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The Anthropocene and Geography I: The back story

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The Anthropocene and Geography I: The back story

Abstract

This and two companion papers (Geography and the Anthropocene II: Current Contributions and The Anthropocene and Geography III: Future Directions) consider the relevance of 'the Anthropocene' to present and future research in Geography. Along with the concept of 'planetary boundaries', the idea that humanity has entered a new geological epoch of its own making is currently attracting considerable attention - both within and beyond the world of Earth surface science from whence both notions originate. This paper summarises the origins and evolution of the scientific discourse since the Anthropocene idea was first proposed in 2000. It ends by outlining the potential relevance of the Anthropocene and planetary boundaries ideas to Geography - potential because both concepts have only recently received serious attention in the discipline. The next paper, following on from this, then reviews these early geographical interpretations of the two scientific buzzwords. The subsequent paper looks ahead to future options should these terms really begin to catch-on outside Geography. If they become societal keywords, then geographers should be participants in, rather than mere observers of, the unfolding discussion. As we will discover, some geographers are well-placed to shape future discourse and practice, but there is considerable potential for many others to join the fray.

Keywords

anthropocene, back, i, geography, story

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Abstract This and two companion papers (Xxxxxxx, 2014a, 2014b) consider the relevance of ‘the Anthropocene’ to present and future research in Geography. Along with the concept of ‘planetary boundaries’, the idea that humanity has entered a new geological epoch of its own making is currently attracting considerable attention – both within and beyond the world of Earth surface science from whence both notions originate. This paper summarises the origins and evolution of the scientific discourse since the Anthropocene idea was first proposed in 2000. It ends by outlining the potential relevance of the Anthropocene and planetary boundaries ideas to Geography – *potential* because both concepts have only recently received serious attention in the discipline. The next paper, following on from this, then reviews these early geographical interpretations of the two scientific buzzwords. The subsequent paper looks ahead to future options should these terms really begin to catch-on outside Geography. If they become societal keywords then Geographers should be participants in, rather than mere observers of, the unfolding discussion. As we will discover, some geographers are well-placed to shape future discourse and practice, but there is considerable potential for many others to join the fray.

Keywords Anthropocene; planetary boundaries; Holocene; Earth system; holism

Introduction

Fourteen years ago ‘The Anthropocene’ was a striking neologism coined by Nobel Prize winning chemist Paul Crutzen and freshwater ecologist Eugene Stoermer (Crutzen & Stoermer, 2000). The duo suggested that the ‘boundary conditions’ characteristic of the last twelve millennia of Earth surface history had been compromised. Today, their concept appears to be a “catchword ... in ascendancy” (Caro *et al.* 2011: 185), at least in parts of the academic world. Some even suggest that it has “...taken root in popular culture as a new time term ...” (Autin & Holbrook, 2012: 60). While this surely overstates the case, there is no doubt that the Anthropocene is currently much discussed across a range of science disciplines and, to a lesser though growing extent, social science and humanities subjects. Looking ahead, Crutzen and others recently speculated that the concept may, in future, “...drive a similar reaction to that which [Charles] Darwin elicited” – such is its profundity. But they then qualify this in one key respect: “[Where] ... Darwin’s [mid-19th century] insights into our origins provoked outrage, anger and disbelief [they] ... did not threaten the material existence of society of the time. The ultimate drivers of the Anthropocene, on the other hand, if they continue unabated ..., may well threaten the viability of contemporary civilization and perhaps even the future existence of *homo sapiens*” (Steffen *et al.*, 2011: 862).

Only time will tell if the Anthropocene becomes a ‘keyword’ in Raymond Williams’ (1976) famous sense: namely, one of those terms that is central to social discourse in the academic, public, political, and commercial domains alike. But, as Crutzen and his co-authors rightly suggest, it certainly has the semantic potential to graduate from its current status as a passing buzzword coined by a few prominent academic researchers. This is because it describes human impacts on the Earth’s surface of such magnitude, scope and scale as to present an existential threat – or, perhaps, to offer transformative opportunities? – to people and other planetary life-forms. At the least, the Anthropocene idea could reset the terms of debate in many academic disciplines in the coming years, arriving on the heels of the (once controversial) ‘anthropogenic climate change’ concept and the broader notion of ‘global environmental change’.¹ If this happens there will likely be knock-on effects for how Earth surface alterations are registered by a myriad of non-academic constituencies – politicians, citizens, chief executive officers, and so on.

In the meantime, the recent attention the Anthropocene idea has attracted within and outside academia shows no sign of abating. Motivated by this attention, and by the idea’s potential to become a keyword, this and two companion essays explore the various ways in which the Anthropocene might be relevant to Geography and geographers. To-date, academic discussions of the term have been dominated by various biophysical scientists, like Crutzen (who, with colleagues, won his Nobel Prize for establishing the causal link between chlorofluorocarbon emissions from certain manufactured goods and thinning of stratospheric ozone). This is true in Geography, where the so-far modest discussion initially involved various physical and human-environment geographers debating whether and how we can consider ‘the Holocene’ a thing of the past.² However, as we will see in this paper’s successor essay, a few other geographers have of late begun to consider what the Anthropocene portends. I will review these new contributions, and show how they relate to the scientific claims and counter-claims coming from the physical side of Geography. The Anthropocene idea cross-cuts the supposed ‘divide’ between the ‘social’ and ‘natural’ domains, and is thus germane to Geography as a

¹In saying that the latter is a ‘broader’ notion, I do mean to imply that climate change is a ‘discrete’ problem” clearly, because of the flows of energy and matter that connect Earth’s various sub-systems, climate change necessarily implies change in all other aspects of biophysical reality, marine and terrestrial.

²I say modest because few formal references to the Anthropocene by geographers exist in print at the time of writing (though this will doubtless soon change). However, geographers of various stripes undoubtedly have discussed the Anthropocene’s ‘collateral concepts’ (Earle *et al.*, 1996: 6) at length, such as ‘global environmental change’. I will say more about the way I approach the published literature presently.

whole. This makes it unusually promiscuous (though not entirely unique – for example climate change has already called the divide into question on a grand scale). Accordingly, my review ranges far more widely across the published literature than other recent surveys of the Anthropocene hypothesis, such as that just published by distinguished palaeoclimatologist Bill Ruddiman (2013). Indeed, it ranges so widely that it extends to no less than three papers.

This said, I place certain limits on my coverage of the literature. In the triptych I do not consider publications, a great many authored by geographers, that consider ‘the human impact’ at the continental or global scales but without referencing the Anthropocene (or the linked idea, to be explored presently, of ‘planetary boundaries’). This may seem like an unwarranted exclusion on my part, not least because these publications have been part of the context in which Crutzen, Stoermer and others were inspired to suggest that the Holocene is over. However, I believe that the Anthropocene concept (and the planetary boundaries idea) have been designed to give a new inflection to the insights contained in these publications (more on this later). We must attend to their specificity. Their substantive content aside, they also possess a symbolic charge – a certain grandeur, if you will – that now familiar, related terms such as ‘ecological footprint’ perhaps lack. This, arguably, is why they are garnering wider attention in ways previous epochal concepts, like environmental journalist Andrew Revkin’s (1992) ‘Anthrocene’, failed to.³ Certainly, those proposing the ideas tend to treat to them as relatively novel (as we shall see), while the inaugural editorial of the interdisciplinary journal *The Anthropocene Review* similarly claims that something new is afoot (Oldfield *et al.*, 2013).⁴ Even so, it is important for readers to bear in mind that my rather strict approach, focussed on publications that make formal reference to the Holocene’s end, does cast into darkness related literature by geographers and others on contemporary humans as important ‘terraformers’. With this in mind, the third paper tries to bring more of this literature into view than the first two, as I look ahead to how geographers might shape future discourse about a thoroughly humanised Earth.

³Prior to Revkin a few others attempted to describe humanity’s global environmental impact by coining various neologisms, going back to the 1870s. However, again, none of these terms caught-on.

⁴The Canadian philosopher Ian Hacking once usefully distinguished between concepts and words to make the simple but important point that old concepts get revived when their meaning is conveyed via new words. In this light, it may seem to some that the Anthropocene and planetary boundaries are mere synonyms for the concepts signified by the terms ‘anthropogenic climate change’ and ‘global environmental change’ – two terms that geographers have undoubtedly helped to infuse with meaning and legitimize over the last quarter century or more. However, I beg to differ. Though they contain the meaning of both these terms, they also – as I will explain later in this essay – add important new emphases.

The present essay has two aims and is, correspondingly, organised into two parts. First, I describe the origins and recent vicissitudes of the Anthropocene idea, with a major focus on academic discussions occurring largely outside Geography. This will involve a presentation of the planetary boundaries concept, which is closely related to (though not entirely synonymous with) the Anthropocene idea. Second, I then suggest the potential relevance of both ideas to a wide range of professional geographers. This done, the next paper looks at how the potential is being realised. The third paper then has a programmatic and forward-looking dimension to it. It speculates on how geographers might, in future, represent the Anthropocene should they, or others, want to make it more than 'a catchword in ascendancy'.

In sum, notwithstanding its origins in parts of the science community, the Anthropocene idea is of potential interest to geographers of *all* persuasions. It is a truly encompassing concept with even greater semantic reach than a venerable, polysemic word like 'nature' and richer connotations than the now familiar term 'global environmental change'. It could, therefore, engender new discussions between physical, environmental, and human geographers. This paper and its successors make that plain. Needless to say, they should be read together and sequentially. Those new to the subject should find the trio a useful introduction, while readers *au fait* with aspects of it should discover something new courtesy of the papers' considerable breadth of topical coverage.

The Anthropocene idea: origins, early academic debates and current public profile

Crutzen and Stoermer (2002) suggested that the Holocene may have ended in a short article in the *Global Change Newsletter (GCN)* the 'house publication' of the International Geosphere-Biosphere Programme (IGBP). The IGBP was (and remains) one of several ambitious research programmes designed to study contemporary environmental change on a global scale by combining the expertises of multiple academic subjects, from climatology to oceanography to biogeography. Two years later Crutzen (2002) broadcast the 'Anthropocene hypothesis' far more widely by publishing an article counter-intuitively titled 'Geology of mankind' (sic.) in the prestigious science periodical *Nature*. Using his networks as a key member of the IGBP, Crutzen went on to co-publish a paper with respected Australian climate scientist Will Steffen and American environmental historian John McNeill. Its dramatic and quizzical title was 'The Anthropocene: are humans now overwhelming the great forces of nature?' (Steffen *et al.*, 2007). The paper appeared in the peer review, multi-disciplinary science journal *Ambio*. More detailed in evidential and analytical terms than

the earlier *GCN* and *Nature* articles, it was also more confident that the Holocene is a thing of the past. Yet it also conceded that questions remain about how, precisely, to *demonstrate* empirically the inauguration of a new phase of Earth history. These questions had already been flagged in an earlier *Climatic Change* editorial by Crutzen and Steffen (2003).

Geological questions: an epoch in the making?

In geological terms the Holocene is an ‘epoch’, and happens to be the period when *homo sapiens* have, in many ways, transcended the ‘natural barriers’ to their physical and cultural development. It was thus no surprise that Crutzen and Stoermer’s initially tentative suggestion that the Holocene’s boundary conditions had been eroded piqued the interest of some geologists. Among them was Leicester University’s Jan Zalasiewicz. In 2007 he was chairman of the Stratigraphy Commission of The Geological Society (located in London). He noticed Crutzen and others’ use of the Anthropocene idea. He proposed to the twenty Commission members that this idea should and could be tested using formal geological criteria for the identification of an epoch. The result was a co-authored article that appeared in *GSA Today*, the house periodical of the Geological Society of America (Zalasiewicz *et al.*, 2008). Entitled ‘Are we now living in the Anthropocene?’, it detailed the measures necessary to establish if and when the Holocene had ended. To quote from it at some length, “... Earth has endured changes sufficient to leave a global stratigraphic signature distinct from that of the Holocene or previous Pleistocene inter-glacial phases, encompassing novel biotic, sedimentary, and geochemical change. These changes, though likely only in their initial phases, are sufficiently distinct and robustly established for suggestions of a Holocene-Anthropocene boundary in the recent historical past to be geologically reasonable. The boundary may either be defined via a Global Stratigraphic Section and Point (‘golden spike’) locations or by adopting a numerical date” (*ibid.* 4).

As a result of this paper and subsequent discussions among the academic networks of Commission members, the International Commission on Stratigraphy (ICS) – which is ultimately responsible for identifying geological epochs – established an Anthropocene Working Group and made Zalasiewicz its chairman. At the same time, Zalasiewicz and his Leicester colleague Mark Williams joined with Crutzen and Steffen to present the question of formally establishing the Anthropocene’s epochal status to non-geologists (Zalasiewicz *et al.* 2010). A set of 2011 papers in the *Philosophical Transactions of the Royal Society A* were intended to do the same (Ellis, 2011; Steffen *et al.* 2011; Zalasiewicz *et al.* 2011). As a consequence of these interventions, and various conference presentations by their authors, the broader environmental science

community has been drawn into a geological discussion of epochal markers normally confined to earth science and normally focused on the deep past.

Which lithostratigraphic, biostratigraphic or chemostratigraphic indicators, if any, are considered sufficiently suggestive of a phase shift in Earth surface conditions to serve as agreed criteria for the Holocene's eclipse? There are several candidates, from lake sediments to greenhouse gas concentrations to artificial isotopes produced by nuclear weapon detonations. Clearly, because these markers all pertain to both recent and ongoing anthropogenic environmental change, establishing the Anthropocene's epochal status in a way satisfactory to geologists requires environmental scientists from a range of disciplines (including physical geography's constituent branches, as we will see) to supply robust evidence of changes that might, thousands of years hence, be considered clear stratigraphic markers by future geologists. For instance, the British Society for Geomorphology has established a fixed-term working group to advise it on whether and how some contemporary landforms might comprise such markers (see Brown *et al.* 2012). More recently, biologist Anthony Barnosky (2013) has summarised the palaeontological evidence, while Zalasiewicz has teamed-up with non-geologists to suggest the composite marker 'technostratigraphy' as preferential to separate ones (Zalasiewicz *et al.*, 2014). As part of this he has explored ways of using anthropogenic minerals as a novel stratigraphic marker (Zalasiewicz *et al.*, 2013).

The complications involved in identifying and interpreting indicators of any kind are manifold (Rull, 2013). First, which indicia – one or several – should be taken as definitive of the Holocene's termination? Second, given that we may only be in the very early years of the Anthropocene, it is more important than usual for any one indicator be resolved to geologically precise temporal scales, like a decade or a year. This is technically challenging in many cases. Third, because the ecological impacts of human activity have been and remain diachronous, significant environmental signatures evident in one part of the world (e.g. Western Europe) may not be replicated elsewhere until the last few years or next few decades. Finally, it is entirely possible that future environmental markers reflective of present-day human activities will prove to be more compelling indicators of the Anthropocene's onset.

Given the several measurement issues itemized above, and given that the ICS is very exacting about what constitutes a new geological time period, there seems little chance that the Anthropocene will be declared a new epoch by geologists any time soon. It is more likely that the Holocene's end will be

left as an open question for a few more years.⁵ In time this may, perhaps, oblige the ICS to reconsider relaxing its criteria for identifying epochs, at least when applied to a period when humanity is said to akin to a 'great force of nature'

⁵The above-mentioned Anthropocene Working Group may well have enough evidence by 2016 to form a firm, if still revisable, view by the time of the 2016 International Geological Congress. The Group's work will be assisted by a new edited work on the possible stratigraphic markers of the Anthropocene to be edited by Colin Waters (of the British Geological Survey) and others.

Beyond Geology: current debates in the environmental sciences

None of this, however, has deterred several investigators from searching for chronometric indicators of the Anthropocene's inception, regardless of their stratigraphic in/significance. In their 2007 *Ambio* paper, Steffen *et al.* divided the Anthropocene into three periods, beginning with 'The Industrial Era' (roughly 1800-1945), followed by 'The Great Acceleration' (1946-2015) and possibly followed by a period of 'Earth System Stewardship' (2016-) in which humans at last take collective responsibility for their huge global environmental footprint (see also Steffen *et al.*, 2011). However, without discounting the chronometric significance of 1800, Bill Ruddiman and colleagues have suggested that a global anthropogenic environmental signal can be recorded hundreds of years *earlier* (see the debate organised Ruddiman, Crucifix and Oldfield [2011] in the pages of *The Holocene*). They propose that even as long ago as the Middle Ages (and perhaps centuries before that) collective human endeavour was able to unintentionally alter climatic conditions (see Ruddiman [2013] for a review of the evidence in favour of 'the early Anthropocene hypothesis'). Relatedly, Chris Doughty and co-workers propose that the early Holocene may not have been quite as much a natural phenomenon as previously thought (Doughty *et al.* 2010; see also Doughty, 2013). As with the discussion of stratigraphic markers, it is unlikely a consensus will soon be reached on a single year or even a decade when the Anthropocene can be said to have begun. Instead, environmental scientists may need to accept that different worldwide anthropogenic signals of varied magnitude appeared at different times over the last six centuries. In this light, the 'beginning' of the Anthropocene might be said to have been cumulative, unsynchronised and strung-out rather than punctual (see Lewin & Macklin, 2013). Alternatively, one could distinguish between an early 'low-octane' Anthropocene and a more recent 'super-charged' Anthropocene (Ruddiman, 2013: 66). Of course, most previous geological epochs did not begin punctually, but given the evident step-change in human impacts on the non-human world there has perhaps been a presumption that a fairly clearly start-date for the Anthropocene may be found.

In light of these ongoing debates about how to measure and pin-point a crossing of the Holocene-Anthropocene boundary, it may be thought that Crutzen and Stoermer's proposition has reached an impasse almost a decade and a half after it was first ventured. However, this is far from true. As palaeoecologist Valenti Rull notes, "... it is not necessary to formally define the Anthropocene as an epoch to accept that human activities have significantly changed Earth system processes [and forms] during the last [few] ... centuries"

(2013: 4). Geologists like Zalasiewicz and Mark Williams, and environmental scientists like Crutzen and Steffen, recognize this too. As they wrote in the journal *Environmental Science and Technology*, "... quite how and when the Anthropocene is formalized is of secondary importance; its real significance is in being a means to integrate a wide range of environmental indicators [and] to consider them within the context of the whole of [the] Earth [surface]" (Zalasiewicz *et al.* 2010: 6008). Consequently, it is possible for the Anthropocene to remain an informal concept in geology even as it becomes a normal part of the vocabulary of many environmental scientists. Its potential facility for the latter and their audiences is that it denotes biophysical changes that are profound relative to (i) the *human*, rather than geological, past, and (ii) the *very recent* character and behaviour of 'big' earth-surface phenomena, such as ice sheets and ocean currents. As Zalasiewicz (2013) suggests in a recent *Nature Geoscience* feature article entitled 'The epoch of humans' (note the resonance with Crutzen's seminal 2002 *Nature* article 'Geology of mankind'), the Anthropocene may catch-on in environmental science regardless of what geologists like himself think of it. This is all the more likely because the term's invention has been coincident with over 25 years of growing concern about the degree and effects of anthropogenic climate change. Indeed, the Anthropocene concept can be seen as a new, more graphic way to frame an existing idea, namely that of 'global environmental change' caused by human activities and extending in causes and effects *beyond* climate change. It is thus no surprise that a number of peer review papers now appearing in environmental and earth science journals with 'Anthropocene' in the title – with the term used as a general framing device for specific investigations of biophysical processes and/or forms.

The 'planetary boundaries' concept

One notable example of how the Holocene's end has been registered outside the field of geology is the recently published work of Johan Rockström and colleagues – colleagues who include Crutzen and Steffen. In a 2009 paper in *Nature* (Rockström *et al.* 2009a) and a much longer essay published in the journal *Ecology and Society* (Rockström *et al.* 2009b), a large number of environmental scientists from across the disciplines have advanced the concept of 'planetary boundaries'. Aside from Crutzen and Steffen, high-profile scientists both, these researchers include prominent ecological economist Robert Constanza and the well-known climate scientist James Hansen.

Rockström *et al.* argue that the environmental conditions of the Holocene are preferable to those of an unknown and potentially inhospitable Anthropocenic future. They identify nine global environment components

constitutive of the Earth system. These pertain to climate, ocean acidity, chemical balances, atmospheric aerosols, biodiversity, land use types, freshwater, nitrogen and phosphorous cycles, and stratospheric ozone density. For seven they specify a quantitative boundary, the crossing of which might take the system beyond Holocene norms (for the remaining two – aerosols and chemical pollution – they are unable, as yet, to specify the boundary). Together, the nine boundaries comprise what Rockström *et al.* call “a safe operating space for humanity” (2009a: 472). Modern humans, they argue, have already transgressed several of these. They synthesise a huge volume of existing data about environmental change in order to sustain this argument. Recognising that “Determining a safe distance involves normative judgements about how societies choose to deal with risk and uncertainty”, Rockström *et al.* nonetheless commend their “... new approach to defining biophysical preconditions for human development” (*ibid.* 472, 474; see also Steffen, Rockström & Costanza, 2011).

The planetary boundaries concept is a particular version of the Anthropocene idea in all but name. We might therefore call it a ‘collateral concept’ (about which see Castree, 2014: 17-20). It signifies environmental changes of the same magnitude, scope and scale as the Anthropocene idea, but in a less politically neutral and more overtly normative way. This is not to suggest that Rockström, Crutzen, Steffen, Constanza, Hansen and others are wilfully dramatizing science to serve political ends i.e. to recommend urgent societal action to stay within a ‘safe operating space’. It is simply to say that, in their view, current evidence of human impact suggests that future environmental change may pose a serious threat to human development in many areas of the world. In part, this is because the concept of multiple planetary boundaries suggests the possibility of ‘coupled and cascading effects’, where crossing one threshold then triggers serious biophysical changes to some or all of the other eight components of the Earth system. Within and outside the Earth surface sciences, this possibility is already a fairly familiar one courtesy of the notion of ‘tipping points’ (see, for example, Gladwell, 2000).

Unlike the Anthropocene concept, the planetary boundaries idea has not – for obvious reasons – preoccupied geologists. It can be taken seriously without any need to satisfy formal geological criteria for the Holocene’s end. Yet, given its novelty, it has not yet received much serious scrutiny by environmental scientists outside the large network of authors represented in the *Nature* and *Ecology & Society* papers. Only very recently indeed has it been subject to any degree of published evaluation. For instance, members of the American environmental think-tank the Breakthrough Institute caution against

uncritical acceptance of the planetary boundaries idea (Nordhaus, Shellenberger & Blomqvist, 2012). Though not practicing scientists, their evidence-based report arrives at two conclusions. The first is that six of the supposed planetary boundaries cannot be said to be global but only regional or local; the second is that there is no compelling evidence that transgressing these six 'non-threshold boundaries' would necessarily diminish human welfare. Nordhaus *et al.* point to the choices and ingenuity humans possess to both adapt to and change their surrounding environments. They argue that people can and must 'trade-off' between alternative goals and courses of action. In this light, they insist, "... attempts to depoliticize [trade-off decisions] ... with reference to scientific authority is dangerous, as it precludes democratic resolution of ... [public] debates, and limits, rather than expands, the range of available choices and opportunities" (*ibid.* 37).

Somewhat differently, British environmental scientist Simon Lewis (2012) worries that a focus on nine boundaries could spread politicians' environmental policy focus too thin, distracting them from prioritizing key boundaries like the concentration of atmospheric greenhouse gases. Lewis's focus on politicians, rather than just scientists, is not fanciful. Almost from the get-go the planetary boundaries idea was noticed by the United Nations High Level Panel on Global Sustainability and by leading non-governmental organizations like Oxfam and the World Wildlife Fund. In large part this is because it featured prominently at the 2012 'Planet Under Pressure' (PUP) conference in London, held just prior to the United Nations (UN) Rio+20 'Earth Summit'. This conference, with scientists in the vanguard, was intended to capture the attention of leading politicians and activists worldwide. Indeed, Johan Rockström has since co-authored a report for the UN with the (in)famous economist Jeffrey Sachs (Rockström & Sachs, 2013). It focuses on how planetary boundaries can be respected while also aiming for social justice given the evident inequities of human life on the planet. The report echoes the insistence of Oxfam's Kate Raworth (2012) that socio-spatial equity issues must be factored into the policy implications of the 'safe operating space' idea.⁶

The Anthropocene and planetary boundaries concepts: wider visibility

Despite these high level reports and the PUP event, there is no compelling evidence that the Anthropocene has yet taken root in popular culture as a new time term, and even less evidence that 'planetary boundaries' is now part of the *lingua franca* of non-scientists. However, both ideas have achieved a

⁶The science and social science aspects of the 'planetary boundaries' idea are together covered in the recent *State of the World* volume published by the Worldwatch Institute (see chapters 2 and 3 of Assadourian and Prugh, 2013).

degree of public visibility because of the lively earth and environmental science discussions summarised above. In other words, even at this relatively early stage in their lives, the two ideas are not the preserve of the academic community from whence they hail.

In this respect, it has surely made a difference that Crutzen is a senior and highly distinguished scientist who people are disposed to listen to, especially when the likes of James Hansen are involved. Furthermore, the ‘fact’ of anthropogenic climate change – albeit a contested one until fairly recently – has, for many non-academics, arguably helped normalise the idea that certain human actions can significantly transform environmental processes at a global scale and with enduring effects.⁷ Indeed, there has long been a genre of popular science and popular environmentalist writing devoted to documenting ‘the human impact’ on all four corners of the Earth. Finally, some of the semantic groundwork for the Anthropocene and planetary boundaries ideas had already been done before one or both terms’ invention. For instance, since the early 1980s the ‘Gaia hypothesis’ has been much discussed outside academic circles, while the already-mentioned notion of environmental ‘tipping points’ has more recently featured in public discussions of environmental change.

Recent signs that the Anthropocene and planetary boundaries concepts are registering outside academia are as follows (note: this is not an exhaustive list). *The Economist* magazine devoted a whole section of a late May 2011 issue to the Holocene’s end, while two months earlier *National Geographic* magazine ran an article by American science writer Elizabeth Kolbert entitled ‘Enter the Anthropocene – Age of Man’ (Kolbert, 2011). The year ended with *The New York Times* publishing an op-ed on the subject (Marris *et al.*, 2011). Meanwhile, science populariser and environmentalist Mark Lynas used the idea of ‘planetary boundaries’ to structure his 2011 best-seller *The God Species: How the Planet Can Survive the Age of Humans*. The following year, scientists involved in the IGBP and other global environmental change research programmes organized the above-mentioned ‘Planet Under Pressure’, which opened with a time-lapse video of recent earth surface change entitled ‘Welcome to the Anthropocene’ (available at <http://vimeo.com/39048998> at the time of writing). This same year *Time Magazine* informed its many readers that ‘Nature is over’ – one of ‘Ten ideas that are changing your life’ – by referring to the writings of Crutzen and others (Walsh, 2012). The BBC broadcast a four part series on ‘The Age We Made’ in November 2012 as part

⁷As acknowledged in note 1 above, several geographers must take some credit for investing this idea with content, along with the idea of global environmental change.

of its World Service's 'Discovery' series. The programmes were later broadcast on BBC Radio 4 in its 'Frontiers' series. More recently, a major exhibition on the Anthropocene was held at Berlin's Haus der Kulturen der Welt (starting January 2013), with a related exhibition subsequently organised in Munich (by the Deutsches Museum and the Rachel Carson Center).⁸ As 2013 ended, Kolbert also authored two extended essays in *The New Yorker* on the Quaternary era, culminating in a discussion of Anthropocene.⁹

If most of the above reached relatively 'high brow' sections of the citizenry, the Anthropocene and planetary boundaries ideas have already been trailed in all-but-name in both recent popular fiction and cinema. Prominent examples include writer Cormac McCarthy's 2006 Pulitzer Prize winning novel *The Road* (later made into a Hollywood film), docufilm *The Eleventh Hour* (2007), the remake of the movie *The Day the Earth Stood Still* (2008), Roland Emmerich's brace *The Day After Tomorrow* (2004) and *2012* (2009), and other works that represent a catastrophic ecological future (human-caused or otherwise). Should both ideas eventually catch-on in the wider society, they will be received by many people who are thus somewhat familiar with what they signify, if only at the level of dramatic fiction and entertainment to-date.

Geography, the Anthropocene and planetary boundaries

Signature features of two epochal concepts

The concepts of the Anthropocene and planetary boundaries belong to no one academic discipline. As we have just seen, they come to us from a mixture of earth and environmental scientists. They are not, of course, *sui generis*: as I indicated briefly in this essay's introduction, they could not have been proposed but for prior research and public debate about climate change and wider global environmental change. Even so they possess a number of signature characteristics, all of which are linked to their evocation of a qualitative alteration in Earth surface processes and phenomena. First, they describe a world in which myriad local actions (e.g. manufacturing concrete, or fertilising a lawn) together have cumulative, biophysically significant global consequences across multiple Earth sub-systems. This implies the need for 'joined-up' analysis of the highest-order, both within and between the environmental and social sciences. Indeed, it is no surprise that some of those

⁸All this has occurred against the background of a shift in some of the discourse about anthropogenic climate change. A number of well known writers have, of late, talked about the Anthropocene in all but name as part of their radical visions of an Earth where climate change changes everything else. See, most notably, the books by leading American environmentalist Bill McKibben (2010) and former Greenpeace chief Paul Gilding (2012).

⁹ Kolbert's brace is a trailer for her new book *The Sixth Extinction: an Unnatural History* (2014).

proposing the Anthropocene and planetary boundaries concepts have had prior involvement in so-called Earth System Science – a hoped-for ‘super-discipline’ that examines the Earth surface as a system of sub-systems. Second, the two terms call into question the power long accorded to several components of ‘big nature’ (e.g. ocean currents) and highlight the capacity humans now have to act as a planetary force – albeit unintentionally. To use a mathematic metaphor, they take the idea of anthropogenic climate change and they square it or even cube it. In some ways this challenges the hypothesis popularised by James Lovelock from the late 1970s that the Earth system would ‘self-regulate’ if ‘perturbed’ by human actions.¹⁰ Some now argue that homeostasis is not guaranteed and ‘thresholds’ may already have been crossed, even if all the signs of irreversible large-scale change are not yet manifest. Third, the two concepts are powerfully forward-facing. They invite us to consider making significant present-day decisions in light of their (non-trivial) effects long into the future.¹¹ They imply that, in the long run, a lack of foresight and action today will have profound consequences tomorrow that are at once hydrological, lithospheric, biological and atmospheric.

Fourth, and relatedly, unlike some ideas that come from science (e.g. black holes), this duo have direct implications for how we currently live our lives (hence Steffen *et al.*’s comparison with Darwin’s concept of ‘natural evolution’, cited in the introduction). More even than anthropogenic climate change, they invite us to question the political-economic and cultural regimes that prevail, especially in the West. Yet like global warming, the Holocene’s termination – if it has indeed ended in geologists’ eyes – has been powered by a plethora of fossil-fuel commodities, from chemical herbicides to gasoline to ubiquitous plastic. These commodities circulate through every area of modern life, from farming to manufacturing to long-distance tourism. Fifth, and again relatedly, the two ideas invite a response from *all* our faculties – not only perceptual and cognitive, but also moral-ethical and even aesthetic. Questions of *episteme* (understanding) *techné* (practice) and *phronesis* (values and power) arise simultaneously. What is more, they arise in ways that beg complex answers that attend to the ‘glocal’ character of modern life, that is to say its simultaneously situated and distantiated nature. Finally, unlike some scientific objects, the ‘discovery’ of the Anthropocene and planetary boundaries invites human actions that will alter the future character of the phenomena the two

¹⁰Though, in fairness, I should note that Lovelock’s later writings are more pessimistic about the homeostatic capacities of Earth surface systems.

¹¹Symptomatic of this is the fact that the lead members of the earlier mentioned IGBP, like Crutzen, are, along with others from outside the Program, are labelling the next phase of international research on global environmental change the ‘Future Earth’ programme.

concepts describe. These phenomena are mutable, depending on the kind and degree of human action on the Earth's surface today and tomorrow. Seen thus, humans are party to a huge and unrepeatable biophysical experiment in which we are not mere observers but a key part of the experiment itself. This is not, of course, to suggest we are somehow in control nor even pilots able to successfully steer the metaphorical (space) ship.

In short, the Anthropocene and planetary boundaries ideas signify a great deal, even when one abstracts from the technical specifics of their scientific invocation by the likes of Crutzen and Rockström. They are 'super-concepts' that frame a myriad of issues and phenomena normally discussed in relative isolation. As such, and to reiterate, they significantly amplify the connotations normally associated with the idea of humanly-caused climate change.

Potential relevance to Geography

What immediate relevance do the two concepts have for Geography? The discipline remains among the few trying to hold together physical science, social science and humanities perspectives on the world – if only nominally, some might argue. Its enormous breadth of topical focus can be traced back to its origins as a late nineteenth century university subject, at least in the Anglophone world. As David Livingstone reminded us in his peerless history of Geography, early proselytizers like Halford Mackinder wanted to resist "the incipient Balkanisation of knowledge that accompanied the professionalization of scientific specialisation" (1992: 177). The 'geographical experiment', as Livingstone called it, was designed to see if the study of society and nature could be kept "under one conceptual umbrella" (*ibid.*).

Though this is not the place to review geographers' varied attempts to understand human-environment relations, the results of the experiment have been decidedly mixed over the last century or so (for recent summary accounts see Castree, 2010a, 2010b). After 1945 there was a gradual move away from the 'middle ground' between human and physical geography, leading to a largely 'pure' form of the latter and a largely nature-free form of human geography by the early 1980s. Ironically, and notwithstanding some notable exceptions, geographers progressively specialised in ways that reproduced the Balkanisation that Mackinder and others had intended Geography to avoid. Relatedly, they also retreated from analysis of larger scale events, finding smaller spatio-temporal scales more intellectually manageable and evidentially tractable.

However, in recent years and for multifarious reasons, a great many practitioners have resumed the geographical experiment – only now under a

wide variety of conceptual umbrellas, not one or two. Some of these involve the intentional dissolution of the (supposed) ontological distinction between 'natural' and 'social' phenomena – thus obliging us to rethinking corresponding forms of academic knowledge (see, for example, Steve Hinchliffe's *Geographies of nature* [2007]). Others involve that distinction's apparent reassertion (see, for example, the neo-environmental determinism of Jared Diamond's best-seller *Collapse* [2005]). Still others, less preoccupied with how permeable the distinction is, focus either on the diverse environmental impacts of human activity or the effects on human thought and action of environmental change (including the effects of 'natural hazards'). As part of the latter many have examined different ways people can mitigate the consequences of, and adapt to, imminent climate-induced changes to Earth surface phenomena (among several examples, see O'Brien & O'Keefe's [2013] *Managing adaptation to climate change*). This sort of work is often occurring in environment centres and institutes as much as geography departments. Then there are some physical geographers who are today working in cross-disciplinary teams trying to understand the large-scale connectivities and feedbacks between climate, ice, water, nutrient cycles, vegetation patterns and so on in a world where the 'natural environment' is ever-more humanly modified (e.g. Piao *et al.* 2013). Again, not all of these geographers are institutionally located only (or at all) in geography departments. Indeed, an awful lot of 'joined-up' environmental research we might otherwise associate with Geography as a discipline is now occurring outside the subject.

In light of all this, the Anthropocene and planetary boundaries ideas could well attract sustained intellectual attention in many parts of Geography. Unlike thirty or forty years ago, there now exist a large number of researchers and teachers already disposed to examine the dynamics of human-nonhuman relationships. Many of them have for some time been engaged in multi-level analysis (extending to the global and longer-term), aiming to understand the reciprocal relations between 'here and now' and 'then and there' events and processes. 'Thinking big' has become relatively common-place in Geography, not only because the world seems to be ever-more interconnected across space and through time, but also because the technical capacity now exists to collect, interpret and visualise data at high resolution yet at large spatio-temporal scales too. One example of this is the fact that several environmental geographers (e.g. the American Robert Kates) have been advocates for 'sustainability science', a multidisciplinary attempt to integrate environmental knowledge so as to significantly reduce humanity's ecological footprint (while still recognising there will be rival views about how large/small this footprint

should be). Another is the fact that a few physical geographers have expressed some interest in the earlier-mentioned Earth System Science and, slightly differently (as some would see it), in 'global physical geography' (e.g. Clifford, 2009). Indeed, George Malanson and co-authors (2014) have recently suggested that such 'integrated' global physical geography will increasingly focus on the 'unnatural' Earth surface nature created by human activities.

There are numerous ways in which geographers could interrogate the Anthropocene and planetary boundaries ideas, looking ahead. This will become evident in the third paper of this triptych (Xxxxxxx, 2014b). But first we must consider geographers' so-far small number of formal engagements with the ideas to see what we can learn from them. These engagements, as the next paper will reveal (Xxxxxxx, 2014a), already reach beyond physical geographers seeking to measure rates and patterns of global environmental change. However, at the time of writing, they do not constitute a *concerted* attempt to flesh-out, consider the implications of, or question the two concepts under review. That could change in the near future.

Conclusion

An invention of a few scientists outside Geography, 'the Anthropocene' is currently a buzzword, an adolescent concept that may mature into a societal keyword. It has recently been complemented by the 'planetary boundaries' idea. Both terms are rich with geographical meaning. They are the latest, and perhaps grandest, additions to a family of terms designed to highlight significant, world-wide environmental changes. Along with these extant terms (e.g. 'sustainable development'), the duo possesses the potential to attract the attention of geographers across the much discussed (often lamented) 'divide' between human and physical geography. They also intersect with a recent 'rediscovery' of Geography's aspirations to be a 'world discipline' that reveals the complex connections between humans and non-humans extending to the largest spatio-temporal scales. Though not primarily associated with the discipline of Geography, both neologisms speak to a subject many geographers have been preoccupied with for years: namely, the growing human impact on the Earth's decreasingly natural physical environment/s. While many geographers have influenced expert and lay discourse about those impacts, few have so far contributed overtly to the discourse about the Anthropocene and planetary boundaries. How, then, have the two ideas been engaged with by practitioners to-date, especially the older sibling (i.e. the Anthropocene)? And how might they, in future, contribute to wider discussions of the post-Holocene era? These questions successively structure this paper's two companion essays.

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