Perspectives and controversies

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What is the relevance of pyrogeography to the Anthropocene?

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Abstract

A defining feature of both the Anthropocene concept and the new discipline of pyrogeography is combustion of carbon-rich fuels by humans. A key objective of pyrogeography is understanding to what degree landscape fires set by hominins has overwritten natural fires through geological time, and whether these changes had substantial ecological knock-on effects. This research is essential to precisely define the onset of the Anthropocene. Nonetheless, the commonly used imprecise definition that the Anthropocene commenced at 1780 is a useful organising principle for pyrogeography because it provides a framework to understand the synergistic effects of anthropogenic global environment changes in shaping global fire activity following the Industrial Revolution.

Keywords

Earth System, environmental impacts, fire, geological time, hominins, humans, landscape burning, wildfire

Introduction

Increasingly, scholars from the humanities, social and physical sciences and members of the broader community are using the term 'Anthropocene' to encapsulate concerns about the enormous scale, biogeochemical scope and unprecedented rate of anthropogenic environmental change. Despite its rapid uptake there is little agreement about its definitional bounds. For instance, the two new journals devoted to Anthropocene research (*Anthropocene* and *The Anthropocene Review*) do not promote the term as heralding a new geological epoch that has superseded the Holocene; rather they accept the Anthropocene as a broad metaphor to motivate holistic understandings of human impacts on the Earth System (Chin et al., 2013; Oldfield et al., 2014). The combustion of carbon-rich fuels by humans is a defining feature of the Anthropocene, thereby linking this concept to

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'pyrogeography' that strives to develop a holistic way of understanding variation of landscape fire activity in space and time (Bowman et al., 2013). This linkage raises the question of how these fields are interrelated.

The temporal framework of pyrogeography and the Anthropocene

The start date for pyrogeography is the Silurian, a geological period when plant life established on Earth's surface; the combination of carbon-rich fuels, oxygen and ignitions from lightning and volcanic activity resulted in landscape fires that have left charcoal traces in geological sediments (Scott, 2000). Variation in fire activity through geological time appears to have closely tracked variation in atmospheric oxygen – free burning needs atmospheres with at least 13% oxygen and damp vegetation burns when O_2 levels exceed 30% (Bowman et al., 2009). Fire activity is believed to have been a powerful selective force in the evolution of plants, contributing to the spread of flowering plants in the Cretaceous and the establishment of tropical savannas in the mid Cainozoic (Beerling and Osborne, 2006; Bond and Scott, 2010; Keeley and Rundel, 2005).

By contrast, the start date for the Anthropocene is disputed. The original conception places the Anthropocene as commencing at the start of the Industrial Revolution around 1780 that led to the rise in atmospheric CO_2 (Crutzen, 2002). Nonetheless, some scholars suggest that earlier anthropogenic impacts on the Earth System, such as forest clearance and the release of methane from rice fields in the mid Holocene (Ruddiman, 2005, 2007), should be factored into the Anthropocene concept. For example, Glikson (2013) has proposed a three-staged model: early Anthropocene when hominins commenced using fire from at least >1.8 million years; mid Anthropocene since the commencement of Neolithic agriculture c. 5000 years ago; and late Anthropocene following the commencement of the Industrial Revolution. Other workers advocated a deliberately imprecise period 'Palaeoanthropocene' to capture hominin (human and our ancestral species) impacts on the Earth System (Foley et al., 2013).

Pushing back the start of the Anthropocene beyond the Industrial Revolution is problematic because of the obvious conflict with existing formally defined geological units such as the Holocene and the Quaternary. More importantly, unlike the start of the Industrial Revolution, which can be defined by historical records and which leaves a clear signal in the CO_2 record, the onset of earlier anthropogenic impacts are much more difficult to delimit (Foley et al., 2013). For instance, there is no clear-cut point in the geological record identifying when hominin species first started using fire for hunting or learned to make fire (Bowman et al., 2011). This uncertainty arises because hominins evolved in naturally flammable savannas so they would have had to first learn how to 'capture' naturally ignited fires, well before developing the capacity to make fire. Such early hominin fire usage does not leave an unambiguous palaeo-ecological signature that can be discriminated from background natural fires. It is true that the occurrence of hearths and burnt bones in the very earliest archaeological records is clear evidence of the 'domestication' of fire but these records do not prove that the hominins who tendered these fires had ignition technologies or the ability to manipulate fire regimes by altering the season, severity, spatial size and patterns of landscape burning.

Whether the spread of fire-weilding humans out of Africa changed the natural fire regimes of colonised lands and caused ecological effects is hotly debated. Some workers claim catastrophic biological and climatic effects of anthropogenic landscape burning while other researchers suggest the effect on natural fire regimes was negligible, or fire regime changes were a knock-on effect following human-induced megafauna extinctions (Bowman et al., 2013). Regardless of the scale of environmental effects, the anthropogenic changes to fire regimes were time transgressive, ranging from the colonisation of Australia around 40 kya (Rule et al., 2012), North America around 12 kya (Gill et al., 2009) and New Zealand 1 kya (McWethy et al., 2010) thereby confounding any simple start date to the 'Paleaoanthropocene' (Foley et al., 2013).

Explanatory frameworks to understand changing human fire use

An important pyrogeographic framework for how landscape fire has changed through Earth history is the 'pyric phase' model (Bowman et al., 2011), that was adapted from the earlier 'pyric transition' narrative of Pyne (2001). The pyric phase model proposed four key phases of fire activity on Earth: (a) natural fire regimes that preceded hominin evolution; (b) hunter-gather fire regimes; (c) agricultural fire regimes; and (d) industrial fire regimes. This later phase broadly aligns to the Anthropocene, defined as post-1780 (Crutzen, 2002). The 'pyric phase' model has been misconstrued as advocating a simplistic, universal model of progressive human cultural 'development' (Coughlan and Petty, 2013), when in reality the model was designed to organise the diversity of fire regimes that have existed on Earth, with explicit acknowledgment of the co-existence and diversity of these phases in the contemporary period (Roos et al., 2014). Likewise, the Anthropocene concept has been critiqued on grounds that current anthropogenic impacts on the Earth System are not caused by all humans in the past or present, rather that these impacts are disproportionate both within and between cultures and societies owing to differing economic, political and historical circumstances of individual actors (Malm and Hornborg, 2014). Such critiques of historical models of changes in human fire use are inevitable consequences of transdisciplinary attempts to span the 'two cultures' of the humanities/social sciences and the physical sciences (Turner, 2002).

Conclusion

The Anthropocene concept provides an intellectual arena for debate about contemporary human impacts on the Earth System, while pyrogeography enables an holistic understanding of the interplay between natural and human biomass combustion. These fields of inquiry share common roots – the use of fire by humans and our ancestral species. A core objective of the field of pyrogeography is developing a better chronology of human fire use, and partitioning out the effect of anthropogenic burning from background fire activity (Bowman et al., 2011). Pyrogeographic research is critical to framing the Anthropocene and Palaeoanthropocene concepts. Nonetheless, the imprecise and commonly applied definition that the Anthropocene started with the Industrial Revolution at 1780 it is a useful organising principle for pyrogeography because it allows an holistic consideration of global change on fire regimes, and knock-on effects to the Earth System (Bowman et al., 2013). Key anthropogenic drivers of fire regime change since the Industrial Revolution include synergistic effects of anthropogenic climate change, human population growth, fire suppression, land cover change due to forestry, land clearance for agricultural, overgrazing and invasive plants and urbanisation (Bowman et al., 2011; Marlon et al., 2008). Debates and contrasting perspectives from the humanities/social sciences and the physical sciences are inevitable consequences of attempting to include humans as agents of change in the Earth System.

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