Polar Record

www.cambridge.org/pol

Ice drift during the 1897 Andrée balloon expedition

Björn Lantz

Technology Management and Economics, Chalmers University of Technology 412 96 Gothenburg, Sweden

Research Article

Cite this article: Lantz B (2019) Ice drift during the 1897 Andrée balloon expedition. *Polar Record* **55**: 385–391. https://doi.org/10.1017/S0032247419000706

Received: 13 September 2019
Revised: 16 October 2019
Accepted: 21 October 2019
First published online: 20 November 2019

Keywords:
Arctic ice drift; Andrée balloon expedition; Svalbard; Franz Josef Land; Andrée diaries

Author for correspondence:
Björn Lantz, Email: bjorn.lantz@chalmers.se

Abstract

The indirect cause of death of the three members of the Andrée balloon expedition on White Island in early October 1897 was the ice drift during their attempted retreat after the forced landing at 82°56′N 29°52′E. They initially tried to reach Cape Flora to the southeast of their current position in the Arctic pack ice even though they could deduce from prior explorers' experience that the expected long-term direction of the ice drift in the area would be to the southwest. However, when they finally turned towards the Seven Islands in the southwest, the ice unexpectedly began to drift in a southeasterly direction. In this paper, trigonometrical methods are used to derive more precise measures of the ice drift the expedition members actually experienced, based on their own position fixes and their own descriptions of their marches. The results confirm that they were exposed to a southwesterly ice drift, on average, during the weeks they were trying to head southeast, and to a southeasterly ice drift, on average, during the weeks they were trying to head southwest. Hence, the disastrous ending of the expedition was, at least to some extent, a result of bad luck.

Introduction

In 1897, the Swedish engineer Salomon August Andrée, together with his colleagues Nils Strindberg and Knut Frænkel, tried to reach the North Pole in a hydrogen balloon. They departed on 11 July from Danes Island (Danskøya in Norwegian) in the northwestern part of Svalbard, but hydrogen leakage in combination with moisture and ice on the balloon forced them to land on the Arctic pack ice at 82°56′N 29°52′E after less than three days in the air (Andrée, Strindberg, & Frænkel, 1931). During the latter part of the summer and the early autumn of 1897, the three explorers struggled desperately to return over the ice to civilisation, pulling supplies on heavily laden sledges for many weeks. In early October, they finally went ashore on the desolate White Island (Kvitøya in Norwegian) between Svalbard and Franz Josef Land. However, the entire party perished on White Island of unclear causes within just a few days. Their last camp and their remains were not discovered for another 33 years (Andrée et al., 1931), but when they were found, their diaries, reviewed by Wordie (1931) in the inaugural issue of *Polar Record*, and many other items were recovered, thus making it possible to follow their intense struggle for survival in retrospect. Figure 1 shows the approximate route the expedition followed in the balloon (black) and on the ice (red).

As mentioned above, the landing with the balloon at 82°56′N 29°52′E after less than three days in the air was forced by hydrogen loss in combination with the fact that the balloon was weighed down by moisture and the forming of ice (Andrée et al., 1931, p. 352). Its buoyancy had simply become insufficient – the balloon basket had been "bouncing" on the ice for many hours already. However, at that point, Andrée and his men were sufficiently prepared (at least in terms of supplies and equipment, albeit hardly mentally) to manage a retreat over the ice. Furthermore, just like Andrée himself had predicted during an interview in 1896 in the Swedish evening newspaper *Aftonbladet* about the intended balloon journey, they were well rested compared to a hypothetical expedition where the same amount of provisions had been hauled northwards to the same point (Andrée, Strindberg, & Frænkel, 1930, p. 143). Hence, their situation right after the landing on 14 July was not necessarily critical, but they had to decide what to do next. Should they stay where they were and drift with the ice? Or should they take matters into their own hands and begin a march across the ice towards some known land? As we know now, they began a march towards Cape Flora in Franz Josef Land with very heavily laden sledges after first having spent a week preparing on the same ice floe they landed on. After two-and-a-half months on the march, Andrée and his men perished on White Island without having seen any other land at any point during their march.

A decisive reason for the disastrous outcome seems to be the fact that Andrée, Strindberg, and Frænkel initially tried to march over the ice in a southeasterly direction, towards their depot at Cape Flora in the Franz Josef Land archipelago, while they experienced an average ice drift with a substantial westerly element. They eventually noted that the ice drift during this period essentially moved them to the west faster than they could march to the east (Andrée et al., 1931, p. 363).

© The Author(s) 2019. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution, and reproduction in any medium, provided the original work is properly cited.

CAMBRIDGE UNIVERSITY PRESS

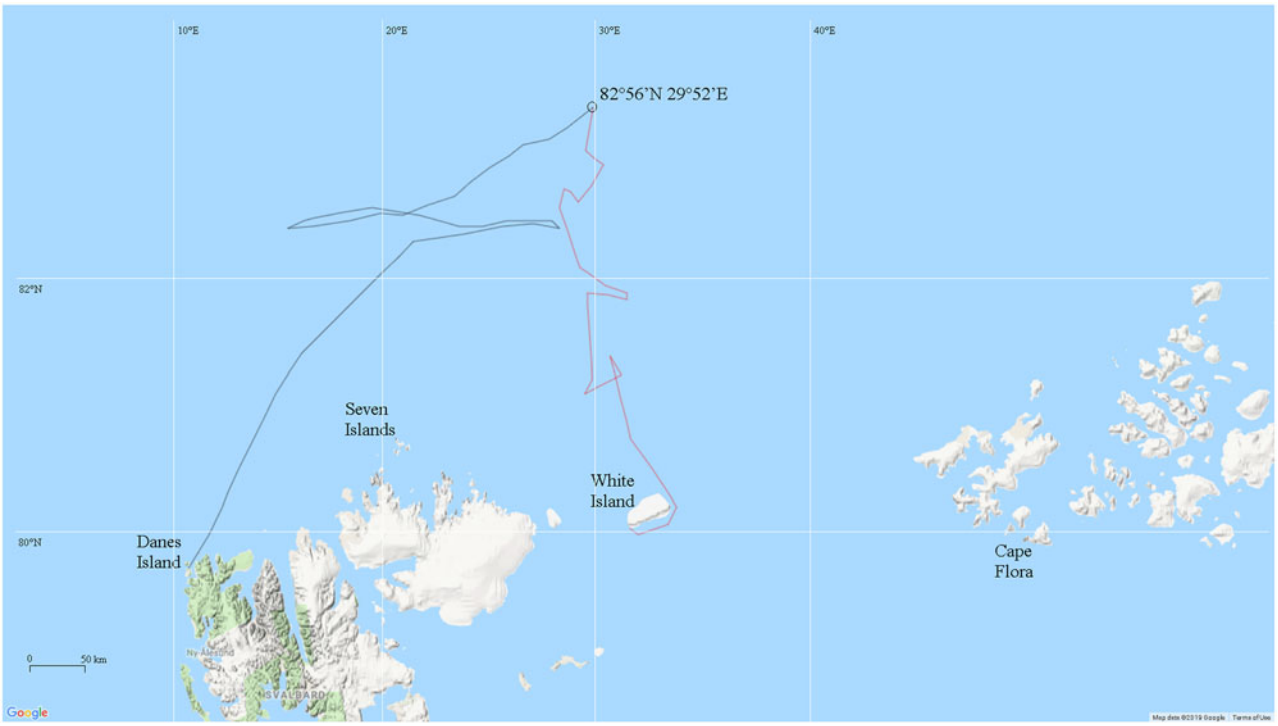


Fig. 1. The route of the Andrée expedition.

After about two weeks on the march, they realised that they could not overcome this drift. Instead, they began to march in a southwesterly direction towards the Seven Islands (Sjuøyane in Norwegian) where a depot had been planned for them (Meisenbach, 1898). However, since they knew the ice conditions in the area were severe and that the depot had not yet been laid when they departed in the balloon on 11 July, that depot was in itself hardly an important factor in their assessment of the situation when they decided to change their course (Lantz, 2019). It is more likely that their experiences of the ice drift so far, in combination with the fact that the Seven Islands simply was the nearest known land from where they were, made them realise that it was their only option at that point.

Modern research (e.g. Macdonald, Harner, & Fyfe, 2005) has shown, in line with contemporary observations at the time of the expedition (e.g. Nansen, 1897), that the average direction of ice drift in the area is about southwesterly, with an average speed of about 2 km per day. However, it is important to note that these measures of direction and speed are long-term averages. In the short term, that is, on a daily, weekly, or sometimes even monthly basis, the ice may drift in any direction, especially in summer time, sometimes slow and sometimes faster, depending on wind conditions, currents, tides, thickness of the ice, and other factors (Holloway & Proshutinsky, 2007; Kwok, Spreen & Pang, 2013). From the diary notes, the daily ice drift the members of the Andrée expedition experienced during their time on the ice was very erratic, even though they apparently perceived the average tendency over the first weeks as westerly (Andrée et al., 1931). However, no deeper scientific analysis of the actual ice drift during the march across the ice, based on the information recorded in the expedition members' diaries, has been made in relation to the expedition members' fundamental decision-making.

Norwegian meteorologist Harald Sverdrup approached the problem in an article (Sverdrup, 1931) wherein the ice drift during the Andrée expedition was sketched based on a compilation of positional observations, daily marching distances and directions, and weather conditions, as recorded by the expedition members themselves. Sverdrup's paper is very interesting, but it is mostly of a descriptive character and does not include a deeper analyses of the decision-making of expedition members during their march across the ice in relation to the ice drift. Furthermore, Sverdrup's study does not cover the entire period the expedition spent on the ice, thereby being subject to the ice drift, and there are minor errors in trigonometrical calculations. Hence, a fully structured analysis of the ice drift during the Andrée expedition with the same methodological approach may provide a better understanding of their fate. The purpose of this paper is to report the results of such an analysis and to relate the results to the expedition members' expressed views of the ice drift, their decision-making, and the outcome of the expedition.

In short, the results show that Andrée, Strindberg, and Frænkel were exposed to a westerly element in the ice drift, on average, during the weeks they were trying to reach Franz Josef Land, and to an easterly element in the ice drift, on average, during the weeks they were trying to reach Svalbard. While this general pattern of actual ice drift during the two parts of the march across the ice, of course, has been known ever since the diaries were found in 1930, this paper provides detailed approximations of the speed and direction of ice drift between all positions they fixed during their time on the ice, verifying the erratic pattern that Arctic ice drift is known to exhibit in the short term. Interestingly, Andrée mentioned the ice drift only a few times in his diary, despite the fact that it was his main foe in his desperate struggle for survival.

Based on the results, one must conclude that the disastrous ending of the expedition on White Island in early October 1897 was, at least to some extent, a result of bad luck. Had Andrée, Strindberg, and Frænkel been somewhat lucky, that is, if they had been subject to ice drift in the statistically expected direction and speed, they

https://doi.org/10.1017/S0032247419000706 Published online by Cambridge University Press

would probably have been able to reach the Seven Islands in the time frame they themselves had estimated (6–7 weeks) when they turned towards that goal. On the other hand, had they decided to march directly towards the Seven Islands after the landing at 82° 56′N 29°52′E, which information about the ice drift they had at the time indicated that they should have done, they would have had good chances to survive given the actual ice drift in the area during the third quarter of 1897.

The historical context

The first to make systematic observations of the ice drift in the area north of Svalbard was likely Captain William Edward Parry. In the narrative of his attempt to reach the North Pole over the ice with man-hauled "boat-sledges" from the northern shores of Svalbard in 1827 (Parry, 1828), the seasoned polar traveller Parry often wrote of the annoying general tendency of the ice to drift southward. These grumbles are not surprising, because the southerly ice drift was what primarily hampered Parry's desire to penetrate further north. He finally had to turn back at about 82°45′N 20°E. Parry's performance was a record for the highest attained latitude that stood for almost 50 years, until Albert Hastings Markham reached 83°20′N during the British Arctic Expedition of 1875–76. Markham, however, came north through Nares Strait between Greenland and Ellesmere Island. Hence, his observations regarding ice drift were naturally different from what Parry noticed in the area north of Svalbard.

Parry mentioned several times in his narrative that their observations had shown that they were south of the expected position from dead reckoning despite southerly winds. In other words, besides discovering the ice drift in the area per se, he must have realised that there were other factors beside the wind that created the ice to drift southward. However, equally important, he also observed a westerly element in the ice drift. For example, on 30 July 1827, at about 82°20′N 17°30′E, when heading back from his farthest north, Parry saw his own old northward tracks on the ice. Parry did not reflect explicitly in his narrative about it, but this observation shows that the ice in the area had drifted substantially westward during his absence further north, because his return march south took place several degrees to the west of his outward march north. Hence, his narrative shows that Parry experienced an approximately average direction of the ice drift somewhere in the third quadrant, seemingly about southwest, during his sledge journey in 1827. On the other hand, Parry understood the concept of external validity, because he was careful to point out that his observations regarding the ice drift were valid only along the meridians he had travelled. Thus, he did not exclude the possibility that the ice might drift differently elsewhere in the Arctic Ocean.

In 1868, Adolf Erik Nordenskiöld led the Swedish polar expedition on-board the steamer *Sofia* to a new record for the highest attained latitude for a ship. He reached 81°42′N 17°30′E, about 120 km north-northwest of the Seven Islands, and slightly west of Parry's farthest north in 1827, before the ice forced him back. The ship never got firmly caught in the ice, and the ice drift in the area is only mentioned briefly in the book from the expedition (Fries & Nyström, 1869). However, the southerly element in the ice drift experienced by Parry in 1827 is mentioned explicitly, as well as the fact that masses of ice were known to drift towards the eastern shores of Svalbard. Later expeditions trying to reach a high latitude north of Svalbard reported similar issues with the drift ice (e.g. Nordenskiöld again in 1871 and Wellman in 1894).

The Austro-Hungarian Polar expedition 1872–74, led by Julius Payer and Karl Weyprecht, got caught in the ice just north of Novaya Zemlya in late August 1872 with their ship, the *Tegetthoff*, during an attempt to discover a northeast passage. During the next year, they drifted helplessly and rather erratically, but on average in a northerly direction, until they ended up almost 500 km northwards close to Wilczek Island, thereby becoming the official discoverers of Franz Josef Land (Payer, 1875). They were eventually able to moor their ship securely to the land-ice of Wilczek Island, and, after spending the winter of 1873–74 there, they used their dogs to conduct several major sledging expeditions and explored the eastern part of Franz Josef Land. They were able to penetrate all the way north to Cape Fligely, which in fact is the northernmost part of the archipelago, although they reported that they thought they could see land even further north (which they named Petermann Land). The expedition eventually abandoned the *Tegetthoff* in order to attempt a return south to Novaya Zemlya over the ice, pulling small boats on sledges. The attempt was successful, even though they had to struggle to overcome the continued northerly ice drift.

The actual drift of the *Tegetthoff* was in itself perhaps of little relevance to Andrée, because it occurred in an area southeast of Franz Josef Land where the behaviour of the ice could be assumed to be different from the conditions north of Svalbard where Andrée had landed with his balloon, for example, because of the Gulf Stream, but there were also general observations made by Weyprecht (1875) regarding Arctic ice drift of relevance for Andrée. Perhaps most importantly, Weyprecht's experiences led him to the conclusion that there existed a continuous ice-stream to the south of Franz Josef Land, flowing from the Siberian Sea towards the west – a fact that convinced him that if they had not been able to fix the *Tegetthoff* to the land-ice of Wilczek Island during the winter of 1873–74, the ice drift would have meant that they ended up north of Svalbard (Weyprecht, 1875, p. 21). In addition, Weyprecht noted that the wind was a major determinant of the ice drift in the short term, even though, surprisingly, the ice never seemed to drift in the exact direction of the wind. In other words, he understood that the wind was not the only factor that caused the ice to drift.

Another major addition to the 19th-century knowledge about the Arctic ice drift in the eastern hemisphere came from the ill-fated *Jeanette* expedition of 1879–81. This expedition comprised an attempt to reach the North Pole through the Bering Strait, led by US Navy officer George W. De Long. The basic idea, or rather speculation, was that the temperate current that was known to flow northward through the Bering Strait (the Kuro Siwo) would provide access to the hypothesised ice-free ocean surrounding the North Pole (the Open Polar Sea theory). In reality, the *Jeanette* became firmly caught in the ice northeast of Wrangel Island in September 1879 and drifted helplessly in a northwesterly direction until the ship was finally crushed in the shifting ice and sank north of the Siberian coast in June 1881. The crew were able to take refuge on the ice before the ship went down, but more than half of them, including De Long himself, died during the following perilous attempt to return over the ice to civilisation (De Long, 1884).

The voyage of the *Jeanette* definitively rejected the long-embraced Open Polar Sea theory, but, on the other hand, gave proof of an ice drift from the east to the west across the polar sea. In June 1884, a number of items that demonstrably came from the *Jeanette* (e.g. signed documents and garments with name tags) were found on an ice floe near the southwestern corner of Greenland (Lytzen, 1885). The discovered debris was assumed

https://doi.org/10.1017/S0032247419000706 Published online by Cambridge University Press

to have drifted with the ice across the Arctic Ocean to that location – given the contemporary knowledge of the Arctic sea currents, there was no other realistic explanation for the find. Based on a review of the evidence, including the abundant presence of Siberian driftwood on the northern shores of Svalbard as well as on the shores of Greenland, Norwegian polar explorer Fridtjof Nansen deduced that "a current flows at some point between the Pole and Franz Josef Land from the Siberian Arctic Sea to the east coast of Greenland" (Nansen, 1897, p. 24). He put so much faith in his theory that he dared to test it empirically by taking his purposely-built ship *Fram* to the New Siberian Islands in the eastern Arctic Ocean and freeze her into the pack ice, with the idea to let the ice drift carry the ship and its crew across the polar sea (Nansen, 1893).

After three years, in 1896, *Fram* was released from the ice northwest of Svalbard, close to Nansen's original prediction. At this point, Nansen himself was no longer on-board the *Fram*. About a year before, he had left the ship together with his companion Hjalmar Johansen to try to reach the North Pole using skis and dog-sledges. However, the ice conditions forced them to turn back south at 86°14′N. They knew they would hardly be able to locate the *Fram* again on their way south – because of the ice drift – so they aimed for Franz Josef Land with the idea that it might be possible to spend the winter there and return alive to civilisation the following year. In the end, they did just that. After having wintered in a cramped makeshift hut at a place in northern Franz Josef Land that is now known as Cape Norway, they continued south and stumbled upon the British explorer Frederick Jackson at his base at Cape Flora – the very same place that the members of the Andrée expedition initially tried to reach during the first weeks on the march after their forced landing at 82°56′N 29°52′E.

The *Fram* expedition made Nansen the first to prove the transpolar drift, which on average makes the ice in the area north of Svalbard and Franz Josef Land drift approximately in a southwesterly direction (Krumpen et. al., 2019). As the map Andrée brought with him in the balloon (Bartholomew, 1897) was published as an attachment to Nansen's book *Farthest North*, Andrée was certainly aware of Nansen's views about and experiences of the ice drift in the area. In fact, Andrée had met with Nansen in the spring of 1897, and Nansen's experiences of the Arctic ice drift must have been one of the discussion topics at this occasion even though the Scandinavian edition of *Farthest North* had not yet been published.

Materials and methods

The analyses in this paper rely primarily on Andrée's and Strindberg's own observations regarding actual latitudes and longitudes at various times during their attempt to return after the landing with the balloon at 82°56′N 29°52′E, as well as the estimated or implied length and direction of their marches on the ice. The actual position of the expedition at various points during the balloon flight and during the march across the ice were extracted through reverse engineering of a high-resolution version of the map of the course of the expedition published in Andrée et al. (1931). For validity and reliability reasons, the obtained latitude and longitude measures were checked against actual positional measures occasionally mentioned in the diaries. They were consistently found to agree perfectly or to differ so little that the difference was clearly insignificant, given the purpose of this paper (e.g. one minute of longitude at 82°N corresponds with only 258 m). However, from 17 September and onwards, when the expedition was within viewing range of White Island, Andrée's interpretations in his diary of their positions in relation to the island were used to derive approximations of latitudes and longitudes. The reason for this was that White Island is erroneously positioned over one full degree of longitude too far to the west on the map in Andrée et al. (1931). Moving the island to its correct position on that map without changing the plotted route would imply that the expedition crossed the island. Hence, when they drifted along the eastern part of White Island in late September 1897, they were definitely further to the east than what the plotted route on that map suggests.

The marching directions during the march across the ice at various stages of the attempted return journey were extracted from the diaries where they appear explicitly throughout. The expedition members' own estimates of their achieved daily marching distances are often, but not always, mentioned in the diary. Where they are not, reasonable approximations were made by the author based on Andrée's own descriptions of the expedition members' actions, the character of the ice, and through comparison with their own estimations of achieved distances under similar conditions. The basis for these approximations was that their best daily marches on flat ice without lanes to cross were about 7 km, a good march on decent ice was about 5 km, a normal day under average conditions may have given them a march of about 3 km, while the worst days with plenty of pressured ice and lanes that had to be crossed could result in as little as a movement of 1 km over the ice. For validity and reliability reasons, these approximations were also checked against the interpretations made by Sverdrup (1931) and were consistently found to agree almost perfectly.

As the actual displacement from one geographical point to another while marching on drifting ice can be seen as a function of two variables – the marching and the ice drift – the ice drift during the period of displacement can be estimated based on the direction and distance of the march itself together with the direction and distance between the two geographical points. The calculation of the resultant force of two forces acting at an angle requires trigonometry (see, e.g., Truong, 2018). This type of maths can also be used analogously to derive one force based on the other force together with the resultant force. In other words, given the length and direction of a march over drifting ice, together with the observed latitudes and longitudes of start and finish, the actual ice drift during the march can be found. For example, if your marching direction over drifting ice is 90°, and you find after an 8-km march that your true geographical displacement is 6.3 km in a 70° direction, the total ice drift you have been subject to during your march can be calculated, through the application of trigonometry (more specifically, by applying the law of cosines twice), to 3.0 km in a 316° direction. This particular method will be used in this paper to estimate the actual ice drift during the periods where marching occurred between two successive positional determinations.

Results

Table 1 shows the geographical positions taken during the time the expedition spent on the ice, distances and bearings related to total geographical displacements and to the marches across the ice, and the calculated resulting ice drift. As mentioned above, it should be emphasised that all position fixes and marching data are approximations and, thus, that the resulting ice drift data are approximate.

In particular, note that the light blue and light red lines in Figure 2 go in almost opposite directions. So does the dark blue and dark red lines. Hence, during the weeks Andrée, Strindberg,

https://doi.org/10.1017/S0032247419000706 Published online by Cambridge University Press

Table 1. Approximate positions, distances, and bearings of the Andrée expedition

	Fixed position				Geographical displacement since the previously fixed position		March across the ice since the previously fixed position		Ice drift since the previously fixed position		
	Latitude		Longitude								
Day	Deg	Min	Deg	Min	Distance (km)	Bearing (deg)	Distance (km)	Bearing (deg)	Distance (km)	Bearing (deg)	Speed (cm/s)
14 July	82	56	29	52							
20	82	41	29	31	28.2	190.1	0		28.2	190.1	5.7
21	82	38	29	58	8.5	130.8	0		8.5	130.8	26.2
26	82	36	30	22	6.8	122.8	14	90	5.6	229.2	1.3
29	82	28	29	49	16.8	208.5	12	90	24.9	233.5	10.5
31	82	22	29	12	14.3	219.4	7	90	19.5	235.5	10.0
2 Aug.	82	26	28	50	9.2	324.1	14	112.5	22.3	280.1	11.5
3	82	27	28	30	5.2	291.0	0		5.2	291.0	9.0
4	82	20	28	19	13.3	191.8	1	90	13.5	196.0	15.6
6	82	11	28	41	17.6	161.6	2	220	16.6	155.7	10.7
9	82	2	29	4	17.7	160.5	9.5	220	15.2	128.0	6.3
10	81	57	29	15	9.7	162.9	2	220	8.8	151.8	8.0
11	81	55	29	36	6.6	124.0	6.5	220	9.7	82.4	11.2
16	81	50	30	26	16.0	124.9	5	220	17.2	108.1	3.9
18	81	47	31	27	17.0	108.5	2	240	18.4	103.9	9.1
21	81	45	31	28	3.7	175.9	5	240	4.8	104.7	2.2
23	81	44	31	29	1.9	171.8	10.5	240	10.0	70.1	5.8
25	81	46	30	35	14.8	284.9	12	240	10.6	338.1	5.1
28	81	47	29	36	15.8	277.2	19	240	11.5	4.1	4.5
29	81	42	29	38	9.3	176.7	0		9.3	176.7	13.2
2 Sept.	81	20	29	48	40.9	176.1	6	225	37.2	169.1	11.2
4	81	11	29	51	16.7	177.1	6	225	13.4	157.7	8.1
6	81	5	29	29	12.8	209.7	9	225	4.7	179.5	2.6
9	81	13	31	12	32.9	62.4	3	225	35.8	60.9	12.7
12	81	21	30	40	17.3	329.0	3	225	18.3	338.2	7.7
15	80	45	31	38	68.8	165.5	0		68.8	165.5	26.5
17	80	19	33	30	59.0	143.8	0		59.0	143.8	34.1
18	80	13	33	48	12.5	153.0	0		12.5	153.0	14.5
19	80	5	33	24	16.7	207.4	0		16.7	207.4	15.0
2 Oct.	80	0	32	0	28.5	251.7	0		28.5	251.7	
5	80	3	31	36	9.5	306.0	0		9.5	306.0	

and Frænkel tried to reach Franz Josef Land, the ice basically drifted towards Svalbard, but during the period they tried to reach Svalbard, the ice they travelled on drifted largely towards Franz Josef Land. It is hard to imagine a worse case of bad luck.

Discussion

When the expedition turned towards the Seven Islands after two weeks on the march, Andrée estimated that they could reach their goal in six or seven weeks. Given their experience of the speed and direction of the ice drift in the area so far, in combination with their demonstrated ability to march, it is easy to see that Andrée's prediction is perfectly reasonable. During their three weeks on the ice, they had experienced an average ice drift of about 5 km per day in an approximately southwesterly direction (as illustrated by the light red line in Figure 2). In addition, they had been able to march about 3 km per day on average; and from where they actually were on the ice on 4 August 1897, the straight-line distance to the Seven Islands was about 220 km. Hence, if the ice drift and their marching performance had remained stable, the expedition would have been able to reach the Seven Islands in the time frame indicated by Andrée. However, as shown above, when they began to march towards the Seven Islands, the ice actually began to drift away from that goal and continued to do so.

https://doi.org/10.1017/S0032247419000706 Published online by Cambridge University Press

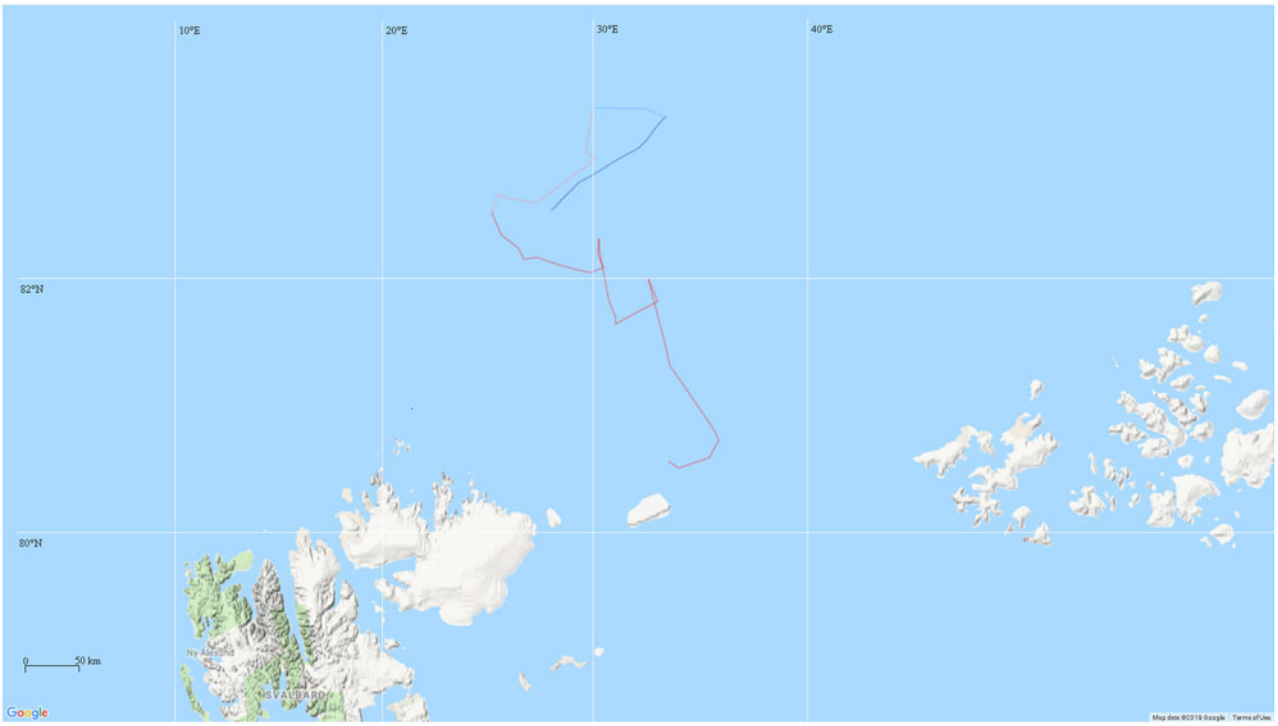


Fig. 2. Total displacement related to marching (blue colour) and ice drift (red colour), respectively.

After having experienced the relentless ice drift for eight weeks, Andrée himself summarised their situation in his diary of 13 September, adequately and certainly without exaggeration, with the words: "Our position is not specially [*sic*] good" (Andrée et al., 1931, p. 400). The quote loses some of its apparent cynicism when translated from Swedish to English, but it is clear that the expedition members at this point were aware of the fact that their chances of survival were slim. Two weeks before, 29 August, they were still hopeful, as indicated by Andrée's explicit assumption in his diary, that a late autumn journey to Mossel Bay (Mosselbukta in Norwegian) probably would be necessary (i.e. after having reached the Seven Islands) to find shelter for the winter in the shape of Nordenskiöld's old hut, which they knew was still standing there. What in particular characterised those two weeks, according to Andrée, was the accelerated southerly ice drift that definitely thwarted their efforts to reach Mossel Bay or any other point at the North East Land (Nordaustlandet in Norwegian). Instead, they had to prepare themselves for a winter on the ice – certainly an option with bleak prospects, but there were no alternatives.

As the accelerated drift southward continued, Andrée and his companions came into viewing range of White Island on 15 September. Two days later, they estimated the distance to the island as 10 km, as the drift seemed to transport their ice floe to the east side of the island. They noted that the island seemed to be entirely covered by a glacier, and that it probably was impossible to land even though they were only a kilometre away from it. Their ice floe continued to drift, albeit slower, along the southeastern shore of White Island where it eventually broke up on 2 October. However, Andrée, Strindberg, and Frænkel were able to move their sledges and supplies ashore on the ice-free "beach" on the southwestern part of White Island that is now known as Andréeneset. The details are unclear, but all three expedition members perished there within just a few days. According to a theory suggested by Uusma (2013), the most reasonable explanation for this development, based on the findings in their last camp 33 years later, seems to be that Strindberg and Frænkel died as a result of a polar bear attack, and that Andrée himself used morphine to commit suicide when he eventually grasped the severity of the situation. Yet, the reasons for the expedition members' sudden death after their arrival to White Island have puzzled scholars ever since, and a number of other more or less viable theories (e.g. trichinosis, botulism, scurvy, hypervitaminosis A, or led poisoning) have been suggested over the years (Personne, 2000).

Given its magnitude and significance for the outcome of the expedition, it is remarkable that Andrée brought up the ice drift so infrequently in his diary. In Table 2, all occurrences of ice drift in his diary comments are quoted – there are only 12 – where the last four were written after they had decided not to march anymore. Hence, during eight weeks on the march, making daily entries in his diary, Andrée did not find it relevant to mention the ice drift more than eight times. Furthermore, Andrée did not mention the ice drift at all in his written prospect about the expedition (Andrée, 1895). Of course, he did not know at that time if or where he eventually would be forced to land with the balloon, but the fact that Nansen's ongoing expedition with the *Fram* (which Andrée did mention in passing in his prospect) relied fundamentally on the Arctic ice drift, it seems unreasonable that he would not have considered it when preparing for his own expedition.

The diary quotes in Table 2 also show that Andrée assumed that the wind determined the ice drift. However, it had previously been shown that it was only one of the determinants, and that the Arctic pack ice could very well drift against the wind (Nansen, 1897; Parry, 1828). More importantly, empirical observations made and published by prior early Arctic explorers clearly showed that there was no reason for Andrée, Strindberg, and Frænkel to expect a long-term ice drift in any other direction than to the southwest in the area where they had landed with the balloon.

https://doi.org/10.1017/S0032247419000706 Published online by Cambridge University Press

Table 2. All occurrences of "ice drift" (or similar expressions) in Andrée's diary

Page	Date	Diary quote
361	27 Jul.	The wind N 25 ... made us happy, for we hoped we were drifting
362	28	The wind is felt much but is always welcome when it drives towards S E
362	30	... we drift almost direct S with a slight trend to W
363	31	... we have driven westwards quicker than we have walked eastwards
369	6 Aug.	Greatest distance of all probably at least three minutes but the wind is almost right against us and has probably driven us just as far back
376	13	The wind has now swung round to SE so that we hope to drift westwards
389	28	The wind has been NW to-day so we hope we have drifted towards the south
392	1 Sep.	... we had been drifted rapidly southwards by the prevailing strong NW wind
401	17	The fact that during the last few days we have drifted towards the south at such a rate contributed essentially I think to keeping up our courage. Our latitude on the 12th September, was 81°21′ and on the 15th we had drifted with a strong N W wind down to 80°45′. ... Thus our drift in 72 h amounts to about 2/3 of a degree of latitude and since then the wind has blown fresh from the same or a more northerly direction. Possibly we may be able to drive far southwards quickly enough and obtain our nourishment from the sea
402	17	Our arrival at New Iceland is remarkable because it points to a colossal drift viz. of more than 1° of latitude since 12 September. If we drift in this way some weeks more perhaps we may save ourselves on one of the islands east of Spitzbergen
403	18	We had had New Iceland in sight all day westward of us and had thus drifted to its eastern side
404	19	We still drift ...

Conclusion

Given the contemporary knowledge regarding ice drift in the area, Andrée, Strindberg, and Frænkel made a questionable decision when they initially chose to march towards Cape Flora. However, they were also subject to bad luck during their march when the ice suddenly began to drift eastwards as they turned towards the Seven Islands. Had the southwesterly ice drift they had experienced so far continued, they could have reached Seven Islands within six or seven weeks, just like Andrée estimated. Hence, the tragic end of the expedition on White Island in early October 1897 was the result of bad luck and questionable decision-making in combination.

Finally, it should be emphasised that had they chosen to march directly towards the Seven Islands in the southwest when they left the camp where they had landed, the team would probably have survived (Lantz, 2018). The expected, as well as the actual, ice drift in the area, at least during the first weeks on the march, was in the right direction. Given the same ice drift they actually encountered during their first three weeks on the ice, and the same average daily marching distance they had accomplished during that time, Andrée, Strindberg, and Frænkel would have covered almost half the distance between 82°56′N 29°52′E and the Seven Islands during those weeks. Moreover, they would then have been so much farther to the west that they could probably have been able to handle the same sudden shift in the ice drift towards the southeast that now indirectly took their lives.

Acknowledgements. This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Conflict of interest. None.

References

Andrée, S. A. (1895). Förslag till polarfärd med luftballong. *Ymer*, *15*, 55–70.
Andrée, S. A., Strindberg, N., & Frænkel, K. (1930). *Med Örnen mot polen: Andrées polarexpedition år 1897*. Stockholm: Albert Bonniers Förlag.
Andrée, S. A., Strindberg, N., & Frænkel, K. (1931). *The Andrée diaries*. London: John Lane the Bodley Head.
Bartholomew, J. G. (1897). *Physical Chart of North Polar Regions. Unpaginated Map in Nansen, F. (1897). Farthest north*. New York: Harper and Brothers.
De Long, E. (1884). *The Voyage of the Jeanette: The Ship and Ice Journals of George W. De Long*. Boston: Houghton Mifflin.
Fries, T. M., & Nyström, C. (1869). *Svenska Polar-expeditionen 1868 Med Kronoångfartyget Sofia*. Stockholm: P. A. Norstedt & Söner.
Holloway, G., & Proshutinsky, A. (2007). Role of Tides in Arctic ocean/ice climate. *Journal of Geophysical Research: Oceans*, *112*(C4), 1–10. https://doi.org/10.1029/2006JC003643
Krumpen, T., Belter, H. J., Boetius, A., Damm, E., Haas, C., Hendricks, S., ..., Stein, R. (2019). Arctic warming interrupts the Transpolar Drift and affects long-range transport of sea ice and ice-rafted matter. *Scientific Reports*, *9*, 5459. https://doi.org/10.1038/s41598-019-41456-y
Kwok, R., Spreen, G., & Pang, S. (2013). Arctic sea ice circulation and drift speed: Decadal trends and ocean currents. *Journal of Geophysical Research: Oceans*, *118*(5), 2408–2425. https://doi.org/10.1002/jgrc.20191
Lantz, B. (2018). Could the members of the 1897 Andrée balloon expedition have survived? *Polar Record*, *54*(3), 234–236. https://doi.org/10.1017/S0032247418000402
Lantz, B. (2019). A note on the depots of the 1897 Andrée balloon expedition. *Polar Record*, *55*(1), 48–50. https://doi.org/10.1017/S0032247419000159
Lytzen, C. (1885). Levninger fra Jeannette-Expeditionen paa Grønlands Vestkyst, *Geografisk Tidsskrift*, *8*, 49–51.
Macdonald, R. W., Harner, T., & Fyfe, J. (2005). Recent climate change in the Arctic and its impact on contaminant pathways and interpretation of temporal trend data. *Science of the Total Environment*, *342*(1–3), 5–86. https://doi.org/10.1016/j.scitotenv.2004.12.059
Meisenbach, G. (1898). En färd till Sjuöarne sommaren 1897. *Ymer*, *18*, 127–140.
Nansen, F. (1893). How can the north polar region be crossed? *The Geographical Journal*, *1*(1), 1–22. https://doi.org/10.2307/1774198
Nansen, F. (1897). *Farthest North*. New York: Harper and Brothers.
Parry, W. E. (1828). *Narrative of an Attempt to Reach the North Pole*. London: John Murray.
Payer, J. (1875). The Austro-Hungarian polar expedition of 1872–4. *The Journal of the Royal Geographical Society of London*, *45*, 1–19. https://doi.org/10.2307/1798702.
Personne, M. (2000), Andrée-expeditionens män dog troligen av botulism. *Läkartidningen*, *97*(12), 1427–1432.
Sverdrup, H. U. (1931). Scientific results of the Andrée-expedition. 1. Drift-ice and Ice-drift. *Geografiska Annaler*, *13*(2–3), 121–140. https://doi.org/10.1080/20014422.1931.11880536
Truong, F. M. (2018). *Trigonometry*. California, CreateSpace Independent Publishing Platform.
Uusma, B. (2013). *Expeditionen: Min kärlekshistoria*. Stockholm: Norstedts.
Weyprecht, C. (1875). Scientific work of the second Austro-Hungarian polar expedition, 1872–4. *The Journal of the Royal Geographical Society of London*, *45*, 19–33. https://doi.org/10.2307/1798703.
Wordie, J. M. (1931). The Andrée diaries. *Polar Record*, *1*(1), 31–33. https://doi.org/10.1017/S0032247400029144

https://doi.org/10.1017/S0032247419000706 Published online by Cambridge University Press