

POLISH POLAR RESEARCH	19	1-2	15-30	1998
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Contribution of H. Arctowski and A. B. Dobrowolski to the Antarctic Expedition of *Belgica* (1897–1899)

ABSTRACT: Alongside the purely scientific nature and the first wintering in Antarctica, another innovative feature of the *Belgica* expedition was its multinational composition. Two, out of its seven persons strong scientific staff, were Polish – H. Arctowski and A. B. Dobrowolski. The first served as scientific deputy-leader of the expedition, the other as laboratory assistant and meteorologist. Their contribution to the scientific success of the Belgian Antarctic Expedition outlined in the present paper, turned into the starting point of brilliant academic careers in the native country and at international level. Both, Arctowski and Dobrowolski, were acknowledged as symbols of the Polish explorations and scientific investigations in polar regions.

Key words: Arctowski, Dobrowolski, Antarctica, *Belgica* expedition.

Introduction

The Antarctic expedition of *Belgica* (1897–1899) occupies a very special place in the history of the discovery and scientific exploration of that part of the world. This is not only due to its timing and the first wintering event in Antarctica, but principally to its scientific achievements. Two distinguished Polish scholars, Henryk Arctowski and Antoni Bolesław Dobrowolski took part in this multinational Belgian expedition led by Adrien de Gerlache de Gomery (see Arctowski 1899a, 1960; Cook 1900; Dobrowolski 1950; Gerlache 1902; Leconte 1904; Kosiba 1960).

Background

Since the middle of the 19th century, scientists followed with growing concern the events accompanying the exploration of the polar regions. In particular, they pointed out to the disproportions between its relatively poor scientific

effects and the exorbitant costs, both financial and in loss of life. In the meantime, the successive polar expeditions turned ever more into competitive sport events and an incoherent race towards the Poles.

In an attempt to reverse that trend, the scientists have succeeded, as a result of a series of international meetings, to organize in 1882/83 the First International Polar Year, providing for an extensive research programme. As a part of it, 49 scientific research stations were established in both polar regions, but only two in Antarctica.

Trying to rekindle interest in that forgotten part of the world, the 6th International Geographical Congress held in London in July, 1895, passed an appeal, stressing that "further exploration of the Antarctic regions should be undertaken before the close of the century".

Preparations for expedition

It was not easy to persuade anyone to freeze his capital in the Antarctic ice, while each penny invested in the tropical regions profited fast and was multiplied manifold. What seemed beyond reach of the learned scholars, was however attained by the modest and as yet unknown Adrien Victor Joseph de Gerlache de Gomery, a 29-year-old Lieutenant in the Royal Belgian Navy. Disappointed in his unsuccessful endeavours to join a Swedish polar research party, this young officer decided he himself would set up an Antarctic expedition.

This timing was faulty, for Belgium was more interested to earmark financial resources for her newly acquired colony Congo, not the Antarctic. However, de Gerlache managed to attract the interest of the Belgian scientific community, the government and the parliament and, after organizing a national subscription, he succeeded by the early Spring of 1896 to raise the necessary funds.

In Norway, de Gerlache bought the 30-m (98 ft) three-masted whaler *Patria*, renamed as *Belgica*. Its 112 kW (150 hp) engine was overhauled, cabins were built on the afterdeck for the officers and scientific staff, a laboratory was fitted under the bridge, while the crew's quarters were crammed in below decks.

One of the most important tasks, on which the expedition's success much depended, was the careful choice of its staff. The request for candidates had brought a polyglot reply from much more volunteers than needed. It was, therefore, crucial to select the best and most reliable ones, who would be able to cope unflinchingly with the extremely harsh Antarctic conditions.

In July, 1896, de Gerlache succeeded to recruit the 25-year-old Norwegian polar explorer Roald Amundsen as the second officer. A number of crew were, like him, Norwegian. The second-in-command, also to be navigating officer, astronomer, hydrographer and geodesist, was a young Belgian, Lieutenant

George Lecointe (born 1869), as was another officer, Lieutenant Emile Danco (born 1869) – geophysicist of the expedition.

Research programme

A. de Gerlache attached much importance to the scope of the expedition's research programme. Strictly limited by the ship's capacity, he had to recruit for the scientific staff not only the best, but also the most versatile scholars. He welcomed, therefore, the Polish scientist Dr Henryk Arctowski (born 1871) who was strongly recommended by Professor Walther Spring from the University of Liège, and contacted him as early as in 1895, starting immediately as scientific deputy-leader of the expedition.

Arctowski assisted de Gerlache not only in setting up the scientific staff, but also in raising financial means by delivering public lectures. Despite young age, he was well educated in geology and chemistry at the universities of Liège and Paris, and also has mastered extensive knowledge in mathematics, physics and astronomy. That prompted de Gerlache to charge him alongside geology with responsibilities in oceanography and meteorology.

Accepting these commitments, Arctowski requested, however, the commander to recruit his countryman Antoni Bolesław Dobrowolski (born 1872), a student in natural sciences at Zurich University. He was expected to assist Arctowski in meteorological observations, alongside his other, navigational duties. Because the list of the staff was already closed, that was done in the last minute before departure, when Dobrowolski replaced one of the crew members who resigned.

Earlier, availing himself of his wide connections in European scientific circles, Arctowski helped de Gerlache to recruit Dr Emile G. Racovitza, a Romanian biologist, who filled the last vacancy in the multinational scientific staff¹.

Preparing for scientific leadership

To prepare soundly for his role as the scientific leader of the Belgian expedition, Arctowski took up intensive and comprehensive theoretical and practical studies in polar sciences. He started with problems of geology and geomorphology of Southern Andes and island archipelagoes between South America and the Antarctic continent (see Arctowski 1895, 1896, 1897). To prepare for gla-

¹ According to the recent disclosures by Professor Alexandru Marinescu, from the Natural History Museum in Bucharest, it was neither Henri de Lacaze-Duthiers nor Edouard van Beneden, as earlier assumed, but H. Arctowski who first recommended E. Racovitza to A. de Gerlache (see Marinescu 1992).

ciological research, he went to Switzerland, where he met in Zurich with Professor Albert Heim, at that time an international authority on glaciers. Then, he set out for a number of excursions on glaciers in the Swiss Alps, mainly in the Bern area.

To get acquainted with the advanced methods in oceanographic research, Arctowski visited in England G. Murray and J. Buchanan, members of the famous *Challenger* expedition, and also H. R. Mill. During his stay in England, he has also sought advice of Sir Napier Shaw and other prominent British meteorologists. For practical experience, he spent some time in the Belgian Royal Meteorological Institute at Uccle.

That increased knowledge enabled Arctowski to become one of the most active members of the expedition and, in fact, its scientific leader.

Off to Antarctica!

The Belgian Antarctic Expedition left Antwerp on 16 August, 1897. In Rio de Janeiro, it was joined by the 32-year-old American arctic explorer surgeon Dr Frederick A. Cook. On 1 December, 1897, the vessel reached Punta Arenas from where intensive research was carried out in the area of Tierra del Fuego. These investigations were aimed at comparative geological studies between the South American and Antarctic continents. They were of particular importance to H. Arctowski (1895) who was seeking evidence in support of his theory of "Antarctandes"² on direct continuation of the Patagonian Andes through a submarine mountain chain to Shetland Islands and Graham Land.

Belgica did not leave Punta Arenas until 14th December, 1897. Desertion of five sailors reduced the number of expedition staff to 19, among which were: 9 Belgians, 6 Norwegians, 2 Poles, 1 Romanian and 1 American.

Critics of de Gerlache pointed to the delay in departure as the first indication that what happened later was not mere an accident. However true these suspicions, the *Belgica* did not heave into Antarctic waters until 20 January, 1898, rather late in the exploring season. On 22 January, a north-easterly gale hit the *Belgica* devastating the vessel and taking the first death toll – Carl August Wiencke (born 1877), the Norwegian sailor who got drowned. By the following day, Sunday 23 January, the gale had blown itself out and the explorers, taking

² Arctowski's (1908a) term "the Antarctandes" in application to Tertiary mountain chains of West Antarctica was in use in geological literature for more than seven decades. The Patagonian Andes were separated from mountain chains of Antarctic Peninsula-South Shetland Islands as a result of opening of the Scotia Sea in the Tertiary (e.g., Dalziel & Elliott 1973).

Field work in West Antarctica was resumed by Polish geologists since 1977 (see Birkenmajer 1978, 1980a, c, 1982, 1987, 1988, 1991, 1996; Birkenmajer & Gaździcki 1991; Tokarski *et al.* 1981).

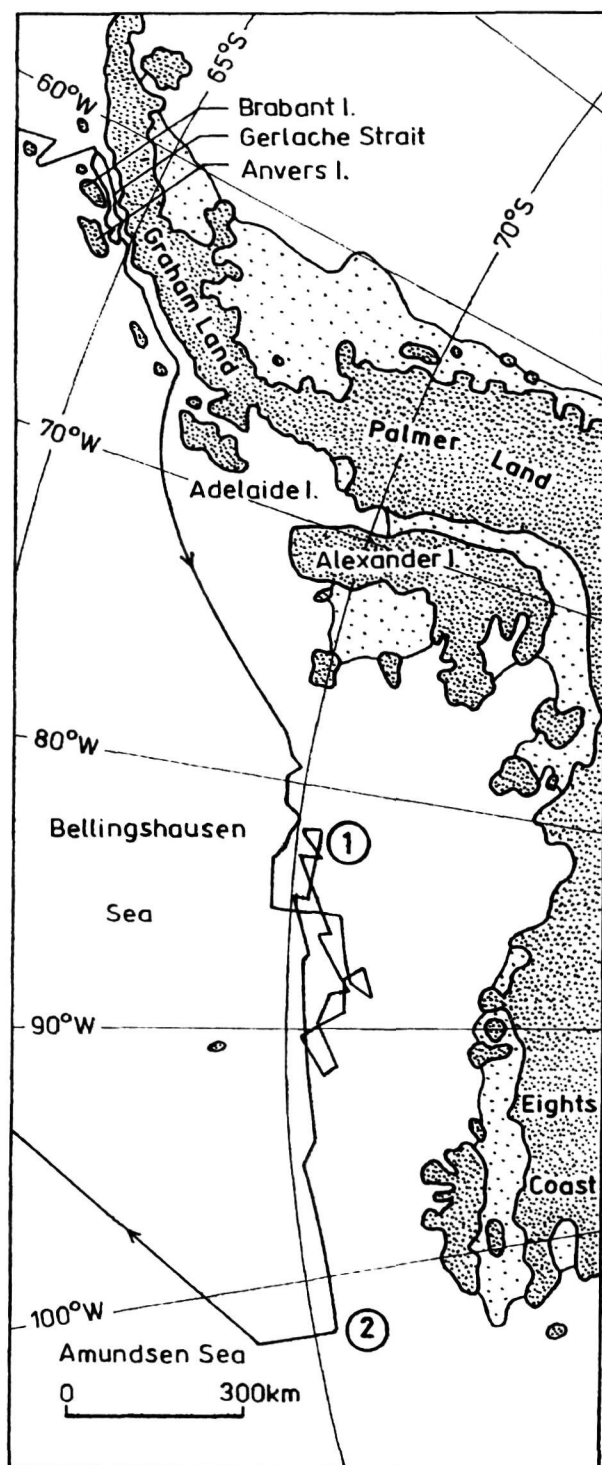


Fig. 1. The route of *Belgica* voyage in the Antarctic waters, 20 January, 1898 – 15 March, 1899 (after de Gerlache, 1902). 1 – *Belgica* trapped in ice on 2 March, 1898, at 70°20'S – 85°W; 2 – *Belgica* freed from the ice trap on 14 March, 1899, at 70°30'S – 103°W.

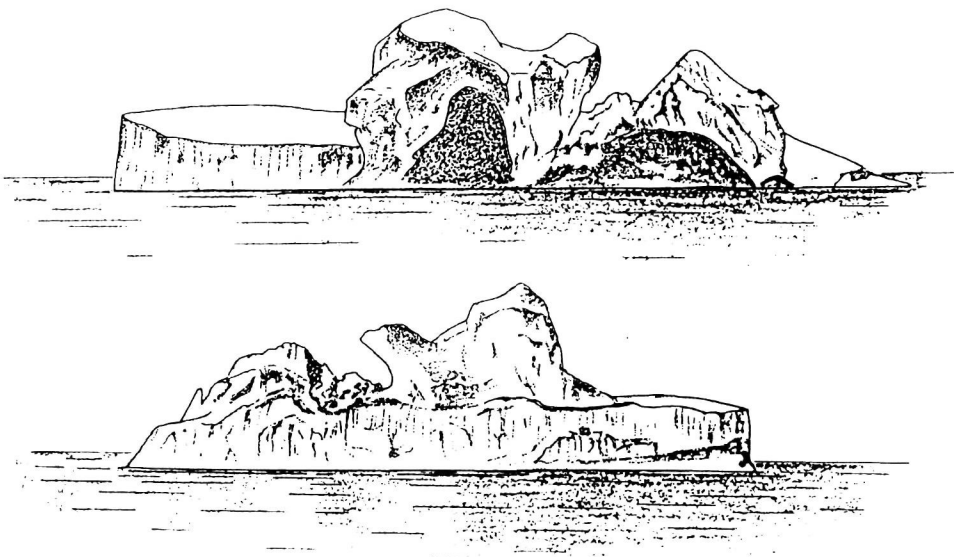


Fig. 2. Antarctic iceberg 40 m high, 250 m long, as seen from two sides (Arctowski 1903).

advantage of the weather, approached the shores of Graham Land and the long string of islands at its west coast. De Gerlache named the floe-filled passage “Belgica Strait”, later recognized as his greatest geographical discovery and renamed in his honour Gerlache Strait (Fig. 1).

Between 23 January and 12 February, 1898, members of the expedition made 20 landings on the islands that fringed the strait, chartered and named the westward-lying islands of Brabant, Liège, Anvers, and – in memory of the sailor they had lost – Wiencke.

During the short landings on the Antarctic islands, H. Arctowski continued his geological investigations which, together with petrographical analysis of the collected rock samples, allowed him to bring more evidence to prove his earlier-mentioned hypothesis on links between Patagonia and Graham Land (Arctowski 1895) – the Antartandes (Arctowski 1900a, 1908a). He also examined traces of previous extent of glaciers in form of roches moutonnées, glacial striae on bedrock, moraines, etc. Basing on his observations in Beagle Channel (Patagonia), he concluded that the snow-limit has risen by 800 m since the last glacial maximum (Arctowski 1900b-d, 1908a).

Heading southwest, on 13 February, 1898, *Belgica* has reached 65°10'S and 64°W, and two days later had crossed the Antarctic Circle. The following day, in clear weather, they got to within 32 km (20 miles) of Alexander Island. From thereon, *Belgica* had to fight her way through the ever denser pack ice.

Sailing through the ice-covered sea, Arctowski continued his glaciological observations on sea-ice formation and types of icebergs. Examining their structures he described them in detail, illustrating his descriptions with hundreds of sketches (Fig. 2). Such rich material allowed him later to draw many interesting conclusions on their origin and transformations, and to make comparison between Arctic and Antarctic ice formations (Arctowski 1901a, b, 1903, 1908b).

On the last day of February, 1898, with the ship now at 70°20'S and 85°W, *Belgica* entered thick pack ice. Hardly finding channels, ponds and narrow passages the whaler could cleave her way through. After they reached another degree south, a few more minutes west, the vessel shuddered grimly and became embedded in the pack ice. The week-long efforts to free the undermanned and overloaded ship out to the open sea turned out futile. By 2 March, 1898, the expedition was trapped in the ice and left at the mercy of the unknown dark antarctic winter. During the following months, the multinational party gave a good deal of thought whether commandant de Gerlache came this far south by accident or was it his intention to let his ship be the first to spend the antarctic winter?

In ice trap – first antarctic wintering

The Belgian expedition caught in the ice of Bellingshausen Sea, ill-equipped to face the polar winter, entered the most difficult period of the whole voyage. There was an acute shortage of everything: fuel to keep warm the cabins, food which was not only inadequate, but also unsuitable for the austral winter season. According to the original plan, only a small party of four was expected to winter on the distant Victoria Land, which *Belgica* was unable to reach. In result, instead of four, now eighteen men, unprepared mentally and physically, had to face the hardships of the Antarctic winter (Fig. 3).

On 17 May, 1898, the darkness of polar winter night closed in. Deprived of all daylight, short of lanterns, frozen to the marrow, suffering of sickness, the men became irritable and morbid; some of them revealed symptoms of depression, nervous breakdown and even madness. On 5 June, 1898, died Lieutenant Danco, whose heart succumbed the cold.

While all the staff fought for survival, the scientists struggled desperately to continue their research. Nearby the ship, they erected a small wooden shack, where Arctowski tried to establish a primitive observatory. Despite the accumulating setbacks, he was striving hard to implement the expedition's scientific programme and to organize continuous observations and systematic research, covering the widest possible range of sciences. All members of the expedition, still charged with other duties, tried hard to assist the scientists in their research work and observation tasks – Lecointe and Amundsen helped in astronomical

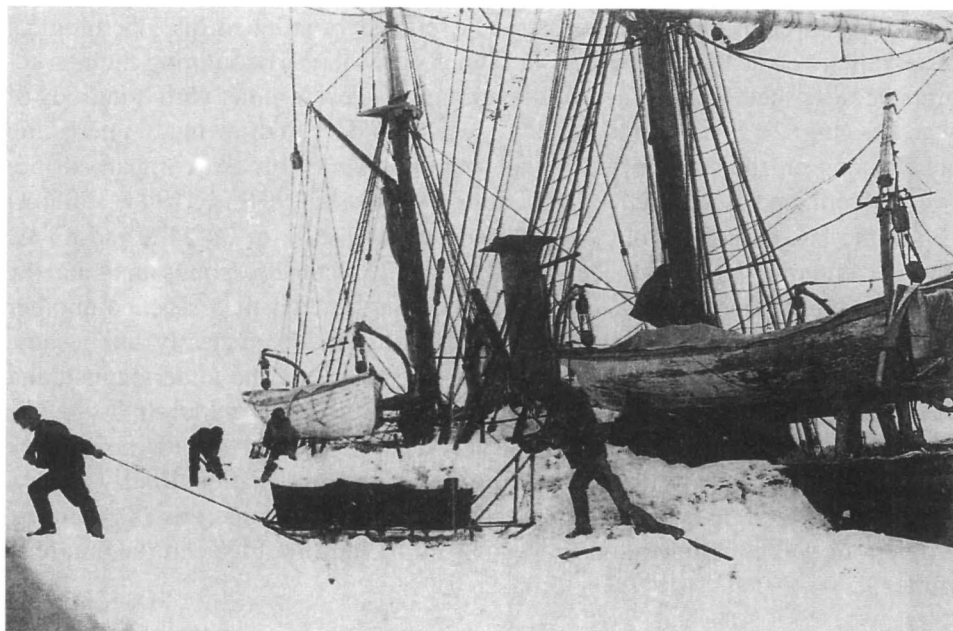


Fig. 3. *Belgica* locked in Antarctic ice, Bellinghshausen Sea
Photo-collection of the Museum of the Earth, Warsaw.

and meteorological observations, de Gerlache in oceanographic ones. To expand the range of observations, Arctowski organized sledge and ski parties in the vicinity of the locked ship, which constantly changed her geographical position together with the drifting ice-field (see Fig. 1). These movements further widened the range of scientific investigations.

During the entire journey, Arctowski's countryman A. B. Dobrowolski, helped him in meteorological observations and as laboratory assistant. Acknowledging his substantial share in research work, commandant de Gerlache transferred him in March, 1898, from the ship crew to the scientific staff of the expedition. Delighted at that change, Dobrowolski has noted in his diary:

"Since then, all the year round, I spent 12 hours daily, with only half an hour break for lunch, collecting meteorological data, gathered on my initiative every hour, instead every two hours, or even more rarely, as it is common during expeditions, as well as uninterrupted and very detailed observations – conducted for the first time in such a way. Watching the clouds and hoar-frost, I have gathered the necessary material for further studies on return".

In fact, that unique material has served him later as basic source in writing his monumental treatise on the crystallography of ice and snow (Dobrowolski 1923).

As oceanographer, H. Arctowski continued during the *Belgica's* ice-drift his soundings of the sea and measurements of water temperature, density and chemi-

cal constitution, collecting the seawater samples from different depths, from open ice crevasses and also through the ice. The gathered data allowed him to prepare a bathymetric map showing, among others, the thermal and salinity stratification of seawater at different points in Bellingshausen Sea. Later on, on the basis of these observations, Arctowski has prepared, together with the British oceanographer H. R. Mill, thermal profiles of that sea, showing for the first time partial structure of the oceanic waters. Its complete structure was elaborated as late as in the thirties of the present century by the famous oceanographical expeditions of "Meteor" and "Discovery". On his oceanic profiles, Arctowski distinguished seawater strata at temperatures below 0°C, contained between two layers of warmer water. He also explained that phenomenon of "median layer" (Arctowski 1899b, c; Arctowski & Thoulet 1901; Arctowski & Mill 1908), which was fully described as late as in the thirties of the present century by Gerard Schott.

While the scientists concentrated on their observations, de Gerlache was doing all he could to prepare the ship for breaking free from the ice. At that time Dr Cook was taking care of his ailing patients, while Amundsen – the perfect mate, served as an experienced link between the scientists, officers and the crew.

It was not until 23 July, 1898, that the first faint glow of sunlight tipped the horizon. From that moment, the health and spirit of the staff was constantly improving, the research work was intensified. Soundings were taken more frequently through the ice, all the more so, as the explorers started to saw and chop the ice field to cut a channel towards the open sea and to set free the vessel out of the trap. More sledge parties were sent to explore the drift, astronomical and meteorological observations went on, air temperature and wind velocity were measured, directions of sea currents gauged, etc.

During that hectic time, Arctowski and Dobrowolski co-operated closely together, concentrating on meteorological observations. The meteorological data gathered systematically and hourly, allowed the two Polish scholars to draw up, for the first time in the Antarctic region, tables representing yearly, monthly and daily changes of all the weather elements. That allowed Arctowski to draw interesting conclusions on the Antarctic atmosphere conditions and to analyse the degree of its changes, leading to the presentation of a general model of weather conditions prevailing in the region visited by the *Belgica*. Arctowski defined that region as "coastal" in relation to the Antarctic ice-cap. The great variability observed there, he explained by changing of the ship's geographic position with respect to course of cyclones following one another along periphery of the ice-cap.

Besides the basic weather observation duties shared by Arctowski and Dobrowolski, they also conducted observations of optical atmospheric phenomena. Arctowski precisely described all the observed apparent deformations of celestial bodies, mirages, luminous clouds, rainbows, halo, corona, etc. His name has



Fig. 4. R. Amundsen (left) and A. B. Dobrowolski cutting marine ice to free the *Belgica*
Photo-collection of the Museum of the Earth, Warsaw.

been later given to a phenomenon observed by him on 20 August, 1898, in which a halo resembling a rainbow, with two other partial arcs symmetrical to the main one, formed around the sun as its light was refracted by ice crystals in the atmosphere. He further described with insight the aurora australis, ascertaining its periodicity with that of aurora borealis (Arctowski 1899d–f, 1900e–i, 1901c–g, 1902a–c, 1904a–c).

Dobrowolski, who assisted Arctowski in meteorological observations, concentrated in his studies mainly on phenomena related to ice and snow conditions, gathering material for his future treatise on the “Natural history of ice” (see Dobrowolski 1923). His meaningful contribution in this field was the discovery of the material prerequisites for the generation of the halo phenomenon. To this

end, he examined optically particular accumulations, as well as individual atmospheric ice crystals responsible for its formation. To prove this, he had first to refute the wrong theory on the least resistance, claiming that the flat snowflakes fall down only in vertical position, while in fact they can also fall in horizontal one, making at the same time characteristic movements. Thus, Dobrowolski proved that the ice-needles do not participate in creation of the halo, while the ice-plates are acting in the formation of some haloes, but only when reflecting the light. An adequate and sufficient element causing formation of the halo phenomena, were found to be ice-piles, the so-called "pegs", that represent piles of ice flat at one end and pointed at the other, with a cavity inside. They were later named "Dobrowolski's pegs".

The intensive research work could not, however, conceal from the scientists the gravity of their situation. Despite the fact that the winter was over, the dramatic attempts to break through turned out futile (Fig. 4). They were still held firm in the massive field of winter ice over two metres thick and drifting all time while within the Antarctic Circle. The expedition was now running short of everything, all those aboard resigned to a second antarctic winter, and with the likelihood of their death in ice. In the meantime, from August through December, 1898, the *Belgica* was travelling uncontrolled westward with the drifting ice-field.

Unexpectedly, in the final month of the austral summer, on 15 February, 1899, at 2 hrs a.m., a sailor on watch alarmed de Gerlache that the ice was in motion, and the vessel was rising and falling on a swell that indicated a proximity of open sea. It was, however, not until another month of exhausting battle with the ice that on 14 March, 1899, *Belgica* was set free from the trap at 70°30'S and 103°W. During almost 13 months imprisonment, she had drifted across more than 17 degrees of longitude, reaching on 31 May, 1898, her farthest southern position of 71°36'S.

After a half-year long sail back home, in November 1899, the Belgian Antarctic Expedition was enthusiastically welcomed in Antwerp, its point of departure, thus ending her over two years long polar journey.

Scientific aftermath

On completing the expedition, an extensive work on the comprehensive systematization, data analysis and publication of the scientific materials collected during the *Belgica* cruise was taken up. Almost 70 prominent scholars from Europe and America, representing a wide spectrum of scientific disciplines and specialities, were invited to cooperate in that task. On their return from Antarctica, both H. Arctowski and A. B. Dobrowolski joined that scientific venture and devoted their entire time to preparing and editing the expedition's

research material, in particular in the field of geology, geomorphology, oceanography, glaciology and meteorology.

In 1899, they were appointed members of the *Belgica* Editorial Board at the Royal Belgian Academy of Sciences. In that capacity, they published numerous papers in various scientific periodicals, but above all they contributed to the voluminous Scientific Reports of the *Belgica* Expedition contained in ten volumes.

H. Arctowski has prepared papers on: hourly meteorological observations, optical phenomena in the atmosphere and aurora australis (in vols III and IV dealing with meteorology); soundings and other oceanographic data (with A. F. Renard); thermal relations within the ocean (with H. R. Mill); density of seawater (with J. Thoulet). Moreover, he elaborated notes on: colour of oceanic waters and on Antarctic ices (journal of observations relating to glaciers, icebergs and drifting ice-field); physical geography of the Antarctic lands (in vol. V dealing with oceanography and geology).

A. B. Dobrowolski has prepared papers on the observations of clouds, snow, and hoar-frost (in vols III and IV).

Summary of scientific contribution by H. Arctowski and A. B. Dobrowolski

The following scientific results of the *Belgica* Expedition to Antarctica are to be credited to the work by the Polish members of this expedition, H. Arctowski and A. B. Dobrowolski (see Kosiba 1960, Pietkiewicz 1960):

(1) They obtained, for the first time in the history of antarctic science, a complete annual observation cycle in meteorology and oceanography;

(2) They recognized the wave character of cyclone movement around the Antarctic, long before the wave theory of frontal cyclones has been proposed;

(3) On the basis of the winter observations, they have established that the Antarctic is much colder than earlier presumed³;

(4) Arctowski has established the rise of the firn (névé) limit in Antarctica by about 800 m since its maximum glaciation;

(5) Arctowski has confirmed the analogy in geological structure between the Southern Andes of Tierra del Fuego and Graham Land in West Antarctica that led to his theory of "Antarctandes";

³ At that time, some scholars presumed that the decrease of the mean annual temperature by 4°C would be enough to cause the return of the maximum glaciation, while Arctowski has proved, basing on his antarctic observations, that to achieve such effect a decrease of no less than 8°C would be necessary.

(6) Arctowski was the first to state that the edge of the Antarctic continental shelf is about 400 m deeper than around other continents, due to isostatic subsidence of continental crust under load of antarctic ice-cap;

(7) Arctowski drew attention to the fact that, within the *Belgica* observation range, the frequency distribution of aurora australis was similar to that of aurora borealis, in corresponding geomagnetic latitudes of the northern hemisphere;

(8) Arctowski and Dobrowolski have together discovered, described and explained new optical atmospheric phenomena characteristic of polar regions;

(9) Dobrowolski was the first to elaborate the general and detailed crystallography of ice and snow.

Geographical place names in Antarctica in honour of Arctowski and Dobrowolski

To pay tribute to the outstanding achievements of H. Arctowski and A. B. Dobrowolski, numerous geographical place names, both in West Antarctica and in Spitsbergen, bear their names:

Arctowski Nunatak, 65°06'S–60°00'W (named in 1902 by the Otto Nordenskjöld expedition);

Arctowski Peak, 1210 m high, 74°44'S–61°28'W (name introduced in 1948 by the Finn Ronne expedition);

Arctowski Peninsula, 15 miles long, 64°45'S–62°25'W (name introduced in 1898 by A. de Gerlache);

Arctowski Cove, near Arctowski Station (Admiralty Bay), King George Island, South Shetland Islands, 62°09'S–58°29'W (name introduced by K. Birkenmajer 1980b);

Arctowski Icefield (Dome), the main ice-cap of King George Island, South Shetland Islands, 61°55'–62°10'S–57°45'–58°50'W (name introduced by K. Birkenmajer 1980b);

Arctowski Mountains, at King Bay, King George Island, South Shetland Islands, 62°01'–62°03'30"S–58°05'–58°15'W (name introduced by A. K. Tokarski 1981);

Dobrowolski Island, close to Anvers Island, Palmer Archipelago, 64°36'–62°55' (name introduced in 1958 by the British expedition on *Discovery*);

Dobrowolski Glacier (at Martel Inlet, Admiralty Bay), King George Island, South Shetland Islands, 62°05'S–58°17'W (name introduced by K. Birkenmajer 1980b);

Dobrowolski Peak (between Admiralty Bay and King George Bay), King George Island, South Shetland Islands, 61°57'S–58°14'W (named by A. K. Tokarski 1981).

Polish Antarctic stations named in honour of H. Arctowski and A. B. Dobrowolski

The first Polish Antarctic Station, opened in 1959 in Bunger Hills, East Antarctica ($66^{\circ}17'S$ – $100^{\circ}45'E$, 35 m a.s.l.), bears the name of A. B. Dobrowolski. The station was operated intermittently till 1979. Presently it is inactive.

The second Polish Antarctic Station, opened in 1977 at Admiralty Bay, King George Island (South Shetland Islands), West Antarctica ($62^{\circ}09'S$ – $58^{\circ}28'W$, 3 m a.s.l.), bears the name of H. Arctowski. The station operates year-round since 1977.

Final remarks

H. Arctowski and A. B. Dobrowolski remained closely linked with polar research, carried out both in the Antarctic and in the Arctic (in Spitsbergen), for the rest of their lives. Their scientific achievements and personal positions have laid a solid foundation for the subsequent Polish explorations and scientific investigations in both the Arctic and the Antarctic.

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