

Fossilised forests

Did the earliest mountain forests chill global climate?
Howard Falcon-Lang investigates.



When plants invaded the land over 450 million years ago, the face of the Earth changed forever. Plants radically overhauled many of the basic ways our planet works, including the ways water and carbon are used and recycled. The first plants were descendants of marine algae, and so would have lived in low-lying coastal marshes. But when did lush vegetation

spread to the mountaintops? And what effects did these first mountain forests have on the world? These are some of the exciting questions I've been wrestling with during my NERC post-doctoral fellowship at the University of Bristol.

When mountain forests appeared, it was a hugely-important stage in greening the Earth. But it's very hard for palaeontologists to figure out exactly

when this happened. The usual approach to understanding plant evolution is to study fossil remains laid down in sedimentary rocks. Unfortunately, over long periods, mountains erode. There simply aren't any sedimentary rocks from upland sites dating from the period when we think mountain forests first formed—the Carboniferous 'Coal Age', more than 300 million years ago.

Want to know more?

Howard wrote about this research in September's *Geology Today*, the magazine of the Geological Society and Geologists' Association. His article is also available at www.blackwell-synergy.com/doi/abs/10.1111/j.1365-2451.2005.00526.x, but if you are not a *Geology Today* subscriber there is a charge.



In Atlantic Canada, I've examined Carboniferous rocks, searching for clues to the first mountain forests. At this time, the region was on the edge of a colossal Himalayan-scale mountain belt. Although these ancient mountains have now eroded away virtually to their crystalline roots, there are still deposits of alluvial fans and river plains along their margins. These gigantic cones of sediment, many tens of kilometres across, are composed of boulders, sand and mud, washed down from the craggy peaks.

During my summer field season in 2003, I hooked up with a local geologist called Arden Bashforth. Together, we spent our time driving along near impassable 'roads' in south-west Newfoundland, and then wading up ice-cold, mosquito-infested streams. One day, rounding a bend in a river near Stephenville, we made one of the most exciting discoveries of our lives: hundreds of giant Carboniferous trees! (Ironically, we later realised that the fossils had first been discovered by the Geological Survey of Canada way back in the 1870s, but these observations had been lost in dusty old survey reports.)

The fossil trees were beautifully preserved, with both rooting systems and branches intact. Many pieces of wood even retained their original cell structure. Based on these features, we were able to identify the trees as cordaites, the extinct cousins of present-day conifers. Much more importantly, they were in the pebbly deposits of a fast-flowing Carboniferous river system near an upland area. Had floods washed them down from nearby mountain ranges? Trees of this type are very rare in Carboniferous rocks and are very different to the giant club mosses that are commonly found in lowland

deposits. Here was indirect evidence of early mountain forests.

Another breakthrough came in 2004, whilst working in the Bay of Fundy in southern New Brunswick. Here, towering sea-cliffs, hewn by the world's highest tides, are a spectacular geological laboratory, particularly rich in plant fossils. Near McCoy Head there are sediments that formed within the foothills of the Carboniferous mountains, and these represent some of the highest-altitude deposits to survive erosion. At one level in the cliffs, I came across more cordaite

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fossil trees. This time they were still rooted in the original soil where they had grown some 315 million years earlier. I almost never returned to tell this tale because, trekking through dense forests on my way back to the car, I ran into a black bear.

Now that I've studied lots of similar fossil sites like these across North America and Europe, a clear pattern is emerging. I've found cordaite tree remains again and again within sediments around the edge of the eroded remnants of Carboniferous mountains. Although direct evidence of the first mountain forests has been destroyed long ago, these remains imply that widespread forests of conifer-like trees covered upland terrains towards the end of the Carboniferous period. So what are the wider implications of these fossil discoveries?

Intriguingly, the Carboniferous was a

period of enormous change for the world. Initially, the Earth's climate was very hot, with warm limey seas, like those of the present-day Bahamas, stretching over much of the globe. But gradually the planet started to slide into a deep freeze. Massive icecaps grew at high latitudes, and sea level fell significantly. There's a lot of debate about why this happened, and little consensus. Could there be some connection between the first mountain forests and the onset of the big chill, I wondered?

We know that plants speed up the way bedrock weathers. They do this by physically breaking up rocks with their roots, and making soils more acidic. The chemical reactions that break down silicate minerals in rocks need carbon dioxide. So as bedrock weathers, carbon dioxide is taken out of the atmosphere. Carbon dioxide is a powerful greenhouse gas, which helps to keep the Earth warm. Although evidence is circumstantial, it seems possible that the spread of mountain forests during Carboniferous times, and the increase in rock weathering around the world because of it, led to severe global cooling by using up atmospheric carbon dioxide.

We really don't know whether the first mountain forests gave the Earth a nasty chill, but it's a useful hypothesis we should test further. What is certain is the great longevity of our planet's terrestrial ecosystems: mountain forests are as old as the hills.

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