scientists from Belgium, the Czech Republic, France, Germany, Japan, Russia, and the UK. The results of these studies showed a surprisingly complex microbial and lichen diversity, but also revealed that different nunataks were hosts to genetically distinct populations of Collembola, which underlines the need to protect these biological communities from homogenization by human activities. A general trend observed is the larger development of biological soil crusts (BSC) and higher microbial diversity on granitic bedrocks than on gneiss, and therefore 3 of the 6 ASPA sites have granitic bedrocks. The sites at Petrellnuten and Teltet are primarily made by gneiss rocks, whereas Yuboku Valley is made of schists. The **observed conditions** for the establishment of biological crusts and communities consist mainly of a combination of (micro)habitat features: exposure to the North, protection from the strong scrubbing winds, presence of some liquid water from melting snow and stability of the substrate (Namsaraev *et al*. 2010).

In addition, Open-Top Chambers (OTC) to mimic future climate warming and its effect on the microbial communities were installed in 2010 and 2018 on Tanngarden Ridge (A), 4th Pingvinane Nunatak (C4), Northern Perlebandet Nunatak (DN) and Teltet Nunatak (E).

In the **ACBR 6** of Dronning Maud Land, there are currently **only 2 ASPAs**, a coastal one in the Schirmacher Oasis (ASPA 163: Dakshin Gangotri Glacier) and one for the nunatak Svarthamaren (ASPA 142: Mühlig-Hofmannfjella). These two ASPA cover in total less than 11 km^2, and serve different conservation goals, one being a retreating glacier and the other an important nesting area for petrels and other birds, respectively. Though terrestrial mountainous habitats (above 1 000 m altitude) are an important feature throughout Dronning Maud Land, only ASPA 142 is representative of this type of ecosystem and its surface is 7.5 km^2. Limited information is also available about its terrestrial biodiversity (Management Plan in Measure 8 (2014)). Its distance from the proposed ASPA is about 700 km.

An additional rationale for the ASPA designation is the establishment since 2007-08 of the Belgian research station Princess Elisabeth that has given access to these terrestrial ecosystems to a greater number of scientists and visitors. This has enabled the more detailed exploration of the biodiversity in the region and new experimental studies of the impact of climate modifications with OTC and snow fences. Moreover, the station has expanded its original capacity to about 40 people (from 20 people according to the comprehensive environmental evaluation prepared for the construction of the Belgian Princess Elisabeth research station, prepared in 2007, hereinafter "the CEE, 2007"), a new airfield (Perseus) was installed at 60 kms from the station and is presently used for intercontinental flights, and a general look at the touristic offers in Dronning Maud Land shows that an increased human impact can be expected. Therefore, this is the right time to apply the provisions of Annex V to the Madrid Protocol and give additional protection to a representative portion of the mountainous terrestrial biotopes in the SRM region.

1. Description of values to be protected

Together, the 6 ice-free areas designated to form the ASPA include outstanding environmental and biological features and are representative examples of major terrestrial ecosystems, including lakes, in mountainous regions of Antarctica. This region of the SRM was considered pristine in 2007 (CEE, 2007) and the six sites have either not or limitedly been accessed for scientific sampling following the rules of the Protocol on Environmental Protection. Two nunataks of the Pingvinane Range (C) are designated to be kept inviolate from human interference, so that future comparisons may be possible with similar localities that have been affected by human activities.

The aims of this ASPA are to preserve its environmental, scientific, aesthetic and wilderness values.

1(i) Environmental values

During the BELSPO projects ANTAR-IMPACT, BELDIVA and MICROBIAN, scientists have determined that the biodiversity of microorganisms and invertebrates was high in ice-free terrestrial habitats of the Sør Rondane Mountains. This includes biofilms and biological soil crusts on rocks and gravels, hypo- and cryptoendolithic growth. In addition, glacial and aquatic habitats consist of cryoconites and a few lakes. Unique **microbial organisms** have been cultivated and described from the region (e.g. Peeters *et al*. 2011; Tahon *et al*. 2018; Tahon *et al*. 2021a and 2021b; Ertz *et al*. 2014). For the terrestrial biotopes, statistical analyses revealed that total organic carbon was the most significant parameter in structuring the **prokaryotic** communities (studied using metabarcoding through Illumina amplicon sequencing), followed by pH, conductivity, bedrock type and water content. Acidobacteria (*Chloracidobacteria*) and Actinobacteria (*Actinomycetales*) dominated the organic carbon-poor samples situated on gneiss, while Proteobacteria (*Sphingomonadaceae*), Cyanobacteria, Armatimonadetes and candidate division FCB (OP11) mainly occurred in granite samples with a high total organic carbon content (Tytgat *et al*. 2016). *Rotifera, Chlorophyta, Tardigrada, Ciliophora, Cercozoa, Fungi, Bryophyta, Bacillariophyta*, *Collembola* and *Nematoda* were present with a relative abundance of at least 0.1% in the eukaryotic communities as assessed using the metabarcoding data of 22 samples from various habitats (Obbels *et al*. 2016). Not only microorganisms but also **collembola** show interesting phylogeographic patterns. Stevens & D'Haese (2014) determined that the molecular marker divergence in *Cryptopygus sverdrupi* collected in different nunataks indicate that they have persisted throughout the Miocene and Pliocene in these glacial refugia.

Terrestrial biological communities, mostly biological crusts that can include mosses, lichens, fungi, invertebrates and microorganisms, show specific biogeographic distributions and may have survived the glaciation cycles in ice-free refugia (e.g. nunataks). They are **vulnerable** to trampling and disturbances by human activities. The local populations could be lost by homogenization due to transfer of microorganisms, invertebrates, propagules, by human vectors (scientists, logisticians, tourists...)(Hughes *et al*. 2013, 2015) between nunataks or mountains.

Moreover, the Yuboku Valley (Northern side of Svindlandfjellet, also called Nomadedalen, *https://stadnamn.npolar.no/Nomadedalen*) holds the only **lakes** currently known in the region and therefore deserves to be included in the ASPA for its environmental value. The valley is protected from the wind and appears to be warmer than the surrounding region. During the abnormally warm summer 2019-20, the presence of 3 lakes was observed but in other years, they might be frozen to the bottom and snow-covered. Abundant black and red cyanobacterial mat communities were observed in the lakes and on the shores by the scientists.

1(ii) Scientific values

As indicated in the CEE (2007), no indication of previous human impact could be observed at the Utsteinen site before the construction of the Princess Elisabeth station, and it can indeed be assumed that all the ASPA sites were pristine in 2007. Dr. Ziolkowski (University of South Carolina, US) received in 2017 the Baillet Latour Antarctica Fellowship for the project "REMACA" to use the natural abundance of radiocarbon to study the rates of carbon accumulation and microbial activity in endoliths. Such measurements are only meaningful if the samples are not contaminated by anthropogenic carbon, and thus, little impacted by human presence. Published results indicate that the endoliths in the SRM were cycling carbon rather quickly despite the climatic extremes (Tyler and Ziolkowski, 2021). The characterization of the terrestrial communities in the SRM was started in 2007 and is still on-going. MICROBIAN, a recent Belgian Science Policy Office project (2017-21) also studied the functioning of microbial communities through ecophysiological and molecular methods. Therefore, sensors to record the temperature and humidity were placed in many sampling sites in the ice-free areas to understand the microclimatic conditions experienced by the biota.

A combination of remote sensing and close-range field observation techniques has been used to assess the mapping of physical habitat characteristics in relation to the presence/extent of microbial mat and biological crust communities. Satellite remote sensing was used to derive spatially resolved datasets of land surface temperature and site elevation and orientation at metre and decametre scale (Vanhellemont *et al.* 2021). Site elevation was accurately retrieved from tri-stereo optical imagery from the Pléiades constellation, and the retrieved elevation compared well to other reference datasets. Land surface temperature derived from the thermal infrared imager on board Landsat 8 showed a good correspondence with *in situ* measurements by sensors, generally within a few degrees. A site dependent performance was identified, related to the deployment location of the data logger and the surrounding environment. The synoptic land surface temperature products could not be used as a representative temperature map of the sites, due to the long day lengths during the austral summer causing different mountain sides to be heated over the course of the day.

Four of the selected ice-free areas are currently hosting climate manipulation experiments. Open-Top Chambers (OTC) which mimic future climate warming and its effect on the microbial communities were installed in 2010 (BELDIVA project) and 2018 (MICROBIAN project) on the Tanngarden ridge (A), 4th Pingvinane Nunatak (C4), Perlebandet North (DN) and the Teltet Nunatak (E). Control areas in the vicinity of the OTC were also delimited to allow a comparison between treated and untreated sites to determine the impact of the climate manipulation on the microbial communities over time (Pushkareva *et al.* 2018). Temperature and humidity sensors were placed in the OTC and are read and replaced each year except if the OTC is completely covered with snow at the time of the visits. It is important to protect these experimental sites from human disturbances and trampling that would affect the results.

The evolutionary history of the (micro)organisms living in the SRM is also of importance to understand their current biogeographic patterns and predict the expansion or contraction of their distribution ranges. Studies based on molecular markers in invertebrate populations and individuals have been started and can help to reveal the factors that shape the population structures (e.g. Czechowski *et al*, 2012).

1(iii) Aesthetic and wilderness values

The landscape of the Sør Rondane Mountains is of striking aesthetic quality, with very scenic views. The darker rocks of the nunataks and peaks, sometimes with bizarre morphologies, contrast beautifully with the white areas of snow and ice, particularly during sunny days. The high mountain ranges partially covered by white snow decorate the horizon. At some distance from the station, the silence and feeling of isolation are complete.

2. Aims and objectives

Management of Western Sør Rondane, Dronning Maud Land, East Antarctica aims to:

- Avoid degradation of, or substantial risk to, the values of the Area by preventing unnecessary human disturbance to the Area;
- Facilitate long-term scientific research while avoiding direct or cumulative damage to vulnerable biological and environmental features;
- Allow scientific research in the Area provided it is for compelling reasons which cannot be served elsewhere, which is consistent with the management aims and objectives and which will not jeopardize the values in that Area;
- Preserve a part of the natural ecosystem of the Area as a reference area for future comparative studies;
- Allow visits for management purposes in support of the aims of the Management Plan;
- Minimize the introduction to the Area of alien plants, animals and microbes.

3. Management activities

- Copies of the Management Plan (with maps included) shall be made available at the Princess Elisabeth Station (Belgium), and the map of the protected area with the 6 sites should be put up at prominent positions in the station mentioned above. Personnel in the vicinity of, accessing or flying over the Area shall be specifically instructed, by their National Programs as to the provisions and contents of the Management Plan.
- The Area shall be visited as necessary, and no less than once every five years, to assess whether it continues to serve the purposes for which it was designated and to ensure that management activities are adequate.
- National Antarctic Programs operating in the Area shall consult together with a view to ensuring the management activities are implemented.
- The Management Plan should be reviewed no less than once every five years and, if necessary, updated or revised.
- Up to date Management Plans, maps and other relevant information shall be made available on National Program websites

4. Period of designation

Designated for an indefinite period.

5. Maps and photos

Figure 1. Map with a general view of the Western Sør Rondane Mountains (Dronning Maud Land) with the situation of the Princess Elisabeth Station, the Tanngarden Ridge (A), Petrellnuten Nunatak (B), range of Pingvinane Nunataks (C), Perlebandet range (D), the Teltet Nunatak (E), and the Yuboku Valley (F) (near Svindlandfjellet).

Figure 2. Map of the Western Sør Rondane Mountains with the positions of the Princess Elisabeth Station and the ASPA sites: the Tanngarden Ridge (A), Petrellnuten Nunatak (B), range of Pingvinane Nunataks (C), Perlebandet range (D), the Teltet Nunatak (E), and the Yuboku Valley (F).

Map contains modified Copernicus Sentinel data [2019]" in the caption) and the Antarctica contour is from Wikimedia Commons (*https://commons.wikimedia.org/wiki/File:AntarcticaContour.svg*), and was released under a CC BY-SA 4.0 license.

Figure 3. Taken from Fig. 1 of Shaw *et al*. (2014). Location of Antarctic Specially Protected Areas (ASPAs) and Antarctic Conservation Biogeographic Regions (ACBRs). Circles indicate ASPAs. Coloured areas represent ice-free land; different colours denote the ACBRs. The two other ASPAs (142 and 163) of ACBR6 and ASPA 141 in ACBR5 are indicated.

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Figure 4. Map of Tanngarden nunatak and ridge (A)

Figure 5. Map of Petrellnuten nunatak (B)

Figure 6. Map of the Pingvinane Range (C) with the 7 nunataks

Figure 7. Map of Perlebandet Northern (DN)

Figure 8. Map of Perlebandet South (DS)

Figure 9. Map of Teltet Nunatak (E)

Figure 10. Map of Yuboku Valley (F)

6. Description of the Area

6. (i) Geographical co-ordinates, boundary markers and natural features

General Description

The ASPA comprises 6 separate sites shown in Figures 4-11 and covers a total area of 4.583 km^2. The site Perlebandet (D) includes two nunataks and the Pingvinane (C) range includes 7 nunataks. The Pingvinane nunataks 6 and 7 form an inviolate area. Maps of each site are shown in Figures 4-11. This fragmented location is due to the mountainous topology, where nunataks, ranges and ridges stick out of the ice. As written earlier, the glaciers between the 7 sites and included nunataks are not part of the ASPA.

The Sites are lettered A to F and referred to by their name.

The boundaries of the nunataks generally follow the outline of the rocks that emerge from the surrounding glaciers. However, these outlines are irregular. To facilitate the calculation of GIS positions, vertices were calculated on the basis of polygons that were drawn as close as possible to the natural boundaries. Therefore, the areas' surface indicated in the descriptions will be the areas of the polygons.

Site A – Tanngarden Ridge

Area enclosed. The Tanngarden site (Fig. 4) includes the Nunatak and a Ridge covering an area of 0.528 km^2. The bedrock is granitic. Apparent depositional age of metacarbonate rocks from the Tanngarden region is estimated as late-Tonian and early-Cryogenian age (880–850 Ma and 820–790 Ma) based on a Sr isotope study (Otsuji *et al.*, 2013).

Boundaries: Tanngarden		
Vertex	**Latitude**	**Longitude**
1	22° 56' 39"	-72° 01' 18"
2	22° 56' 58"	-72° 01' 38"
3	22° 57' 05"	-72° 01' 46"
4	22° 56' 23"	-72° 01' 55"
5	22° 55' 59"	-72° 01' 42"
6	22° 56' 11"	-72° 01' 12"

Scientific value: OTC 7 and 8 were installed in January 2010 in a windscoop on the Northern side of a granite outcrop on the Northern side of Tanngarden ridge. The coordinates are S 72°01'17.5", E 22°56'29.5". One bamboo pole with a flag was placed. They have not yet been sampled because they were covered by snow during the field campaigns of 2018, 2019 and 2020.

Site B - Petrellnuten Nunatak

Area enclosed. The area of the Petrellnuten nunatak (Fig. 5) is 0.283 km^2. The bedrock is granitic.

Boundaries: Petrellnuten		
Vertex	**Latitude**	**Longitude**
1	22° 50' 04"	-72° 00' 25"
2	22° 50' 21"	-72° 00' 45"
3	22° 49' 19"	-72° 00' 50"
4	22° 49' 41"	-72° 00' 25"

Scientific value: This nunatak has a granitic bedrock. It has been studied since 2010 and 4 temperature and humidity loggers were placed.

Site C – Range of 7 Pingvinane nunataks

Area enclosed. The seven nunataks of the Pingvinane range (Fig. 6) are enclosed in the ASPA as separate subsites. The glacier zones between them are not included in the ASPA. They are composed of typical alkali granite with coarse-grained equigranular texture. (Shiraishi *et al.*, 1992).

The respective areas are 0.161 km^2 for Pingvinane 1 (C1), 0.201 km^2 for Pingvinane 2 (C2), 0.159 km^2 for Pingvinane 3 (C3), 0.430 km^2 for Pingvinane 4 (C4), 0.054 km^2 for Pingvinane 5 (C5), 0.247 km^2 for Pingvinane 6 (C6), and 0.210 km^2 for Pingvinane 7 (C7).

The 6th nunatak (C6) which was visited in 2010 by scientists and the 7th nunatak (C7) which has never been visited constitute an inviolate area inside the ASPA. This inviolate area is designated to be kept free from human interference for 50 years, so that future comparisons, using increasingly sophisticated cutting-edge research techniques may be possible with localities that have been affected by human activities. In 2070, these locations may be the last areas on Earth known to have remained unvisited for at least 50 years (C6) or not to have been visited at all (C7), and therefore of immense scientific worth (Hughes *et al.* 2016).

Boundaries: Pingvinane 1		
Vertex	Latitude	Longitude
1	23° 00' 01"	-71° 58' 41"
2	23° 00' 00"	-71° 58' 53"
3	22° 59' 47"	-71° 58' 55"
4	22° 59' 48"	-71° 58' 59"
5	22° 59' 27"	-71° 59' 01"
6	22° 59' 27"	-71° 58' 52"
7	22° 59' 29"	-71° 58' 41"
Boundaries: Pingvinane 2		
1	22° 59' 48"	-71° 58' 59"
2	22° 59' 47"	-71° 59' 19"
3	22° 59' 09"	-71° 59' 19"
4	22° 59' 07"	-71° 59' 08"
5	22° 59' 27"	-71° 59' 01"
Boundaries: Pingvinane 3		
1	22° 59' 28"	-71° 59' 26"
2	22° 59' 22"	-71° 59' 44"
3	22° 58' 52"	-71° 59' 44"
4	22° 58' 59"	-71° 59' 27"
Boundaries: Pingvinane 4		
1	23° 00' 12"	-71° 59' 49"
2	23° 00' 47"	-71° 59' 56"
3	23° 00' 49"	-72° 00' 13"
4	22° 59' 44"	-72° 00' 13"
5	22° 59' 44"	-71° 59' 49"
Boundaries: Pingvinane 5		
0	22° 59' 56"	-72° 00' 17"
1	23° 00' 13"	-72° 00' 25"
2	22° 59' 39"	-72° 00' 27"
3	22° 59' 52"	-72° 00' 17"
4	22° 59' 56"	-72° 00' 17"

Boundaries: Pingvinane 6		
Vertex	Latitude	Longitude
1	23° 00' 20"	-72° 00' 42"
2	23° 00' 20"	-72° 00' 50"
3	22° 59' 13"	-72° 00' 50"
4	22° 59' 17"	-72° 00' 36"
5	22° 59' 35"	-72° 00' 35"
6	22° 56' 11"	-72° 01' 12"
Boundaries: Pingvinane 7		
1	23° 02' 29"	-72° 00' 30"
2	23° 02' 29"	-72° 00' 49"
3	23° 01' 36"	-72° 00' 51"
4	23° 02' 13"	-72° 00' 30"

Scientific value: Since 2009, the Pingvinane range of nunataks has been accessed to study its biodiversity, except the seventh nunatak (C7). The bedrock is made of granite and visible microbial mats are present in suitable habitats. In January 2010, OTCs 3 and 4 and control sites were installed on the SW slope of the fourth nunatak (C4). The coordinates are S 72°00'04.6", E 022°59'57.6"and a bamboo pole was placed. The OTC 4 was found to be broken in 2018 and was removed. Five temperature and humidity loggers were placed.

Site D - Perlebandet range

Area enclosed. Perlebandet range is one of the westernmost nunataks in the SRM, where granulite facies layered gneisses are exposed (Kawakami *et al.* 2017). Two nunataks of the Perlebandet range are enclosed as separate sub-sites. Surface area of Perlebandet North (DN) (Fig. 7) is 1.038 km^2 whereas it is 0.769 km^2 for Perlebandet South (DS) (Fig. 8). They both include marble intrusions in a gneiss bedrock. The glacier areas in between are not included in the ASPA.

Boundaries: Perlebandet_North		
Vertex	Latitude	Longitude
1	22° 50' 27"	-71° 50' 35"
2	22° 49' 33"	-71° 51' 12"
3	22° 48' 23"	-71° 51' 18"
4	22° 48' 21"	-71° 51' 02"
5	22° 49' 35"	-71° 50' 26"
Boundaries: Perlebandet_South		
1	22° 45' 02"	-71° 52' 56"
2	22° 44' 31"	-71° 53' 30"
3	22° 43' 56"	-71° 53' 30"
4	22° 43' 51"	-71° 53' 17"
5	22° 43' 17"	-71° 53' 14"
6	22° 43' 20"	-71° 53' 07"
7	22° 44' 51"	-71° 52' 46"

Scientific value: The two nunataks were sampled to characterize their biodiversity. In the most Northern nunatak (DN), OTCs 9, 10, 15, 16 and 17 were installed with the corresponding control areas (sites with similar biomass in the vicinity of the OTC). The OTC 9 and 10 were installed on a marble vein in January 2018, as this geological feature is very rare. The OTC 15, 16 and 17 were installed on gneiss and marble gravel in February 2019. Temperature and humidity loggers are placed in the OTCs and control areas, except when unavailable, and were read till 2020 annually except when the snow cover hindered their retrieval. Metal poles indicate the position of the OTCs. The Southern nunatak (DS) was accessed in 2010 and 2018. Three temperature and humidity loggers were left in place.

Site E. Part of the Teltet nunatak

Area enclosed. The Northern slope of the nunatak (Fig. 9) where the OTCs and control sites were placed is enclosed in the ASPA. This represents 0.032 km^2.

Boundaries: Teltet		
Vertex	**Latitude**	**Longitude**
1	23° 29' 43"	-71° 59' 10"
2	23° 29' 31"	-71° 59' 02"
3	23° 29' 24"	-71° 59' 03"
4	23° 29' 23"	-71° 59' 11"

Scientific value: Since 2009, samples were taken from the Teltet nunatak to explore its biodiversity. On this gneiss rocky nunatak, there are hardly any visible Biological Soil Crusts but a microbial diversity is present as shown by molecular methods. OTC 5 and 6 were installed in January 2010 on a small plateau on the Northern slope of Teltet nunatak. The purpose was to observe whether the obstacles to the establishment of visible communities could be counteracted by the changes in microclimatic conditions due to the OTC, or whether the problems were linked to the substrate. The coordinates are S 71°59′56.8″, E 23°31′02.06″. One bamboo pole was placed.

Site F. Yuboku Valley

Area enclosed. The entrance of Yuboku Valley (Fig. 10) with the two lakes that have been sampled is enclosed, and the polygon measures 0.459 km^2.

Boundaries: Yuboku Valley		
Vertex	**Latitude**	**Longitude**
1	23° 47' 30"	-72° 04' 33"
2	23° 48' 01"	-72° 04' 41"
3	23° 48' 05"	-72° 05' 03"
4	23° 47' 09"	-72° 05' 05"
5	23° 47' 04"	-72° 04' 39"

Scientific value: In 2011, the Yuboku Valley was discovered. It appears to contain 3 lakes, with conspicuous microbial mats on the bottom or floating under the thin ice layer. The mats are also present on gravel and sand moraines outside of the lakes, but their abundance and size decrease with the distance to the shore. Depending on the year, the lakes may be in frozen or liquid state. Temperature and humidity data were recorded by loggers in the period 2018-2020.

General climate conditions

An automated weather station (AWS), installed during 2005 at the site of the new PES station indicated an average annual temperature of -18°C, varying between -8°C (December) and -25°C (September). The daily maximum does not exceed zero in summer, while the daily minimum reaches -36°C in winter (CEE, 2007).

The climatic conditions at the Usteinen ridge are milder than in the surrounding regions of the SRM. This can be explained by "two principal factors, namely, a favorable location for warm air advection associated with local intense cyclonic activity, and a lack of drainage of cold air from the high plateau due to the Sør Rondane Mountain sheltering" (Gorodetskaya *et al.* 2013). Mean summer wind speeds are around 4.5 ms-1 (Pattyn *et al.* 2010).

An automated weather station of IMAU, Universtity of Utrecht (NL) was installed from February 2009 to January 2021 (*http://www.projects.science.uu.nl/iceclimate/aws/antarctica.php*). It is now dismounted. EPFL Lausanne, Switzerland, has moved one of their AWS in December 2020 from the Utsteinen air strip to the Eastern side of Utsteinen ridge, few hundred meters of PEA. WSL, Switzerland, also operates several AWS in the surroundings of PEA, one also at Utsteinen air strip since 2014. Other meteorological instruments are listed on the website of the HYDRANT project (*https://ees.kuleuven.be/hydrant/instruments/index.html*), including a Ceilometer, Infrared Radiation Pyrometer and a Micro Rain Radar.

6. (ii) Access to the Area

Access to the area may be gained overland on foot, by skidoos or other vehicles. Access to the area by land vehicles such as snowmobile should take care to avoid destroying the local biological and other geological and natural physiognomy.

6. (iii) Location of structures within and adjacent to the site

Princess Elisabeth Station (PES) is located on the southern end of the Utsteinen Ridge, 8 km from Teltet nunatak (Site E) and at 15-20 km from the 5 other ice-free areas that are included in the ASPA. OTCs are located in 4 ASPA sites, and temperature and humidity loggers are present in Pingvinane 4 (C4) and Perlebandet North (DN). For air transportation, a seasonal snow landing strip is located NW of the PES.

Further away, the former Asuka station (Japan) is situated at 55 km from PES (Fig. 1). The Perseus airfield (71°25′09″S 23°31′06″E) is located at a distance of ca 60 km. All other structures are hundreds of km away.

6. (iv) Location of other protected areas in the vicinity

There are no other protected areas nearby. In ACBR 6, ASPA 142 is ca 700 km distant and ASPA 163 is 400 km distant (Fig. 2). ASPA 141 (Yukidori Valley, Langhovde, Lützow-Holmbukta (69°14′S; 33°45′E) is located in a different ACBR (ACBR5, Enderby Land) and is ca. 650 km distant to the east (Fig. 3).

6. (v) Special Zones within the Area

A prohibited zone, not to be entered by anyone, will be set up in the 6th and 7th Pingvinane nunataks (C6 and C7) to serve as an 'inviolate reference site' for Antarctic microbial diversity for a period of 50 years.

7. Terms and conditions for entry – Permits

7. (i) General permit conditions

Entry into the Area is prohibited except in accordance with a Permit issued by an appropriate national authority. Conditions for issuing a Permit to enter the Area are that:

- It is issued for compelling scientific reasons which cannot be served elsewhere, or for reasons essential to the management of the Area. A permit shall not be issued unless the applicant can demonstrate to the appropriate competent authorities that specimens or samples already collected from other parts of the world cannot fully meet the needs of the research proposed;
- The activities permitted are in accordance with this Management Plan;
- The activities permitted will give due consideration via the environmental impact assessment process to the continued protection of the scientific, environmental, aesthetic and wilderness values of the Area;
- The Permit or its valid copy shall be carried when in the Area;
- The Permit shall be issued for a finite period;
- Report on the activities must be submitted to the national authorities issuing the Permit.

7. (ii) Access to, and movement within or over, the Area

- Vehicles are prohibited within the Area and all movement within the Area should be on foot. Pedestrian traffic shall be kept to the minimum necessary to undertake permitted activities and every reasonable effort shall be made to minimise trampling effects. Movement within the Area by foot shall be on bare rocks only (with no visible biomass). Due to the rocky nature of the substrate, there are no designated tracks.
- Visitors shall avoid areas of visible vegetation and care should be exercised when walking in areas of moist ground, particularly near the lakes, where foot traffic can easily damage sensitive soils, plant and algal communities, and degrade water quality.
- Climbing up is strictly prohibited, if not for scientific purposes.

7. (iii) Activities which may be conducted within the Area

- Compelling scientific research which cannot be undertaken elsewhere and which does not jeopardize the values of the Area;
- Sampling, which should be the minimum required for approved research programs;
- Essential management activities, including monitoring, inspection, maintenance or review;
- Operational activities in support of scientific research or management within or beyond the Area, including visits to assess the effectiveness of the Management Plan and management activities.

7. (iv) Installation, modification and removal of structures

- No structures are to be erected within the Area, or scientific equipment installed, except for compelling scientific or management reasons;
- All the structures erected and scientific equipment installed within the Area shall be specified in the Permit issued by the competent authority of the particular country. Where possible, such installations should avoid sensitive geomorphological features;
- All the structures erected and scientific equipment installed in the Area must be clearly identified by country, name of the principal investigator or agency and year of installation. All such items shall be made of materials that pose minimal risk of contamination of the Area. These facilities must be removed when they are no longer required, and so shall other abandoned equipment or materials as far as possible.

7. (v) Location of field camps

The ASPA sites are located sufficiently close to Princess Elisabeth Station that they can be accessed after a short ride by skidoos or other vehicles, and thus the set-up of a field camp is not necessary. Moreover, the ice-free areas with horizontal slopes are very limited. Therefore, camping is prohibited within the Area.

7. (vi) Restrictions on materials and organisms which may be brought into the Area

- No depots of food or other supplies are to be left within the Area beyond the time period or activity for which they are required;
- Fuel or other chemicals shall not be stored in the Area unless specifically authorised by Permit condition. They shall be stored and handled in a way that minimises the risk of their accidental introduction into the environment;
- No living animals, plant material or micro-organisms shall be deliberately introduced into the Area. All necessary precautions shall be taken to prevent accidental introduction.
- All materials introduced shall be for a stated period, shall be removed at or before the conclusion of that stated period, and shall be stored and handled so as to minimize the risk of environment impacts.

7. (vii) Taking of, or harmful interference with, native flora and fauna

Taking of, or harmful interference with, native flora and fauna into the Area is prohibited except in accordance with a Permit issued by an appropriate national authority and in due respect of the provisions of Annex II of Protocol on Environmental Protection to the Antarctic Treaty.

7. (viii) Collection or removal of materials not imported by the Permit holder

- Material may be collected or removed from the Area only in accordance with a Permit and should be limited to the minimum necessary to meet scientific or management needs. The collection of material should be carried out with sterile (or clean if sterilization would be destructive) equipment, to avoid cross-contamination between sampling sites.
- Material of human origin likely to compromise the values of the Area, and which was not brought into the Area by the Permit holder or otherwise authorized, should be removed unless the impact of the removal is likely to be greater than leaving the material *in situ*. If this is the case, the appropriate national authority must be notified and approval obtained.

7. (ix) Disposal of waste

- At a minimum, all wastes, including all human wastes, shall be managed in accordance with Annex III of the Protocol on Environmental Protection to the Antarctic Treaty.
- All wastes, including all human liquid and solid wastes, shall be removed from the Area.
- Waste generated as a consequence of and during the activities developed in the Area shall be temporarily stored in such a way as to prevent their dispersal into the environment and removed when activities have been concluded.

7. (x) Measures that may be necessary to continue to meet the aims of the Management Plan

- Any long-term monitoring sites shall be appropriately marked and the markers or signs maintained.
- Permits may be granted to enter the Area to carry out biological monitoring and site inspection activities, except in the prohibited zone.
- To help maintain the ecological and scientific values of the Area, visitors shall take special precautions against introductions. Of particular concern are microbial, animal or vegetation introductions sourced from soils from other Antarctic sites, including stations, or from regions outside Antarctica. To the maximum extent practicable, visitors shall ensure that footwear, clothing and any equipment – particularly sampling equipment – is thoroughly cleaned before entering the Area.

7. (xi) Reporting requirements

- The principal permit holder for each visit to the Area shall submit a report to the appropriate national authority as soon as practicable, and no later than three months after the visit has been completed.
- Such reports should include, as appropriate, the information identified in the visit report form contained in the Guide to the Preparation of Management Plans for Antarctic Specially Protected Areas. The national authority should also make the visit report copy available to the Party that proposed the Management Plan, to assist in managing the Area and reviewing the Management Plan.
- Parties should, wherever possible, deposit originals or copies of such original visit reports within a year in a publicly accessible archive to maintain a record of usage, for the purpose of any review of the Management Plan and in organizing the scientific use of the Area.

8. Supporting documentation

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Figure 1. Map with a general view of the Western Sør Rondane Mountains (Dronning Maud Land) with the situation of the Princess Elisabeth Station, the Tanngarden Ridge (A), Petrellnuten Nunatak (B), range of Pingvinane Nunataks (C), Perlebandet range (D), the Teltet Nunatak (E), and the Yuboku Valley (F) (near Svindlandfjellet). The map contains modified Copernicus Sentinel data [2019] and the Antarctica contour is from Wikimedia Commons (https://commons.wikimedia.org/wiki/File:AntarcticaContour.svg), and was released under a CC BY-SA 4.0 license.

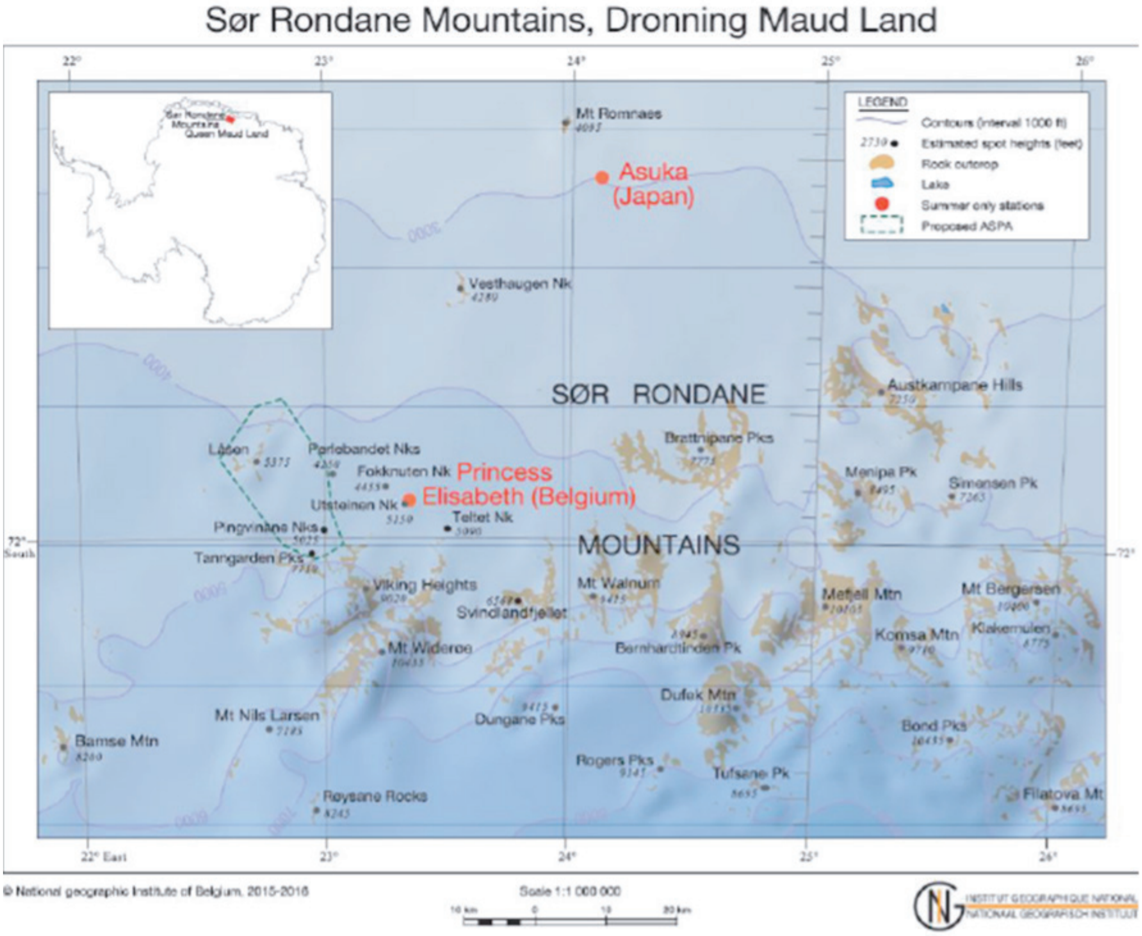

Figure 2. Map of the Western Sør Rondane Mountains with the positions of the Princess Elisabeth Station and the ASPA sites: the Tanngarden Ridge (A), Petrellnuten Nunatak (B), range of Pingvinane Nunataks (C), Perlebandet range (D), the Teltet Nunatak (E), and the Yuboku Valley (F).

Map contains modified Copernicus Sentinel data [2019]" in the caption) and the Antarctica contour is from Wikimedia Commons (https://commons.wikimedia.org/wiki/File:AntarcticaContour.svg), and was released under a CC BY-SA 4.0 license.

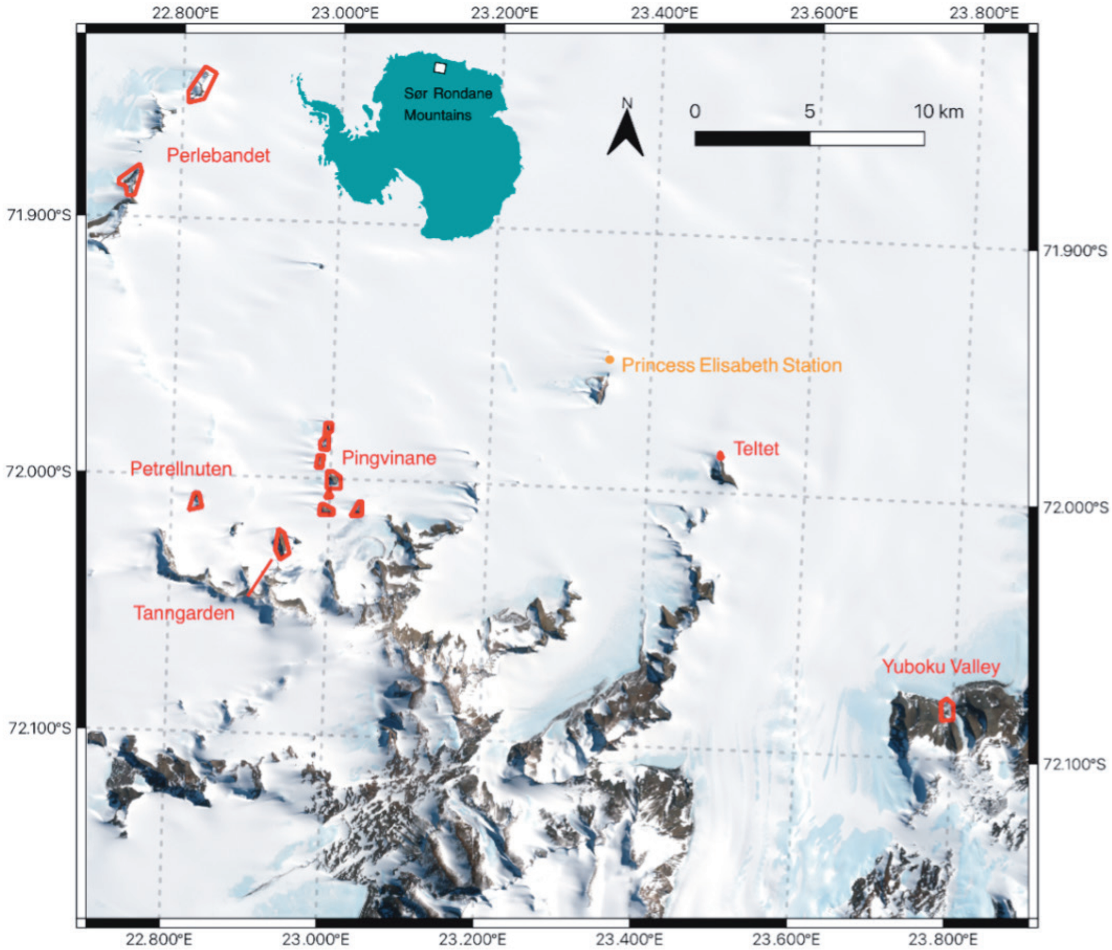

Figure 3. Taken from Fig. 1 of Shaw et al. (2014). Location of Antarctic Specially Protected Areas (ASPAs) and Antarctic Conservation Biogeographic Regions (ACBRs). Circles indicate ASPAs. Coloured areas represent ice-free land; different colours denote the ACBRs. The two other ASPAs (142 and 163) of ACBR6 and ASPA 141 in ACBR5 are indicated.

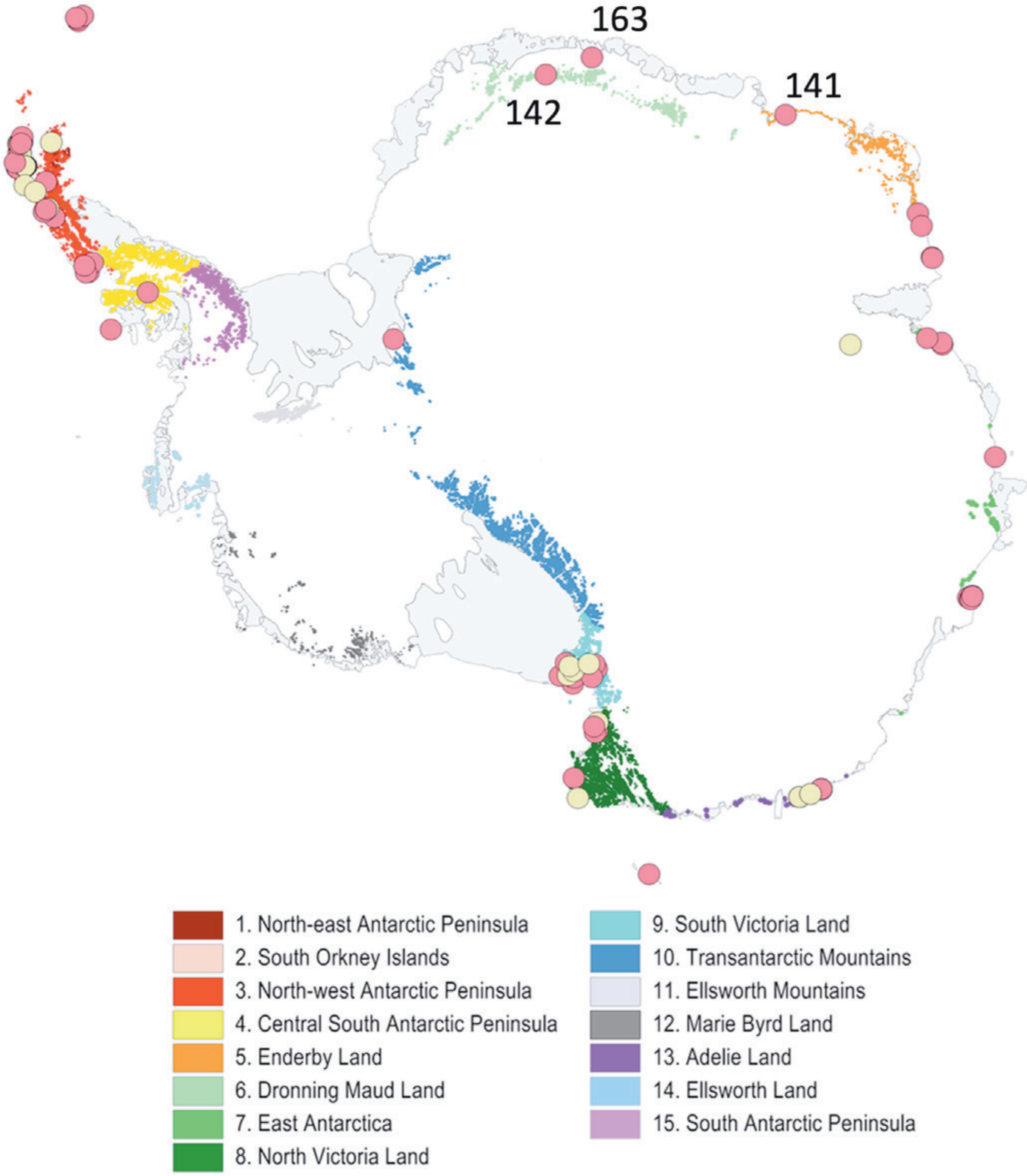

Figure 4. Map of Tanngarden nunatak and ridge (A) with protected area in the red polygon. Map contains modified Copernicus Sentinel data [2019].

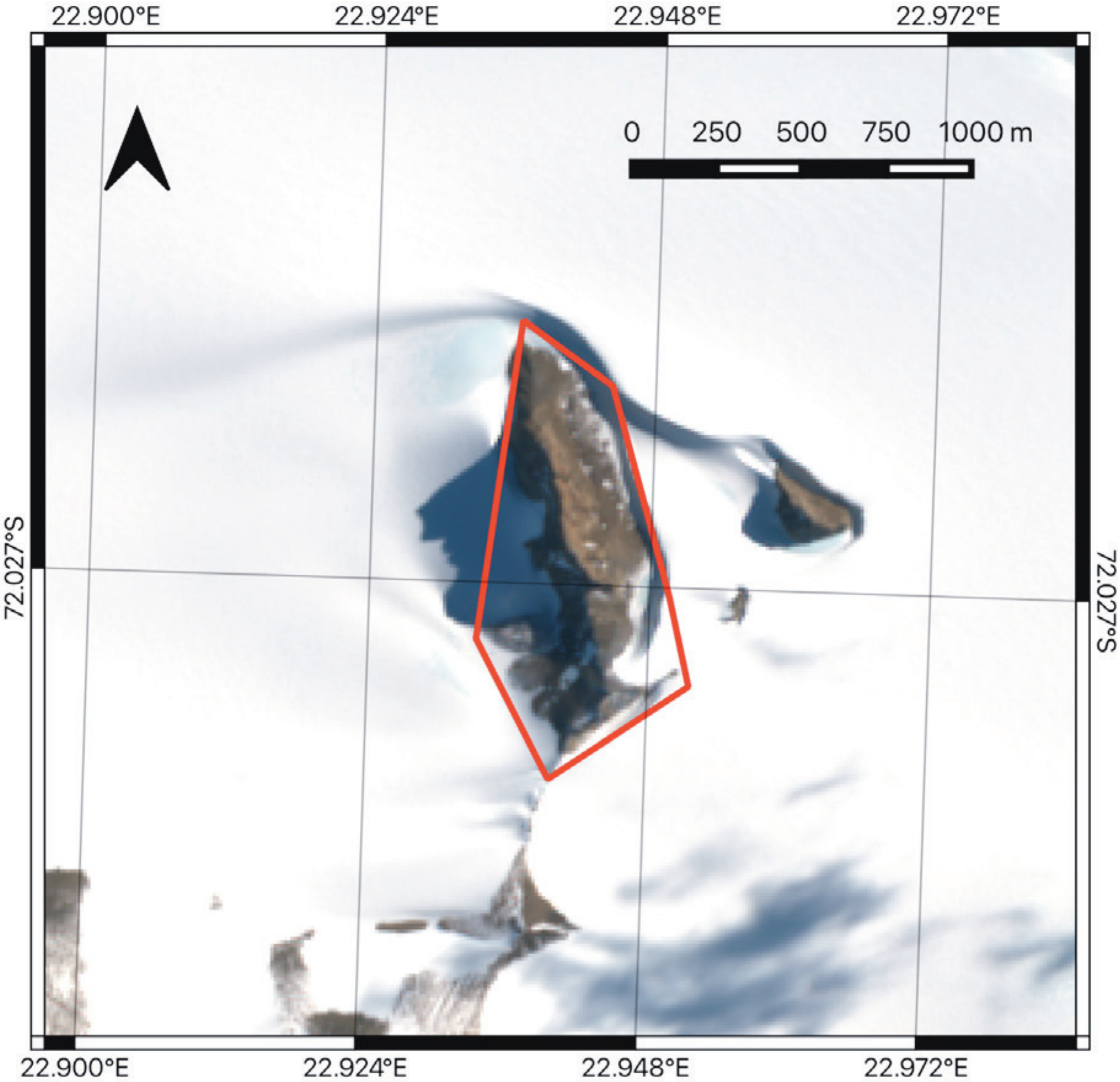

Figure 5. Map of Petrellnuten nunatak (B) with protected area in the red polygon. Map contains modified Copernicus Sentinel data [2019].

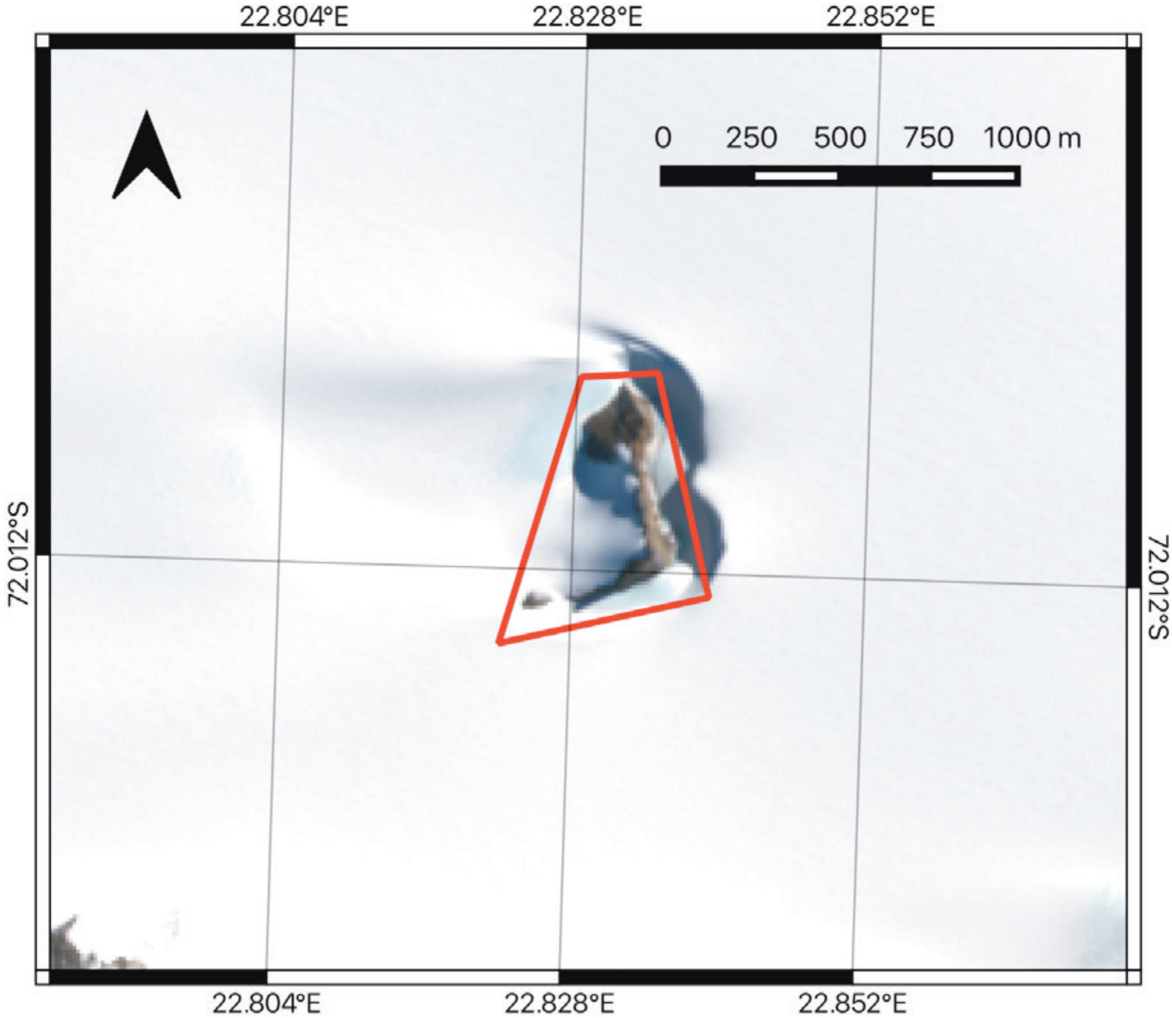

Figure 6. Map of the Pingvinane Range (C) with the 7 nunataks, with protected area in the red polygons. Map contains modified Copernicus Sentinel data [2019].

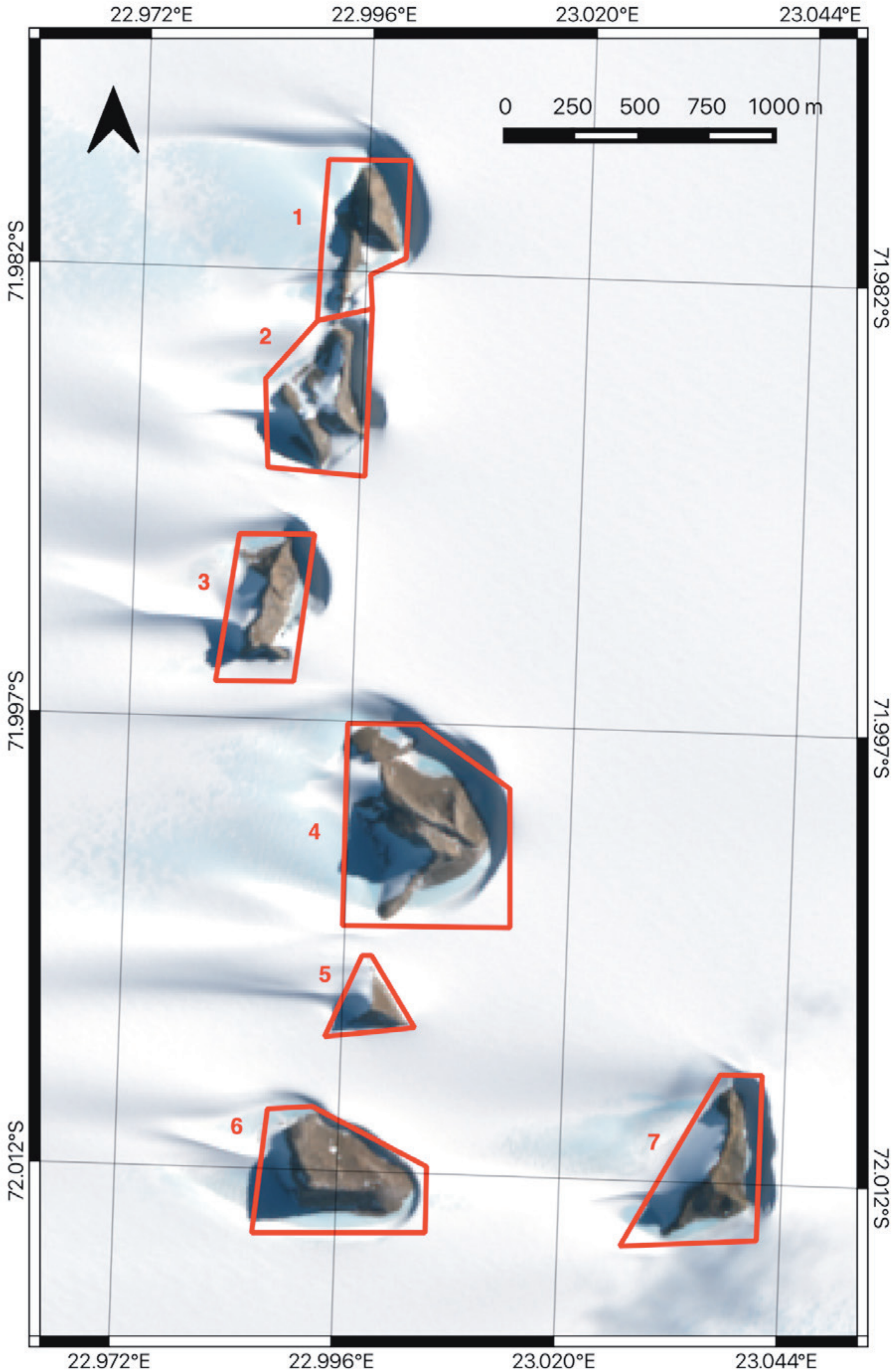

Figure 7. Map of Perlebandet Northern (DN) with protected area in the red polygon. Map contains modified Copernicus Sentinel data [2019].

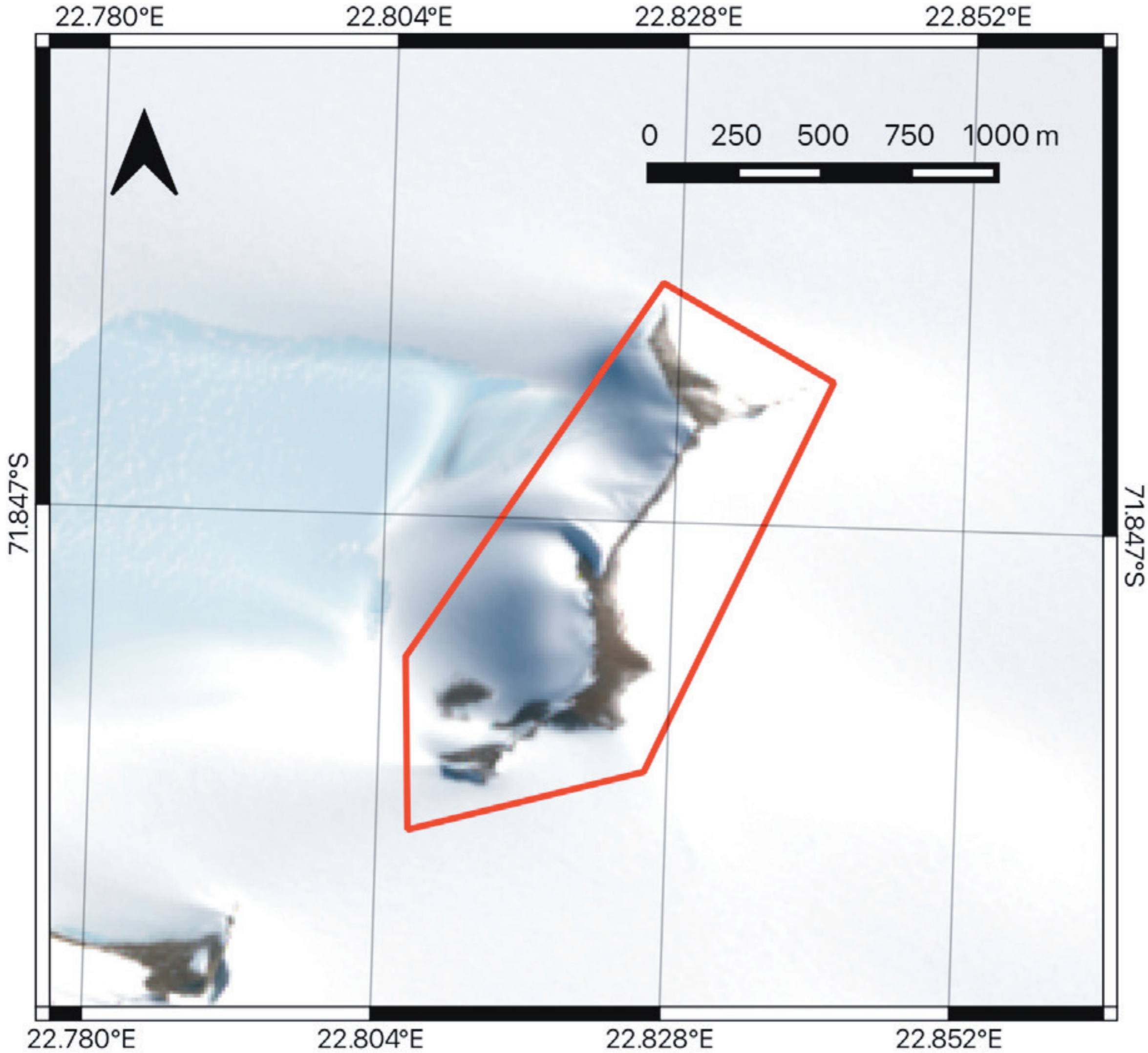

Figure 8. Map of Perlebandet South (DS), with protected area in the red polygon. Map contains modified Copernicus Sentinel data [2019].

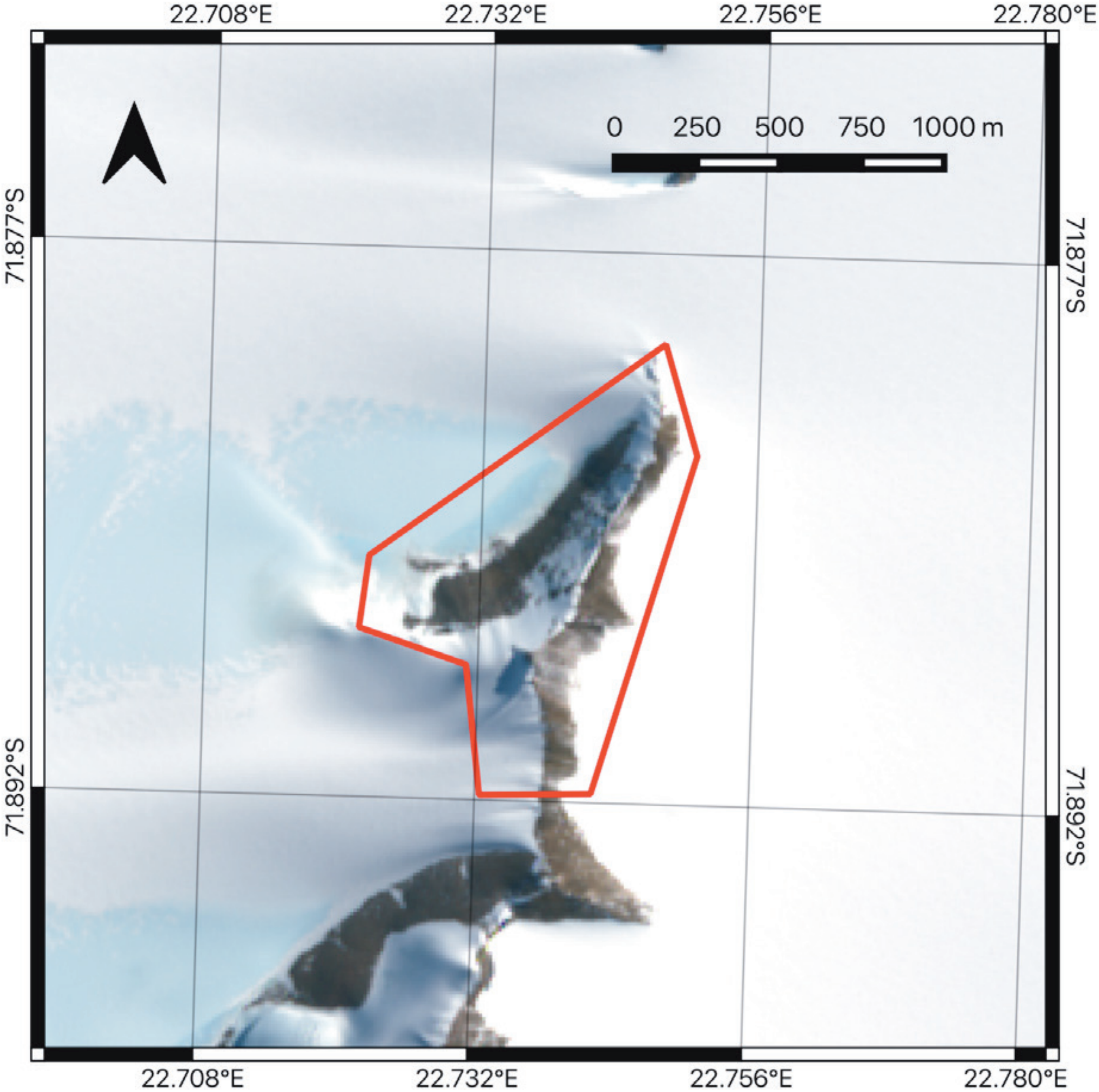

Figure 9. Map of Teltet Nunatak (E), with protected area in the red polygon. Map contains modified Copernicus Sentinel data [2019].

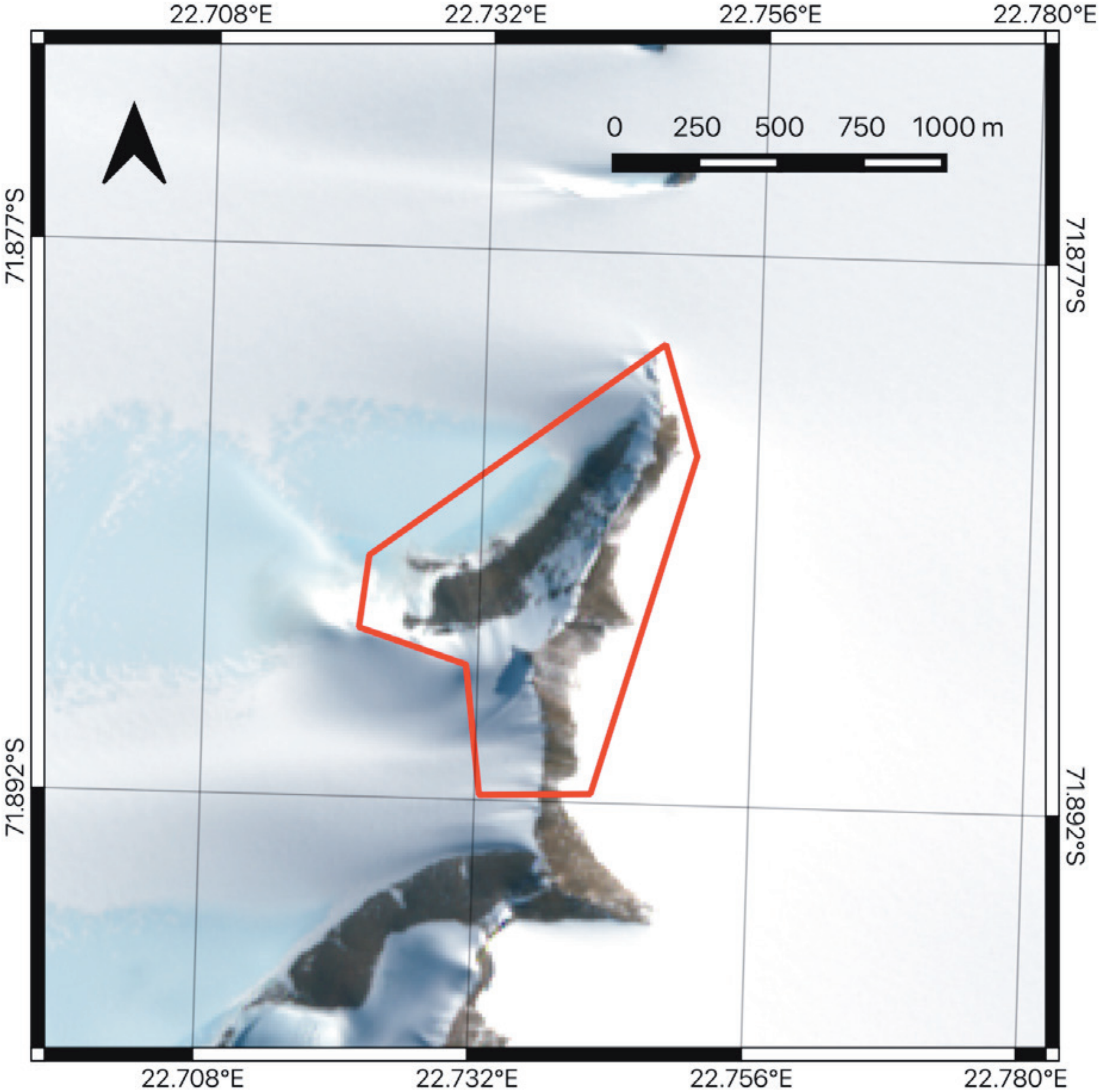

Figure 10. Map of Yuboku Valley (F), with protected area in the red polygon. Map contains modified Copernicus Sentinel data [2019].