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Coal has provided us with some stunning fossils. Bart Bernardes/Flickr, CC BY-NC-ND

Coal's formation is a window on an ancient world

June 8, 2016 6.23am AEST

As the world moves to combat climate change, it's increasingly doubtful that coal will continue to be a viable energy source, because of its high greenhouse gas emissions. But coal played a vital role in the Industrial Revolution and continues to fuel some of the world's largest economies. This series looks at coal's past, present and uncertain future, starting today with how it's formed.

Author

John Long

John Long is a Friend of The Conversation.

Strategic Professor in Palaeontology, Flinders University

Love it or hate it, coal played a crucial role in launching us into the modern world by fuelling the Industrial Revolution. The byproducts of that role were, of course, the rise of greenhouse gases in our atmosphere and dangerous levels of air pollution in the big coal-fuelled cities.

But despite its insidious influence on the climate and our health, coal has a lesser-known positive side to its otherwise dark soul. It has provided us with some stunning fossils.

Geologists have known for centuries that coal is an accumulation of plant material that, once buried in the Earth's sedimentary layers, gets compressed by gravity into a denser, compact form. Yet, in recent years, scientists have hotly debated the early phases of coal formation.

The discussion hinges on whether coal formed due to the absence of certain organisms that actively break down the woody tissues of dead trees, or whether other non-biological factors were the reason.

Contested origins

Coal starts its cycle of formation with the accumulation of plant material in swamps or bogs. Decaying plant matter that builds up at the bottom of bogs or swamps is called peat. After other sedimentary layers bury the peat deposit, the weight of these sediments builds up and compacts it.

Other chemical and physical processes also alter the peat, including pressures exerted by tectonic forces as continents move and crash into one another. These processes eventually turn the layers of compacted peat into rock we can mine.

Pure black coal, richer in organic carbon and tempered by heat and pressure, is called anthracite. Brown coal, or lignite, is mostly just compressed peat and has more sediment mixed in with plant matter.

Coal has formed as very large deposits at certain times in Earth's prehistory. So much so that Reverend William Conybeare, the esteemed British geologist of the early 19th century, first named the Carboniferous or "carbon-bearing" period (359 million to 299 million years ago) after the distinctive coal deposits of Britain in his book of 1822.

These great coal swamps formed in what were the Earth's first great forests. They were home to many varieties of giant amphibians and early reptiles and huge insects, as global oxygen levels were very high at this time.

Scientific treasures from coal: the Iguanodon dinosaur display in Brussels Museum of Natural Sciences. Brussels Museum of Natural Sciences website

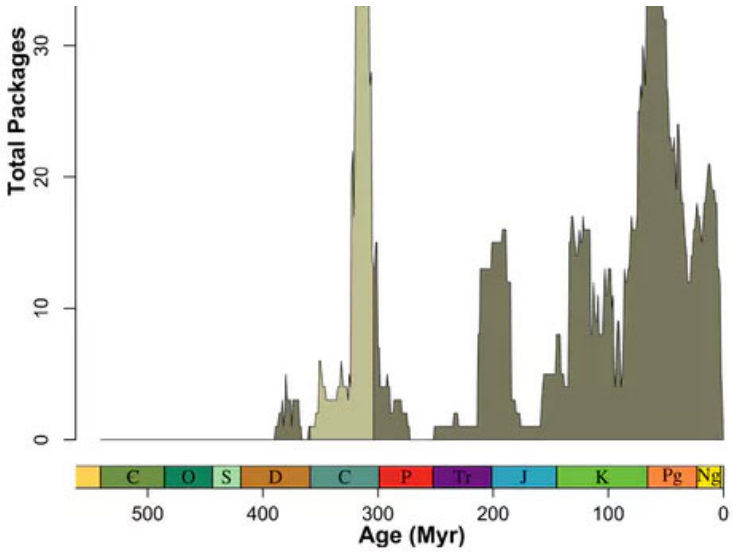
For many years, scientists believed that coal formed in such large deposits at these times because certain fungi that helped break down the lignin, or woody tissues, had not yet evolved. The molecular clock estimates for the appearance of these fungi, called Agariomycetes, suggest they should appear in the Permian period (299 million to 252 million years ago), after the formation of the vast Carboniferous coal deposits.

A new theory

But this doesn't account for the huge amounts of coal that formed in much later geological periods, such as the Cenozoic, over the past 65 million years. And a new study, led by Matthew Nelsen of Stanford University, takes issue with this model, as well as presenting a new hypothesis for coal formation.

The study authors argue that coal formed in the Carboniferous period consists dominantly of plants such as horsetails, or Lycophytes. These trees grew to enormous sizes and their periderm, or outer cuticles of the trunk, lack lignin, so wouldn't be affected by the absence of lignin-degrading fungi. Their argument points to the biochemical composition of the plants having little to do with how coal accumulates.

The distribution of coal deposits through time is seen in the chart below of the estimated total volume of coal in North America. Large deposits of coal also accumulated during the age of dinosaurs (Mesozoic Era, from 252 million to 66 million years ago) and during the first half of the Cenozoic period (between 66 million and 30 million years ago), well after the predicted first appearance of lignin-degrading fungi.



Terrestrial coal accumulation in North America, through time. Note the large peaks during the Carboniferous 'C' and early Cenozoic 'Pg'. Taken from the paper by Nelsen et al. (2016). Prof. Kevin Boyce, with permission.

The paper argues that tectonic factors are the most likely reason such big coal deposits built up at certain times. Large basins fill up with thick sedimentary piles when continents collide and mountain-building occurs. Some really excellent fossils have been found in such coal deposits, although the acidity of coal often dissolves bones.

The best-preserved fossils are those caught in the cleaner sediments laid down by streams between coal seams. Such fossils are routinely uncovered as part of coal mining. Several of the large fossil amphibians that lived in the Carboniferous swamps have been found this way.

A famous site at Nyrany in the Czech Republic was discovered because the director of the natural history museum there had coal delivered to heat his room. Splitting the coal sometimes yielded well-preserved fossils of early amphibians, so he could add scientifically significant specimens to his collections without leaving his office.

Perhaps the most famous fossils found in a coal mine were uncovered at Bernissart in Belgium. Many skeletons, representing 33 individuals of the large plant-eating dinosaur Iguanodon, were found there in 1878. These skeletons were among the first complete dinosaurs ever found.

Although coal is much maligned because of its byproducts from combustion, the factors responsible for coal accumulation also give us fossil treasures from the past. To stop coal mining would undoubtedly mean many good fossils remain in the ground. But the long-term health of our planet is a bigger priority.

This is the first article in our series on the past, present and future of coal. Look out for others in the coming days.

John will be online for an Author Q&A between 2:30 and 3:30pm AEST today (Wednesday 8 June, 2016). Post any questions you have in the comments below.

Fossils **Coal** **brown coal** **Author Q&A** **Past, present and future of coal** **Peat** **Carboniferous** **Permian period**