

Tundra on Spitsbergen | Photo: Magdalena Opala-Owczarek



Clima

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IN SHRUBS



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Climate change is mobilising crowds of scientists to search for the causes of global warming, which is destroying our planet, and the methods to slow it down. The Arctic has become a testing ground for specialists from around the world, as this is where climate change is most pronounced and begins the earliest, and is being explored by teams of highly specialised glaciologists, geographers, geologists, biologists, chemists, meteorologists, oceanographers, seismologists, and ecologists. Although their presence might be understandably surprising, dendrochronologists have also joined the group of experts. What can areas so poor in species variety offer tree researchers? Magdalena Opała-Owczarek, PhD, DSc, Assoc. Prof. – climatologist, dendroclimatologist, and palaeogeographer from the Institute of Earth Sciences of the University of Silesia dispels all doubts.

Prof. Magdalena Opała-Owczarek has participated in numerous research expeditions and collected samples for dendroclimatological research in various parts of the world, including the Scandinavian Mountains, the Pamir Mountains, the Armenian Highlands, and northern Canada. Since 2020, she has been focusing on the Arctic: Iceland, Greenland, and Spitsbergen (National Science Center research project: 'Reconstruction of climatic conditions in the Arctic before the period of instrumental measurements on the basis of dendrochronological analysis of tundra dwarf shrubs and historical botanical collections').



Salix polaris (polar willow), Spitsbergen | Photo: Magdalena Opała-Owczarek

JOURNEY THROUGH TIME

What can be studied in the Arctic? The Northern Hemisphere at high latitudes is primarily covered by Arctic tundra, a treeless vegetation formation consisting mainly of low creeping shrubs, mosses, and lichens. However, it turns out that the Arctic is home to prostrate shrubs, small dwarf plants with woody stems that grow in extreme climatic conditions. Although they produce very narrow growth rings, they are an excellent material that can be used as an indicator of past climate change. But there is one problem – the oldest shrubs growing today are only slightly over 100 years old. In order to reconstruct climatic conditions, a dendroclimatologist needs research material covering many hundreds of years, as it is necessary to compare contemporary specimens with those from centuries ago. Archaeological wood is also difficult to find in the Arctic, as wooden artifacts are relatively rare. The work of Magdalena Opała-Owczarek's team was significantly hampered by restrictions imposed by the COVID-19 pandemic, especially those regarding field research. The geographer then decided to look into old botanical collections and began searching through museums. Her itinerary included

the Natural History Museum of Denmark, the Kew Herbarium at the Royal Botanic Gardens in London (United Kingdom), and the National Museum of Natural History in Washington, D.C. (United States). The finds vastly exceeded her expectations. The depths of museum storerooms contained some real treasures, e.g. the forgotten boxes in the Copenhagen Museum containing 150-year-old wooden discs, each with 400-500 growth rings. The researchers opened boxes that no one had ever looked into before.

'We came across fascinating materials and memorabilia collected mainly by participants of the first polar expeditions, conquerors of the North Pole, and seekers of the Northwest Passage', recalls the researcher. 'The precious collections were gathered by those searching for the British expedition of John Franklin, which went missing in 1845, and Robert Peary's expedition from 1908. It was an extraordinary discovery and invaluable research material – beautifully described and well-preserved plant specimens, fascinating herbarium cards with detailed descriptions of their locations'.

IN THE FOOTSTEPS OF VIKINGS

Thanks to the labels containing precise geographical coordinates, the researchers set course for the same places where the ancient junipers came from – Greenland. That was truly invaluable for the dendrochronologists, as it allowed them to compare samples of the same plant species collected over 100 years ago with those growing in the same location today.

'Precise analysis of the width of annual growth rings in contemporary and historical shrubs, combined with meteorological data allows us to determine past climatic conditions', explains Prof. Opała-Owczarek.

While on site, the researchers realised that they had reached the former habitats of Vikings. Their colonies lived there until the 15th century, when some of the inhabitants left the island and the rest, according to one hypothesis, were overcome by hunger and the cruel winter of 1460.

Today, dendrochronologists' knowledge goes back about five centuries. The geographer does not attempt to hide her excitement. 'We are not far off – only about 100 years – from discovering the real reasons for the Vikings' escape from Greenland'.



The oldest card from the polar collections in the Kew Herbarium at the Royal Botanic Gardens in London (1790) | Photo: Magdalena Opała-Owczarek

WHAT DO THE GROWTH RINGS REVEAL?

The rings of long-lived dwarf junipers are like a coded book; you can read a lot from them. The annual growth of wood during the tree's growing season reflects its living conditions. This unique archive contains information about the temperature in a given year, local disturbances, atmospheric circulation, and climate change. By analysing the anatomy of the wood, it is possible to infer what the climate was like at the time. Researchers focused on collecting plants, including polar willow and dwarf birch, and gathered samples from, among others: Bellsund (Spitsbergen), Abisko (Scandinavia) and Sermilik (Greenland). They also visited the Polish Polar Station Hornsund on the White Bear Bay in the southern part of Spitsbergen.

Depending on the specific climatic conditions of subsequent years, annual growth rings form sequences of varying thicknesses. When the conditions are favourable to the growth of a given species, the growth rings are wider, and in unfavourable conditions, they are narrower. This cannot be observed with the naked eye. A dwarf Arctic juniper with a diameter of no more than 5 cm (found in Iceland in May of this year) had approx. 800 rings... It is simply impossible to count them without detailed laboratory testing using a microtome and microscope.

The appearance of blue-coloured rings, whose cell walls are not fully lignified, indicates that they were formed during

a severe cooling period, which may be related to volcanic eruptions. Traces of many eruptions have been found in Arctic shrubs, both those closer (e.g., Laki in southern Iceland in 1783) and those from lower latitudes (including the eruptions of Mount Parker in 1641, Tambora in 1815, and Krakatoa in 1883). The eruption of Tambora caused 1816 to be referred to as the year without a summer. The Laki eruption was so powerful that a cloud of gas and dust reached Europe. This phenomenon contributed to a decrease in the average temperature in the Northern Hemisphere by 10C, and in Iceland itself by 50C – this is where the Laki eruption caused the most severe natural disaster.

Why does it happen? During an eruption, huge amounts of ash, dust, and gases (including sulfur dioxide) are released into the atmosphere, forming sulfur aerosols that inhibit or even reflect some of the Sun's radiation back into space. As a result, less light reaches the Earth, causing temperatures to drop. All this can be inferred from a microscope slide with a sample taken from an 800-year-old shrub.

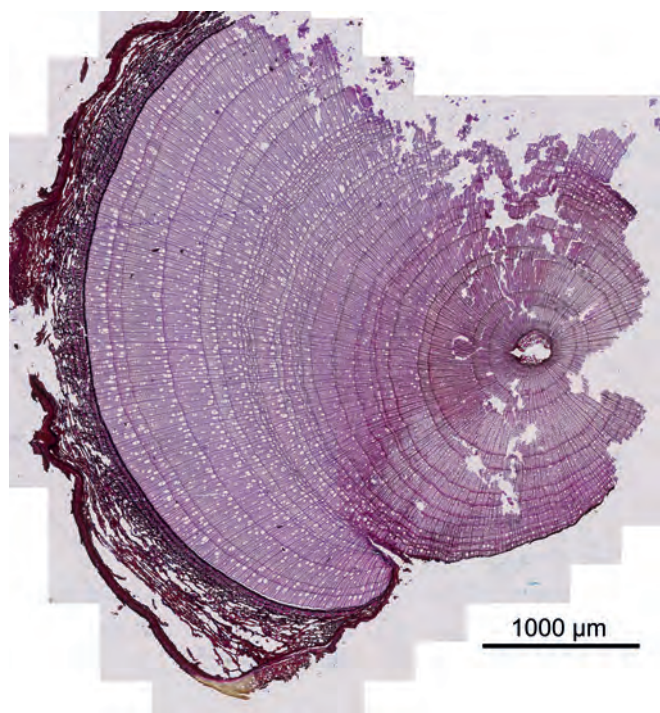
'The post-volcanic cooling was so severe that plants stopped growing normally and began to behave as if they had entered a state of dormancy, as evidenced by the blue growth and frost growth. The impact of volcanic eruptions on summer cooling allows us to assess the potential impact of future eruptions,' explains the geographer.

THE PAST IN SERVICE OF THE FUTURE

Although the role of dendrochronologists was previously marginalised, the Arctic has proved to be an excellent research area for them. They can reach places with no ice and plentiful vegetation, and their work brings new and sometimes sensational discoveries. This innovative approach, which has not been used in any dendrochronological research to date, allows for accurate and reliable reconstruction of climate change over the past few centuries. A thorough understanding of past climate variability in the Arctic is important for future climate projections.

Contemporary climate models leave no room for doubt – global warming is a fact and the pace of change is still accelerating. One of the challenges of modern climatology is to find a method to separate climate variability caused by natural factors from variability associated with the growing impact of human activity. This difficult task can only be accomplished if scientists have access to a sufficiently long record of climatic conditions. Thus, the findings of Silesian dendrochronologists perfectly fit into the search for solutions to this challenge.

Heated debates about whether the current state of the climate is the result of natural changes or the effect of our civilisation's development do not solve the problem. Researchers are, therefore, leaning towards reconciling both hypotheses – human activity, which accompanies natural changes, accelerates and intensifies the course of changes that do not bode well for the Earth.



Cross-section of a polar willow shoot taken from a historical herbarium | Photo: Magdalena Opała-Owczarek



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