Three new extinct walnut species discovered in high Arctic mummified forest

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The fossil site is nestled in the Princess Margaret Mountains of Axel Heiberg Island. Credit: James Basinger

In a new study, scientists describe three new, but long-extinct, walnut species on an island above the Arctic Circle. The fossils were discovered

further north than any known walnut species, living or extinct, and represent some of the oldest-known records of this group. The work is published in the *International Journal of Plant Sciences*.

Today, the Canadian island of Axel Heiberg is a frozen desert devoid of nearly all life. But 45 million years ago, it supported a lush rainforest on the shores of the Arctic Ocean. Since then, the forest has been buried first beneath layers of sediment, then accumulated ice, leaving it frozen in time.

"When you walk into the site, the first thing you notice are these big stumps, a meter or more in diameter, and they're still rooted in the soil that they grew in. It's completely out of place. The closest living trees are 3,000 kilometers away," said study co-author James Basinger, professor emeritus of geological sciences at the University of Saskatchewan.

The stumps are so conspicuous, they can be spotted from the air. In 1985, staff from the Geological Survey of Canada discovered the Axel Heiberg fossil forest while conducting a survey of the area from a helicopter. A year later, paleobotanists returned to the site and found fossils unlike anything they'd seen before.

"There aren't really that many places around where you can go to see fossils that are preserved that well," said Steven Manchester, lead author of the study and curator of paleobotany at the Florida Museum of Natural History.

In most cases, fossilization is characterized by organic matter being replaced with minerals over time. In other cases, organic matter is heated and compressed into coal or burned in forest fires and preserved as charcoal. But this isn't the case with the Axel Heiberg fossils. The wood, leaves, cones, nuts and fruit are seemingly unchanged. This unique form of preservation is referred to as mummification, and it only takes place

under a very specific and rare set of circumstances.

"Things can be broken down by bacteria and fungi, they can be rumbled along in a riverbed and destroyed; there are lots of ways of losing the material before it becomes fossilized," Basinger said. But the ancient forests on Axel Heiberg were buried rapidly under swamp and lake sediments. As the global climate cooled, these processes were slowed.

Basinger was among the first researchers to study the forest. The Arctic's barren surfaces and strong winds made it remarkably easy to collect specimens. "You can see a few fossils on the surface and pick what you can. But you go back next year, when there's been a little erosion, and there's a few more on the surface. Over a number of years, you can actually get a large collection," he said.

The walnuts had been eroded from the soil and were sitting on the surface. "In one case, the walnuts are concentrated at one spot, possibly cached there by animals," Basinger said. Some of the fossil nuts also have gnawed holes, indicating they were a food source for local animals.

Over a period of fifteen years, Basinger and his colleagues retrieved over a thousand nut and seed fossils and returned with them to Saskatchewan to be studied.

Three new species of walnuts have been found above the Arctic Circle, remnants of a time when the North and South Poles were covered in forests. Credit: Florida Museum, Jeff Gage

Visualizing a globally warm planet

If you looked back 45 million years ago to the middle Eocene, the Earth's poles would be unrecognizable. At the time, Antarctica and the Arctic Circle were warm and blanketed with forests, in stark contrast to the freezing deserts that we associate with the region today.

Due to their high latitude, polar regions had relatively short growing seasons, but they made up for it with exceptionally long summer days, receiving up to twenty hours of sunlight. Inversely, the winters were characterized by near-total darkness, yet temperatures seldom reached

freezing.

Paleontology and geology records indicate there was more CO_2 in Earth's atmosphere at the time, which resulted in temperatures that were much higher than they are now. This global greenhouse, in turn, created warm ocean circulations that kept the Arctic Ocean free of ice.

"The far north supported redwood-style forests," Basinger said. There were cypress swamps and upland forests, where statuesque trees grew up to 40 meters in height. The canopy included dozens of trees, such as redwoods, cedars, hickories, pines, spruces, hemlocks, larches, birches, ginkgos and, of course, walnuts.

What we can learn from the Axel Heiberg walnuts

As an expert in the evolutionary history of the walnut family, Manchester helped bring the decades-long project to completion. He performed CT scans on walnuts from the island and described three previously unknown species.

"The CT scans allow us to show details of the internal structure of these nuts that were once really hard to get," Manchester said. Before CT scanners, traditional methods for studying fossils involved tediously dissecting and slicing the specimens in various orientations, destroying them in the process.

After scanning several of the most completely preserved fossils, Manchester compared them to walnuts from both modern and extinct walnut species. National repositories, like iDigBio, allow researchers to easily locate museum specimens stored anywhere in the United States. The fossils didn't match anything that had yet been discovered and were thus found to represent three new species in the genus Juglans.

Based solely on genetic data from living species, researchers once thought the walnut family originated somewhere in Asia. More recently, however, fossil data indicates they instead first appeared in the warm, moist environments of North America or Europe. As the family diversified, some species adapted to cooler conditions, which allowed them to extend their range into higher latitudes.

The fossils from this study add a clearer picture of how walnuts evolved during periods of intensely shifting climates and where our modern species came from.

More information: Steven R. Manchester et al, Arctic walnuts! Nuts of Juglans (Juglandaceae) from the middle Eocene of Axel Heiberg Island, Northern Canada, *International Journal of Plant Sciences* (2024). DOI: 10.1086/730541

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