Polar water reservoirs

The Sixth Continent

STANISŁAW RAKUSA-SUSZCZEWSKI
rakusa.suszczewski@gmail.com
Prof. Stanisław Rakusa-Suszczewski is founder of the Henryk Arctowski Polish Antarctic Station.

Antarctica's "oases" differ from the continent's ice-covered desert in terms of their climate, rocky landscape, and the presence of numerous lakes, shallow reservoirs, and streams that appear briefly in the summer. These oases vary in age from around 5,000 to around 15,000 years old and their development is linked to the glacial retreat

Antarctica is covered by an ice cap up to 4,000 m thick (rising to 3,488 m above sea level in the region of Vostok Station). Infrequent ice-free areas, commonly referred to as oases, are characterized by the occurrence of liquid water and cover a mere 0.3% of the continent. There are around 20 such oases in Antarctica and most of them are situated close to the coast, accounting for a total of around 8% of the continent's coastline.

Some researchers believe that today's ice shelves, or masses of ice flowing down from the continent to the sea, are relics of the continental glacier from the previous era. Between 200 and 350 m thick, these ice shelves usually rise to 20 m above sea level and cover around 12% of Antarctica's area. Situated on their edges, Antarctic oasis can have maximum air temperatures exceeding zero degrees, although average yearly temperatures remain below zero. Characterized by a clean atmosphere and dry climate, the oases are exposed to strong direct sunlight, so the temperature of the surface of rocks and land may range from 35^0C during the day (even 41^0C in January) to -12^0C at night. This is why oases have a positive heat balance.

Average monthly air temperatures in the Thala Hills oasis (Enderby Land) are negative while extreme maximum temperatures may reach 10^0C in summer. Antarctica's coastal sites are the windiest places in the world, with winds blowing for 220 days a year at speeds exceeding 15 m/s. Katabatic winds blow regularly, compared with irregular hurricane-force cyclonic winds.

Subglacial lakes

In recent years, numerous lakes have been discovered beneath the Antarctic ice away from the continent's coast, where water has been isolated for millions of years from today's environment. So far, several hundred subglacial lakes have been identified and they are presumably interlinked by under-ice rivers. In addition to Lake Vostok (measuring 250 km long, 50 km wide, and 670-800 m deep), the best known and largest subglacial lakes include Lake Ellsworth, Sovetskaya Lake, 90^0E Lake, and Lake Concordia. After 20 years of drilling, the Russians reported a significant success in 2012 by obtaining the first samples of water from Lake Vostok. Results of samples collected at the depth of 3,769.3 m in February 2012 were inconclusive as to the presence of bacteria. The Americans also managed to drill down to Lake Whillans, located west of McMurdo Station. Similar drillings have been made by scientists from England, Japan, and France, who expected to find life from millions of years ago in subglacial lake water along with records of changes in Antarctica's climate in the ice above the lakes and lake-bed sediments. Sulfuric acid, nitric acid, formic acid, and sea salts found in the ice might act as nutrient substances for oligotrophic psychrophiles. The thermal regime of the group of continental lakes remains as yet unknown. Water in the lakes is presumed to be exceedingly oxygenated and under great pressure. Likewise, it is suggested that its warm temperature is a result of geothermal heat or volcanic factors.

There are many relatively well-known water reservoirs in oases on the edges of Antarctica. Some of them retain their ice surface throughout the year while others thaw. In some cases, the ice shelves border on oases, preventing them from being directly accessed from the sea. Consequently, such lakes have a layer of freshwater near the surface and a layer of salt water at the bottom that reaches the edges of the oasis under the ice shelf. Such lakes have been limnologically classified as a new type of reservoirs, called epishelf lakes. One special example is Lake Vanda in the Wright Valley (one of the so-called Dry Valleys). It is frozen near the surface, but the bottom layer of water at the depth of 70 m has a temperature of 25^0C. Another example is Lake Don Juan, which has such high salinity that it does not freeze in the winter, although the water temperature can drop even to -48^0C.

A large group of lakes can be found in the Schirmacher Oasis, while the Vestfold Hills oasis has 300 water reservoirs varying from 5 to 110 m in depth, including many meromictic lakes characterized by salinity levels from 4 to 235 grams per liter and temperatures from -14^0C to 24^0C. In coastal oases, water reservoirs are located in rocky valleys, in areas where glaciers retreated after the extensive glacial period in Antarctica. In summer, the ice cover thaws partially or completely. Direct thermal stratification occurs when the layer of water near the surface heats. In winter, however, inverse thermal stratification is observed, with temperatures reaching around 4^0C at the bottom. A separate type of lake consists of shallow bodies of water several meters deep, where temperatures in the summer may reach around 15^0C. In winter, such reservoirs freeze to the bottom or almost to the bottom. There are certain distinctive lakes found on volcanic islands in Western Antarctica. For example, there is an oxygen-free lake situated in a volcanic crater in Penguin Island (South Shetland Islands). It was the first lake to be identified in Antarctica as stratified with saltwater at the bottom and fresh water, inhabited by copepods, at the top.

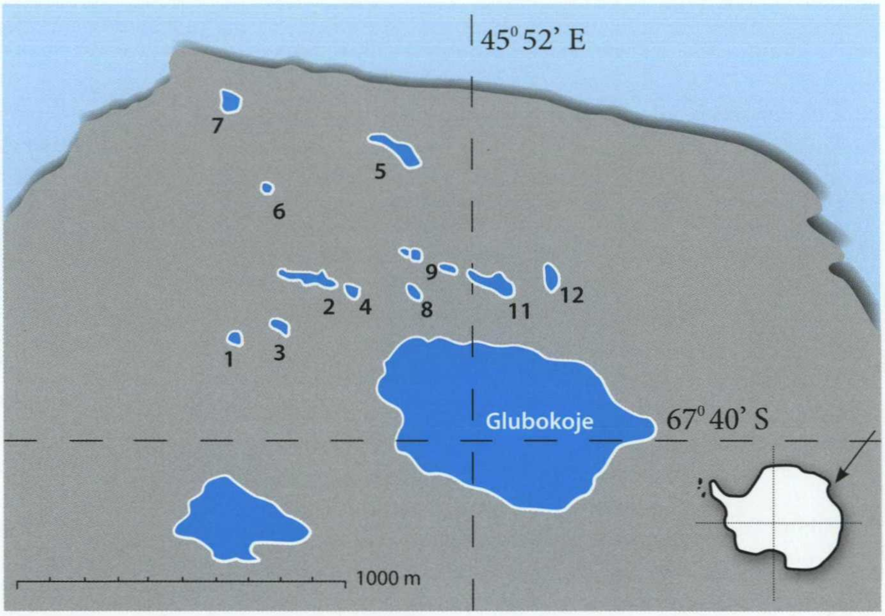
The Thala Hills oasis

Bodies of water in the region of the Thala Hills were studied by the first two-person expedition of Polish biologists, S. Rakusa-Suszczewski (the present author) and K. Opaliński from the Nencki Institute of Experimental Biology, the Polish Academy of Sciences, as early as in

Author's archives (2)

1968. A stay at Molodyozhnaya Station allowed us to collect material and describe the flora and fauna of local reservoirs. There are 50-60 bodies of water in the Thala Hills that vary in depth from less than 1 m to 2-3 m and sometimes freeze to the bottom as well as a large lake, Lake Glubokoye, which is 30 m deep. The shallow bodies of water are covered by ice for around 10 months in a year and the thawing begins in October. The large lake remains frozen all year, apart from shallow areas near the edges and the outlet. In spring, water temperature rises very fast in November despite the presence of ice and may reach 6-7^{0}C in ice-free areas in the first days of December. In summer, shallow bodies of water are characterized by considerable and irregular fluctuations in water temperatures, up to around 15^{0}C. The water temperature in a dark shallow puddle on the rocks reached even 21.5^{0}C as a result of rapid weather changes and climate characteristics, chiefly strong radiation, rocky ground, and low air humidity. This is the opposite of diurnal temperature variations in the shallow Arctic bodies of water in Spitsbergen, characterized by minimum diurnal variations, high humidity, and diffuse radiation. In the fall, Antarctic reservoirs have a considerable heat reserve while the cooling process following the freezing of the surface is relatively slow.

Drawing by Paweł Adamów



Studied bodies of water in the Thala Hills oasis Glubokoye

The largest lake in the Thala Hills is Lake Glubokoye (230 ha). As a result of rising water levels in the lake, the snow barrier closing off the lake›s access to sea from an open valley was broken. In the course of two or three days, there was a rapid and catastrophic outflow of more than 10 million cubic meters of water, chiefly from the lake›s epilimnion. The surface of the frozen lake lowered by 8 m and the coastal ice rested in the rocky valley around its dry edges. The layer of the thermocline, the hypolimnion, was beneath the surface of the ice. In the following months, the layer gradually cooled down. As we observed in one lake, when a body of water situated in a rocky valley freezes to the bottom, the ice expands and cracks along the longer axis. We also observed an interesting and somewhat surprising phenomenon that occurred on the surface of the lake when a large mound of snow was formed after a period of strong cyclonic snowstorms. The snow pressed on the ice in the lake, causing the water to flow rapidly to the surface through a hole in the ice (just like in a bottle of Coca Cola). Growing water pressure in reservoirs situated in rocky valleys is also caused by freezing. Scientists use the term "Coca Cola effect" to describe the phenomenon and expect it to occur during drilling in continental lakes.

The small bodies of water are characterized by considerable fluctuations in temperature. From tens of degrees below zero in winter, the temperature in the reservoirs heats up to tens of degrees above zero in summer. Organisms that live in such bodies of water are subject to significant changes in temperature. Salinity varies as a result of freezing: it rises when a reservoir freezes and falls when the ice and snow thaw. The content of biogenic salts depends on their location and influx from penguin colonies.

Molecular studies of Antarctica›s groups of lakes have just begun. Many organisms found there are endemic and may represent a potential source of enzymes and proteins able to prevent freezing. Especially abundant are groups of cyanobacteria and other bacteria as well as viruses. Their presence has been noted along with their possible role in the exchange of genetic information. Analogies between the presence of water and ice in the environment of Antarctica and conditions potentially found in space are described frequently, and studying the water in these subglacial lakes may prove useful in future space exploration.

Further reading:

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