Hair Ice on Rotten Wood

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By chance, I was able to observe a strange and little-known tuft of ice that forms on damp, rotting wood, and found an interesting association with a fungus.

The appearance of this ice differs so greatly from all known forms of frost, and it occurrs in such isolation that the observer does not at first think that it could be ice, but automatically assumes it to be a fungus. My observations about this are as follows:

As early as the winter of 1916-17 I found such tufts of ice about 4 cm long on a rotten piece of wood lying on the ground in a forest in the Vosges. My companions and I both thought it was a fungus, and we only realized our mistake when the ice melted in our hands. It was just after the snow had melted. Now and then you could still find a remnant of winter snow in the forest, and the forest was very wet. On the whole path, however, this was the only piece of wood on which the remarkable ice formation occurred, although of course the ground was covered everywhere with apparently quite similar pieces of wood.

Soon afterwards I had the opportunity in Hamburg to discuss with the elderly Dr. Flögel his observations on sleet and hail. He told me that he too had twice encountered this strange form of ice under the same conditions in the forest, and the first time he too had been under the same illusion that he was dealing with a fungus. He put the twig in the botanical drum to examine it at home and was very surprised when he opened the drum and the supposed fungus was gone. With the second find, he therefore left the ice in the forest and fetched his microscope, but could not find any trace of organic tissue in the tufts of ice. Unfortunately, his death prevented him from complying with my request for the publication of these observations.

On February 14, 1918, I made a new find of the same kind in the garden of my parents' property in Zechlinerhütte near Rheinsberg (Mark), and here it was possible to examine the strange phenomenon a little more closely. On this day, too, the melting of the snow was almost complete; only in a single spot, sheltered from the midday sun, was a remnant of the winter snow still lying. There was no frost anywhere. The whole rather large garden was dripping wet, especially since it had rained the whole day before. Since the evening of the previous day the temperature had dropped after the rain had stopped and on the day of the find it was a little below 0 degrees, so that a window thermometer showed +0.3° and icicles were forming on the gullies on the roof. The conditions were so similar to those observed earlier in the Vosges that, while walking in the garden, the sight of the remaining snow, the wetness and the rotten wood covering the ground everywhere reminded me of that find, and I began to look around. Then I did in fact discover the same conspicuous formation of ice on a small branch ½ m long lying loose on the ground. Again the whole appearance was such that the assumption seemed quite improbable that it was ice, and this impression was supported, as then, by the fact that the remarkable formation appeared only on this one branch, and in such magnificent abundance, while the countless other scraps of wood and twigs that covered the ground everywhere under the same conditions showed no trace of ice. Aside from what remained of winter snow, aged like firn, this was the only ice in the garden.

The branch was only 1 to 1½ cm thick. Four inches of bark was still attached to the wood at each end, and there was no ice here. On the middle section, 30-40 cm long, however, the bark had split open and lifted off, so that it was only attached to the end pieces on both sides. And here the hair ice grew in dense, irregular tufts about 1½ cm long with crest-like separations in between, mostly straight, sometimes increasingly curved in the upper part, even rolled in a spiral in some places. It appeared as if the bark had been cracked and lifted by the pressure of the growing ice, while on the other hand the clumps of ice seemed bent up by the pressure of the overlying bark. In each tuft the hairs were exactly parallel to each other. In addition, a kind of stratification was usually seen, which ran through the entire tuft parallel to the

original surface, in that all the hairs at the same distance from the wood became more or less transparent, which probably indicates growth stagnation. I stripped off some tufts of hair and placed them on white paper. In the heat, they melted into a light brown and apparently faint-smelling liquid with no discernible solids. I also tried to photograph the branch. Unfortunately, the photograph (Fig. 1) has become very out of focus due to an oversight in the distance setting, but it shows how the central part of the branch where the bark had split open was strongly overgrown by hair ice. I also drew a few sketches straight from nature, which were later elaborated somewhat more and are reproduced in Figs. 2 and 3. When I then brought the whole twig into the warm room, after the hair ice had melted, a fine white and slippery powdery mildew remained everywhere in its place, which could be wiped off with a finger. At first I thought it was a bottom layer of ice, however, as I said, it did not melt, but remained even after the wood had dried, and was now considerably more permanent, so that fingerprints could be recognized on it for a long time. When dry, this coating gave the impression of an extraordinarily fine mould-like fungus.

I took part of the branch with me to Sofia, and here on February 19th I again succeeded in producing hair ice on it. For this purpose, the twig was moistened by dipping it over its entire length and then placed with the lower end in a glass of water, which was exposed outside on the windowsill to a night temperature of -4°. After just a few hours, up to about 5 cm above the water line, i.e. as far as the wood kept moist by sucking up the water, the same tufts of ice formed, up to about ¾ cm in length. Since the contents of the water-glass also froze, they did not grow any further, but remained unchanged until the next morning, when two photographs were taken of them (Figs. 4 and 5).

The photos show the remains of the frozen contents of the glass at the lower end of the wood, above which is the zone with the beard-shaped hair ice, while the uppermost part has remained completely free. Although the appearance of this forced repetition was far from being so rich and handsome, the composition of parallel ice threads and all other characteristics could be recognized with extreme clarity. 5 also shows one of the crest-like separations. Incidentally, both images show that the otherwise dark (almost black) wooden surface is covered with numerous bright, round spots. However, these have nothing to do with the hair ice, because both the fine white fungus cover and the hair ice itself pass over these areas unaffected. The white fungus reference can be seen in Fig 4. In this figure one sees a line going across the wood at about the upper end of the hair ice; below this line the wood is darker, above it lighter. The limit is due to the fact that in a first, unsuccessful attempt, the wood was immersed in water up to this line, with the apparent result that the fungus cover was partially destroyed, while above it was better preserved.

On March 8th another attempt was made: the twig was again placed with its lower end in a glass of water and left for a few hours in the heated room. With the high magnification eyepiece of a theodolite, one could now see numerous tiny water droplets on the wood surface on the lower part of the branch up to about 10 cm above the water. However, I could not tell whether these droplets were sitting on the wood itself or on the fungus, nor could the structure of the fungus be distinguished with these tools.

On March 30th and 31st, when again negative night-time temperatures prevailed in Sofia, another attempt was made to produce the hair ice in order to determine the axis orientation of the same with a polarization microscope. Unfortunately this failed. Even the development of the hair ice was much weaker than in the earlier experiment, apparently because the fungus had suffered as a result of the repeated complete drying out of the wood, or also as a result of the experiments carried out. Only in the bottom half centimeter, just above the water level, did hair ice start to form. However, their microscopic examination failed because the ice melted during transport to the Mineralogical Institute. A repetition was not possible because of the warming that occurred.

At my request, Privy Councillor Arthur Meyer, director of the botanical garden and the botanical institute of the University of Marburg, kindly agreed to examine the piece of wood and the fungus. His response after investigation was:

“I examined the piece of wood. It was overgrown with fungal hyphae and already very brittle and drained. I placed the pieces in a glass cylinder with some water on the bottom and moistened them slightly. After a

few days, the bark-free areas of the wood were covered with a very delicate, whitish film. It consisted essentially of a tangle of scarcely 2 microns thick hyphae. They were richly branched and from time to time sent out small terminal branches obliquely or vertically. The irregular hyphae ends were probably the starting point of the ice threads, if the morphological conditions that have arisen now are the same as those that existed at the time the ice formed. The mycelium probably belongs to a small ascomycete. Of course you can't determine it; and don't expect it to produce any fructifications by which to recognize it."

During a later oral conversation, Privy Councillor Meyer informed me that he too was of the opinion that the fungus had caused the hair ice. However, he considered it possible that the latter had arisen from the air by sublimation, i.e. represented frost, and that the fungus only created particularly favourable conditions for this frost formation through increased radiation, while in my opinion the water came from the wood and through mediation of the fungus is brought to the exit.

From the literature I know of only one description of this strange hair ice. It was written by J.F.W. Herschel. He also reports two observations. In the first, hair ice formed around the roots and stems of dried thistles. These stalks were found "to incrust the stalks in a singular manner in voluminous friable masses, which looked as if they had been squeezed, while soft, through cracks in the stems ". It was in the early days of a severe frost, and though there was little frost in the neighbourhood, Herschel remarks: " This peculiarity of situation, and the comparative absence of hoar-frost elsewhere, induced me at the time to attribute it either to some different cause from hoar-frost, or to some singular modification of that atmospheric deposition by local and temporary circumstances."

The second observation is illustrated by figures which immediately show identity with the hair ice observed by me. This time the ice grew out of the stalks of sunflowers. He describes it as a “ribbon or frilly wavy mass which appeared to have swollen from longitudinal fissures in the stalk when soft. The ribbons had a lustrous, silky surface and a fibrous texture resembling that of certain types of plaster. The fibres were perpendicular to the stem or horizontal".

"Although, as mentioned, the ice frills seemed to have swollen from the stalk, on examination they were found to have sharp ends on the surface of the same, and adhered so weakly that one could not touch any of these stalks without them falling off. They were also never connected to an inner mass of ice; on the contrary, most stems were healthy and solid, and many were still green when cut. The point of attachment of the ice, however, was always on the surface of the wood, beneath the outer bark or epidermis, which was always stripped and bowed outwards by the ice flakes. Where the ice frills were large and well formed, the bark had fallen off altogether; but where this was more firmly seated, it seemed to have prevented the extension of the former. In such cases the stalk had the curious appearance of a thick, massive layer of ice sandwiched between the wood and the swollen, ruptured covering." The weather had been mild the day before, but during the night there had been a severe chill and a mild frost formation. Nevertheless, Herschel says here too: "The phenomena just described are in complete contradiction with the idea of deposition of these ice frills from the water vapour of the atmosphere, in the manner of ripening. Only in the plant itself or in the relatively warm earth under it, may their exhalations have perhaps formed a kind of chimney, we can seek the same mechanism."

My own observations, described above, may go a step further in clarifying the formation of this ice, as they indicate that a fungus is a key contributor.

Crystallographically, hair ice seems to belong to the growth forms known as "trichites". Zirkel, who first used this word in 1867, used it for hair-shaped crystals. O. Lehmann also includes lamellar and striped growth forms, but considers bends and twists to be the main characteristics of trichites According to the cases mentioned by him, the origin seems to be different and is mostly not completely explained. As with skeleton formation, formation of trichites is also a general property of crystallizing substances. To my knowledge, it was not known in the case of ice.

Translation Notes

John Keery, Dalbeattie, Dumfries and Galloway, April 2023

Alfred Wegener's paper on hair ice was published in 1918, in a German scientific journal shortly before the end of the First World War. This wasn't the most propitious timing for a German citizen with military as well as scientific experience to publish an article which might be fascinating, but which offered few insights into matters which might help to rebuild a war-weary continent.

This may partly explain why his work on hair ice failed to reach an English speaking readership at the time of publication, but with growing awareness of his work in recent years, it's surprising that an English translation of this paper hasn't been made widely available.

I was taught German at school in England in the 1970s, and if I remember correctly, I got a good grade at 'O' Level, but with more of an interest in science subjects, I didn't study German any further. The translation presented here was compiled partly with what I could dimly remember of the language, assisted with my copy of the Collins Pocket German Dictionary, but also relying heavily on the frequently maligned Google Translate. I hadn't looked at this online translation utility for several years, and I recall that its suggestions were then the source of much humour, so I was rather surprised at how impressive it has become. Wegener's paper describes a phenomenon that I have frequently observed myself, and since context is often key to understanding of a foreign language, I had a slight head start in my attempt to create a readable but accurate translation. I knew, for example, how to correct Google Translate's frequent referrals to 'hairy ice-cream', but I was baffled by its literal translation to provide the phrase 'botanical drum', until I found that this term was in fact commonly used to describe an item used by botanists, until the invention of plastic made metal drum-shaped containers obsolete. It was also sometimes called a botanist's 'vasculum' and examples in good condition will attract interest on online auction sites.

I've attempted to keep the translation of Wegener's words as literal as is practical, while recognising that the different word orders in German and English sentences often need a degree of flexibility in translation. Where Wegener has directly quoted from publications in English, but in German translation, I have quoted from the English originals where I have been able to access them. I haven't included the illustrations in this translation, as they are available in the original paper.

Any howlers in this translation are mine alone.