
Scientific Work at the Winter Station

Author(s): Otto Nordenskiöld

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violent gale on January 10, and finally abandoned on February 12, the crew making their way amid great difficulties to Paulet island. The various parties being happily reunited on the arrival of the *Uruguay* at the last-named island on November 11, the homeward voyage was commenced.

II. SCIENTIFIC WORK AT THE WINTER STATION.

By Dr. OTTO NORDENSKIÖLD.

We arrived at the place selected for our winter station, at the foot of Snow hill, in Admiralty inlet, on February 12, 1902, and on February 21 our ship, the *Antarctic*, finally left us, not for some months, as we expected, but never to return. The members of the winter party, besides myself, were Dr. Bodman, meteorologist and magnetician; Dr. Ekelöf, physician and bacteriologist; Lieut. Sobral, of the Argentine navy, assistant meteorologist; and two sailors. As soon as possible the observations were started, and the scientific work was carried on without interruption until November 8, 1903, the day of the arrival of the Argentine Relief Expedition, commanded by Captain Irizar.

In the preliminary plan of the expedition the meteorological observations are entered as one of the most important parts of our work. But it is not only their intrinsic interest that makes me, in trying to give a general view of the physical geography of the region, begin with a discussion of our meteorological observations. In fact, not only is the climate of that region of specially great geographical importance, but there are some rather unexpected features that seem to lend that section of our results a peculiar interest.

The principal meteorological features of the region appear in the following table, communicated by Dr. Bodman, and comprising the *approximate* monthly means of temperature, barometric pressure, and velocity of the wind:—

			Temperature.	Barometer.	Velocity of wind.
1902.			° Fahr.	inches.	feet per sec.
March	...	...	14.90	29.25	30.84
April	...	...	7.88	29.31	23.95
May	...	...	1.40	29.12	36.74
June	...	...	-0.58	29.34	36.74
July	...	...	-11.92	29.29	36.09
August	...	...	-8.50	28.96	28.54
September	...	...	6.26	29.10	26.25
October	...	...	9.14	28.99	30.51
November	...	...	17.42	29.28	24.61
December	...	...	28.40	29.26	13.12

	Temperature.	Barometer.	Velocity of wind.
1903.	° Fahr.	inches.	feet per sec.
January	30·38	29·28	19·69
February	25·70	29·05	22·97
March	11·48	28·96	44·29
April	6·44	29·07	26·25
May	-2·92	29·18	19·69
June	-6·34	29·13	19·69
July	0·86	28·95	26·25
August	2·48	29·12	27·89
September	1·22	29·18	—
October	20·48	29·02	—
Mar. 1902–Feb. 1903	10·04	29·19	27·56

The minimum for the whole time was in August, 1902, $-42^{\circ}16'$; the maximum, in the same month of August, 1903, $48^{\circ}74'$.

As other meteorological questions will soon be discussed more extensively by Dr. Bodman, I here restrict myself to those most important for the climate, viz. the temperature and the velocity of the wind. The first thing shown by this table is the unexpectedly low mean temperature. According to approximate calculations of our astronomical observations, the situation of the winter station was in $64^{\circ}22' S.$ and $57^{\circ}0' W.$ The nearest places where meteorological observations have been carried out during a time of sufficient length are at Cape Horn and in the region where the *Belgica* wintered, and from the results thus obtained we might have expected to find here a yearly mean of about 20° or 25° Fahr. Instead of this we obtained for the first year $+10^{\circ}04'$ Fahr. Though it is possible that this temperature is somewhat lower than general, as the summer was undoubtedly exceptionally cold, and even the mean for the eight colder months (March–October) was in the first year $2^{\circ}3'$ Fahr., but in the second 4° , it does not seem probable that the difference from that general mean temperature should be even so great as between the two winters. A mean temperature of 10° Fahr. at the same distance from the pole is in the northern hemisphere found in the environs of Hudson strait, and in Siberia, in the region of Yakutsk, still one or two degrees further south. In both cases we see the influence of the extremely low winter temperatures of a continental climate, while for a thoroughly marine climate the temperature is unexpectedly low. It must be left to the discussion of the observations of the other expeditions contemporaneous with ours, including the *Scotia* Expedition, to discover whether there exists an especially cold area on the east coast of Graham Land, or even south of the Atlantic ocean.

The difference in temperature between summer and winter is, of course, not so great as in the regions mentioned, and, notwithstanding that the temperature of the three winter months was during the two years as low as -4° Fahr., the winter could not be called very cold if

it was not for the wind. The great violence of the wind in all Antarctic regions is a well-known fact, but I doubt if a violence such as that during our first winter has ever been experienced in an Arctic or Antarctic climate, and even the average for the whole time must be considered unexpectedly high.* However, the table shows that the differences between different seasons, and also between different years, are very great.

The factor that really determines the climate is the direction of the wind. The situation of the station, on the shore of a strait, may partially account for the predominance of the winds from the south-west and north-east quadrants. Besides this, there is a high percentage of calm or nearly calm weather. The south-west winds are by far the most common and the strongest, and because they are also the coldest, all the really bad weather is to be ascribed to them. The calm hours are not much warmer, but of course their influence on the general feeling is absolutely different. The real north-east winds are comparatively strong and cold; but, besides them, there is another class of winds which are, if not as common as the others, still exceedingly characteristic of the climate. They are the winds from north or even north-north-west, and when once started they are very strong and very long-continued, and bring the warmest weather. It is these differences that bring out another characteristic of the climate—its great variability. The variations from day to day are in winter-time greater, as in most other regions of the world, and, as far as our short experience goes, it is quite probable that this also holds good from year to year. Though the mean temperature of these two winters is nearly the same, the difference between the two is very great. In the first year the south-west storms were absolutely overwhelming, alternating with periods of calm, warmer weather. In the second year the calm periods were generally colder, and, at least during the first part of the winter, very common and long-continued, and to this cause during the second half were due long periods of warm northerly winds.

In the closest connection with that state of the weather stand the ice-conditions. After the winter of 1902, with its south-west storms, came a summer that was not only the coldest hitherto known in any region of the world, but also, and that to our bad luck, marked by an accumulation of ice such as never has been seen in that region. It was in the battle with that ice that the *Antarctic* was lost, but it may be said that we on the station had really no reason for uneasiness, as never, except perhaps for two or three days, was the sea in our neighbourhood so free from ice as to render the arrival of the ship probable. On the other hand, even in the middle of the winter, the north and north-west

* The only similar observations from the Antarctic hitherto published are those by the Borchgrevink Expedition (preliminary), the mean being considerably lower than ours.

winds would cause large openings in the ice, and after the strong gales in August to October, 1903, the second summer started with an almost clear sea, and probably this year is of the same type as the summer of 1893-94, when Larsen made his well-known voyage south.

During our stay I brought together rich material from investigations on the ice, both sea-ice and land-ice, and especially that typical Antarctic ice-cap of Snow hill—its temperature compared with that of the sea-ice and the soil, its movement, surface structure, and stratification. Interesting is the great accumulation of snow during the summer 1902-3, which is important for explaining the formation of such ice-caps and their great extension in those regions: a few years such as this would cover the whole region with snow.

Because of this accumulation, the land-ice forms at all seasons an easy travelling road, and only where there are large crevasses it might be difficult to pass in summer-time. On the contrary, just as in the north, so also here the sea-ice is during the summer to a great extent covered by water, making the travelling very difficult. But even if this had not been the case, we could not have used the first summer for distant sledge-travelling, as we had then to wait for the return of the *Antarctic*, and later to provide ourselves with the supplies necessary for another wintering. All sledge-work, therefore, was mainly during the two springs. Its results have been the survey of the coast with its outlying islands from the end of Louis Philippe Land to our southernmost point in 66° S., 62° W. The accompanying rough sketch-map, compiled by Lieut. Duse, gives an idea of the general geography of the region rather different from older maps. As a matter of fact, the whole mainland from Louis Philippe Land past King Oscar Land forms a narrow strip of high mountainous land, the continuation of Graham Land. Further on in the same direction, Joinville island seems really an archipelago of islands. East of the mainland we find two other island groups, divided by the wide gulf extending between Snow hill and Robertson island.

The northern archipelago is divided from the mainland by a broad channel studded with islands. It consists of two groups, divided by Admiralty sound, with its two islands, Cockburn and Lockyer. Inside of this strait the principal mass of land is divided by a narrow winding channel into two large islands, the largest of which, with Mount Haddington for its highest point, I propose to call, after its discoverer, James Ross island. Though in cold summers the ice in those channels and straits does not break up, it is probable that there is in other years much open water.

Very different is the aspect of the southern "archipelago." No real islands exist here; even the mildest summer will not melt away the ice so as to allow a boat to come round any of the islands. All visible land consists of nunataks rising out of a high, extensive

mass of ice. Still, I believe it is very probable that should once there come a change to a warmer climate, then the ice would be found to rest for a great part in a shallow sea, and not only on the land, forming in reality a connection between the mainland and a group of outlying islands. The mainland, so far as known, is composed of crystalline rocks, mostly granites, and also porphyries, and, as shown by Dr. Andersson, though perhaps to a less extent, of folded sedimentary rocks of pre-Cretaceous age. On the contrary, in all parts of the eastern archipelago young volcanic rocks are in predominance, while granitoid rocks are entirely wanting. What is found is mostly basalt, and to a great extent tuffaceous rocks, sometimes belonging to types of great petrographical interest. I need not state that, as a consequence of this geological difference, the mountain forms and the whole aspect of the country show very marked contrasts.

Amongst the southern nunataks I have only observed volcanic rocks. Besides those, there occurs in the northern region, around our station, another far more interesting series of rocks. Those are the fossiliferous sedimentary rocks, generally sandstones, that are to be found cropping out at the foot of the hills below the volcanic series in most parts of Ross island, and also on Cockburn island, and which form the whole of the two large outlying islands, Snow hill and Seymour islands. The study of those rocks and their fossils will be of great interest for the knowledge of the conditions of those regions in former times, though it is, of course, impossible at this time to go further into the matter. The whole formation is generally very rich in rather well-preserved fossils, belonging to numerous groups of marine forms. In the lower part ammonites are common, and the age must be considered as Mesozoic; higher up those are wanting, and it is not improbable that the strata here pass into the Tertiary.

It is in those upper strata that I found numerous plant-remains, and also remains of some vertebrate animals, showing not only that in a period geologically not very distant land has existed in this region, but also that the climate was at that time mild, and the land covered by vegetation and inhabited by animals. There is in all this, in the whole configuration of the country as well as in its geology, a very marked analogy to Patagonia, and farther studies may prove the resemblance to be still greater. Even the inner channels are interesting, because of their analogy with the great plains and the lakes on the eastern side of the cordillera. But it seems undeniable that there are great differences in the structure of the southern cordillera and the Antarctic mountain chain, and more investigation is necessary to determine whether it is possible to consider this part of Antarctica as a continuation of the South American continent or not.

Of our other investigations I will here only mention the bacteriological work. Just as in the Arctic regions, bacteria are also here scarce;

but Dr. Ekelöf has made the interesting observation that in the upper layers of the soil there is to be found a comparatively rich flora.

Our studies came to rather an abrupt end with the arrival of the Argentine relief expedition, as we thought we had reasons to expect that we should have a good deal of the summer at our disposal. Still, the time has been long, and undoubtedly it has been an advantage that the scientific work could be continued two years instead of one.

III. THE SCIENTIFIC OPERATIONS ON BOARD THE *ANTARCTIC* IN THE SUMMER 1902-1903.

By DR. J. GUNNAR ANDERSSON.

On November 5, 1902, the *Antarctic* left Ushuaia for the south. The ship had been thoroughly equipped for the coming cruise in the Antarctic sea; a full supply of coal was taken on board, together with some additional provisions in case of having to winter. A plan for a relief expedition was sent to Sweden and to the Scandinavian General Consulate in Buenos Aires.

As I had been told that coal had been recently discovered in Tekenika bay, in the southern part of the Fuegian archipelago, I so arranged our route southwards that we stopped two days in this bay to survey the coal-bearing formation. This led to an unexpected result. Instead of what I had expected to meet here, an isolated patch—like that in Slogget bay—of the Tertiary formation, with plant-fossils and lignite, which is widely distributed in northern Tierra del Fuego, and, in my opinion, more recent than the folding period of the Fuegian cordillera, I found a strongly folded sedimentary series, chiefly a conglomerate, with marine shells and trunks of driftwood. The sedimentary beds were traversed by eruptive dykes. Unfortunately, my collections from this place were lost with the *Antarctic*. For this reason I cannot give any definite opinion as to the age of the sedimentary beds nor the petrological character of the eruptions traversing them. Moreover, I have decided to return to Tekenika bay to survey in detail this locality, as it will evidently contribute to deciding the unsettled age of the Fuegian cordillera.

Late in the evening of November 7, the *Antarctic* crossed the latitude of Cape Horn to the west of Hermit island, and in the night of the 9th to 10th of the same month, in lat. $59^{\circ} 30' S.$, long. $66^{\circ} W.$, we passed the first water-worn floes of drift sea-ice, the first iceberg having been sighted the previous day. As soon as we had entered the region of drift-ice, I started regular observations on the frequency and size of sea-ice and icebergs. These running observations were carried on by me up to my departure from the ship on December 29, and after that they were continued by Mr. Skottsberg.

On November 11-12 we met the dense pack in lat. $61^{\circ} S.$, and