

## Volcanology

# Events in Iceland explain years of famine in Europe's Dark Ages

*A song of ice and fire*



Ragnar Th Sigurdsson/Arctic-Images.com

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IT SEEMED like a curse. The summer of 821 was wet, cold and yielded a poor harvest. Then winter came. Temperatures plunged. Blizzards smothered towns and villages. The Danube, the Rhine and the Seine—rivers that never froze—froze so hard that the ice covering them could be crossed not just on foot but by horse and cart. Nor did spring bring respite. Terrible hailstorms followed the snow. Plague and famine followed the storms. The next few winters were worse. Fear stalked the land. Paschasius Radbertus, a monk of Corbie, in what is now northern France, wrote that God Himself was angry. Yet it was not God that wrought this destruction,

according to Ulf Büntgen of the University of Cambridge, but rather a volcano now called Katla, on what was then an unknown island, now called Iceland.

At the moment Katla, one of Iceland's largest volcanoes, located near the island's southern tip, sleeps beneath 700 metres of ice. It has so slept, albeit fitfully, for almost 100 years. Its last eruption big enough to break through the ice was in 1918. A score of such ice-breaking awakenings have been recorded by Icelanders since the first Norsemen settled there in 870. In 821, however, Iceland was not on the Norsemen's horizon. They were concentrating their activities on the lootable monasteries and villages of coastal Europe. There is thus no man-made record of what Katla was up to then. But Dr Büntgen thinks he has found a natural one. A memorandum of an eruption that coincides with the events described by Radbertus is, he believes, written in a prehistoric forest.

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Large volcanic eruptions can affect the weather. In particular they eject sulphur dioxide, which reacts with atmospheric gases to form sulphate aerosols that reflect sunlight back into space, cooling the air beneath. That is well known. So the suspicion that what happened in the early 820s was precipitated by such an eruption has been around for a long time.

This suspicion is backed up, moreover, by ice cores collected in Greenland. These show a spike in sulphate levels in layers laid down during those years. But the cores give no hint of the volcano's whereabouts, because sulphates from an eruption mix rapidly into the atmosphere and are soon spread evenly around Earth.

Things changed, though, in 2003, when flooding exposed the forest which has piqued Dr Büntgen's interest. Preliminary research suggested that the trees in it were alive during the 9th century. This led him to assemble a team of physicists, chemists, biologists, historians and geographers to investigate the matter, starting with an analysis of the buried trees' annual growth rings.

In particular, the team searched for signs of an ill-understood atomic marker found in tree rings of a certain age from all around the world. Rings that grew in 775, palaeobotanists have found, contain 20 times the normal amount of carbon's most common radioactive isotope,  $^{14}\text{C}$ . That year is also the date of an enigmatic event recorded in the Anglo-Saxon Chronicle, a collection of annals describing the history of early England. This is the appearance of a "red crucifix" in the heavens after sunset. The best modern guess is that the Chronicle's writers were looking at an unusually powerful manifestation of the northern lights, and that the high  $^{14}\text{C}$  levels are a consequence of this isotope being generated abundantly in the atmosphere by elevated levels of solar radiation, which also stimulated the auroras.

Dr Büntgen and his colleagues searched the trees for this  $^{14}\text{C}$  spike—and they found it. As they report in *Geology*, the spike appears in rings that grew 47 years before the burial of the forest. That dates the cataclysm which caused the burial to 822.

The cataclysm itself appears, from the direction the knocked-over trees are pointing in, to have been a flood resulting from the melting and sudden rupturing of Myrdalsjökull, the glacier that overlies Katla. This glacier is 35km from the forest, so the flood in question must have been enormous. The forest's fate, combined with the ice-core data from Greenland, suggests Katla was either erupting in 822, or had done so recently, and thus weakened the glacier. Any eruption of sufficient power to provoke such a flood would also have been big enough to precipitate a temporary change in the world's climate of the sort that Radbertus reports.

Those of Norse descent who lived through the events of the 820s, would not, of course, have feared the anger of a god they did not believe in. But they might have feared they were witnessing Fimbulwinter—three summerless years marking the onset of Ragnarok, the twilight of their own gods. Katla, however, ceased erupting and both Ragnarok and the Day of Judgment were avoided. As for Radbertus, a quarter of a millennium later, in 1073, he was canonised by Pope Gregory VII.

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