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Transgressing Time: Archaeological Evidence in/of the Anthropocene

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Abstract

Archaeological evidence of human-influenced transformations of physical strata and the Earth system provides strong support to the broad concept of the Anthropocene, yet it also presents a powerful material challenge to some of its most entrenched assumptions. This substantial and growing body of time-transgressive evidence has the potential to radically alter the concept from the ground up and to provide a literal ground on which interdisciplinary collaboration among the natural sciences, social sciences, and humanities can take place.

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INTRODUCTION

Archaeology occupies an unusual position in relation to interdisciplinary debate on the Anthropocene. On the one hand, it is a scientific discipline that produces data relevant to the idea of the proposed new geological epoch and how it should be formulated. On the other hand, it is part of the larger field of cultural anthropology, which questions some of the assumptions underlying the concept of the Anthropocene. The review argues that archaeological evidence provides a common ground on which the approaches of the natural sciences and social sciences/humanities can be brought closer together.

The term "ground," as used here, is not just a metaphor. It denotes more than merely a theoretical ground or abstract philosophical basis for discussion. Underlying that is a vast and substantial mass of physical strata, which is the subject matter of archaeology—a literal ground that is underfoot and buried out of sight most of the time. This ground is made up of the human-modified strata that now cover large parts of terrestrial surfaces of the Earth, extending also into marine zones, and which should form a major part of the stratigraphic basis of any definition of the Anthropocene. Composed of the traces, residues, cuts, and deposits of past human activities laid down in stratified sequences, it can be characterized in its totality as a new geological layer, formed mainly by human geological agency intermeshed with natural geomorphological forces.

Up to now, the implications of the existence of this globally extensive and rapidly growing body of human-modified strata have not been fully taken on board either by geologists pushing the case for the proposed new epoch or, for that matter, by archaeologists contributing to the debate. This review goes beyond concerns about threats posed by Anthropocene phenomena for heritage conservation or issues to do with how human-influenced environmental pressures such as climate change, melting ice, and rising sea levels are endangering known archaeological sites (Solli et al. 2011), important though these matters are. Instead, attention turns to the implications of archaeological evidence for the wider Anthropocene debate, the terms and frames of reference of which are starting to shift to accommodate it. By the end of the review, it becomes clear that archaeological evidence is pivotal to the task of reconfiguring the concept of the Anthropocene and enhancing our understanding of the processes currently at work in Earth system change.

WHEN DID THE ANTHROPOCENE START?

The term "Anthropocene" was coined in 2000 by atmospheric chemist Paul Crutzen and biologist Eugene Stoermer to denote a proposed new geological epoch marked by human impacts on Earth systems (Crutzen & Stoermer 2000). The idea of an age of humans is problematic for many scholars, including some archaeologists, in part because of the way it clumps all humans together while simultaneously separating them from other entangled forces at work in bringing about Earth system change (González-Ruibal 2018b, Woodfill 2019). Alternative names have been suggested that take account of such concerns—Capitalocene, Plantationcene, Chthulucene, etc.—but the Anthropocene term has spread so rapidly across disciplines and into the public domain that this article assumes that it is here to stay.

Geologists have been prominent in leading the debate (Waters et al. 2014, Zalasiewicz et al. 2019), with their primary focus on the question of when the Anthropocene should be assumed to begin. Establishing the precise moment of start is held to be important because, for any new geological time unit to be formally designated, it must fit within the hierarchy of eons, eras, periods, epochs, and ages that is used to divide up time, as depicted on the International Chronostratigraphic Chart (Cohen et al. 2013).

At first, the Industrial Revolution was favored as the date of onset, with various dates suggested that roughly coincide with the invention of the steam engine. More recently, the preference of mainstream Anthropocene proponents shifted to the mid-twentieth century, coinciding with the sudden upsurge in indications of Earth system change known as the Great Acceleration (Steffen et al. 2015). They argue that the radioactive fallout from nuclear weapons tests, spread around the globe via the atmosphere and into soils worldwide, provides the primary stratigraphic marker for the transition from one epoch to another (Waters et al. 2016).

This background information is important to know if archaeological responses to the Anthropocene proposal are to be put in their context and properly understood. Some archaeologists regard the debate as having little relevance to archaeological time classifications (Paz 2014) and tend to steer clear of it, perhaps heeding the warnings of Clarke (2014). Of those who do see it as relevant to their work, most take the view that stratigraphic evidence of human impact from earlier periods is being overlooked (Braje et al. 2014, Woodfill 2019). Thus Smith and Zeder draw attention to large-scale transformations of landscapes that took place in relation to the domestication of plants and animals and the development of agricultural economies. They propose that the start of the new epoch should be placed near the end of the last Ice Age and that, instead of the Anthropocene being distinct from the Holocene, the two epochs should be regarded as roughly coeval (Smith & Zeder 2013). Other archaeologists support that view (Balter 2013, Erlandson & Braje 2013, Kluiving & Hamel 2016).

There is more to this than just the earthworks, settlement mounds, and cultivation soils associated with prehistoric agricultural communities, extensive though these are. Erlandson points out that the development of new sea-fishing and seafaring technologies led to population growth along the coastlines of several continents, giving rise to the formation of shell midden soils, which provide a useful stratigraphic signal of the Anthropocene. These are roughly contemporaneous with the development of agricultural economies and the extensive soil and landscape changes pointed to by Smith and Zeder (Erlandson 2013), amounting to a transformation of the terrestrial biosphere (Ellis 2011).

Palaeoclimatologist William Ruddiman put forward the Early Anthropocene hypothesis on the basis of ice-core evidence (analysis of bubbles of ancient atmosphere trapped in glacial ice). He argued that prehistoric agriculture emitted enough greenhouse gases into the atmosphere to cause global warming and offset what would have been another Ice Age (Ruddiman 2003, 2007). This hypothesis is supported by archaeological evidence of rice production and animal husbandry. Excavations of sites in the Lower Yangtze area of China show that rice production began at least 8,000 years ago and within two millennia had spread over many other parts of Asia (Fuller et al. 2011). The link drawn between rises in atmospheric methane and rice agriculture (with all the terraforming of landscapes and soils that goes with it) hints at broader connections between human transformation of soils (Richter 2020) and climate change (Bauer & Bhan 2018).

Archaeological evidence provides a touchstone against which proposals can be evaluated. For example, a soil science paper proposed that "anthropogenic soils are the golden spikes of the Anthropocene" (Certini & Scalenghe 2011), but the suggested date of onset 2,000 years ago seems much too late, given that human-modified soils were manifestly forming on a large scale in many parts of the world for thousands of years before that. Examples are anthropogenic soils associated with Neolithic tells across Syria and other parts of the Fertile Crescent region (Menze & Ur 2012) or extensively terraced hillsides that characterize large areas of Asia, southern Europe, and elsewhere, with some terraces dating back to the early Bronze Age (Tarolli et al. 2014).

Many other proposed dates for the start of the Anthropocene have been suggested, ranging as far back as the first use of fire by hominids hundreds of thousands of years ago (Glikson 2013). Archaeological data are typically invoked in support, either explicitly or implicitly, alongside other forms of evidence. For example, a powerful argument is made for the Anthropocene beginning with the European colonization of the Americas, suggesting a start date of 1610, marked among

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other things by stratigraphic evidence of the transfer of domesticated plant and animal species between continents (Lewis & Maslin 2015). Of all the places where such evidence is to be found, the archaeological record would be the first place to look.

TIME-TRANSGRESSIVE EVIDENCE

One might suppose that all this archaeological evidence of human transformation of land and physical strata, and early effects of human activity on the biosphere and atmosphere and the Earth system as a whole, would be useful in developing and honing the idea of the Anthropocene. However, it has proved distinctly problematic and challenging to the concept on a fundamental level—and not just in the sense of indicating much earlier start dates than the mid-twentieth century or the Industrial Revolution. Because archaeological evidence is so heavily diachronous, it undermines the idea that the Anthropocene can have a precisely defined single date moment of onset, suggesting instead diachronous beginnings spread out through time (Braje & Erlandson 2013, Edgeworth et al. 2015). Imposition of a single globally synchronous date onto such time-transgressive stratigraphic evidence seems inappropriate, leading many scholars to doubt whether the application of the chronostratigraphic method is useful (Braje 2015, 2016; Edgeworth et al. 2019). Simonetti (2019) argues that it "petrifies" evidence of environmental change and "fossilizes" Earth processes.

For proponents of the mid-twentieth-century start, one way of acknowledging the existence of all that diachronous archaeological evidence while simultaneously putting it to one side is to create a pre-Anthropocene category into which it can be placed: the Palaeoanthropocene (Foley et al. 2013). But this hardly solves the problem; it merely reframes it by the creation of yet another conceptual divide. There is an assumption implicit in such a move that archaeological evidence by definition relates only to the past, and that it can somehow be conceptually cordoned off from what is happening in modern and contemporary times. But this assumption makes little sense in stratigraphic terms. There has never been a point in time when archaeological strata stopped forming and accumulating. As a material residue of human activity that will leave substantial and lasting traces in the stratigraphic record, sequences of diachronous archaeological strata have continued to grow and accumulate throughout the modern period, are forming at increasing rates today, and will carry on doing so into the foreseeable future.

The burgeoning mass of human-modified ground—sometimes characterized as the "archaeosphere" (Edgeworth 2014, 2017; the term was coined by Capelotti 2010)—is growing at such rates that it constitutes an unstoppable material force. It started forming in isolated patches thousands of years ago, with some of these gradually coalescing over time. Now it is a veritable hyperobject (Morton 2013, Hudson 2014) of immense near-global scale, impossible to grasp in anything like its entirety. Much of it is buried out of sight and remains hidden, so usually only its surfaces are seen. No discipline, least of all archaeology (which traditionally works on much smaller scales), has yet gained a proper understanding of it. Accumulating mainly on land, it extends from terrestrial settings into rivers, lakes, and seas—especially around coasts in the form of "reclaimed land" (Hudson 1996, Masoud 2021) and "drifts" (Pétursdóttir 2017, 2020)—and is present in patches even on the remotest parts of the Earth's surface (Zarankin & Salerno 2014). It smothers and destroys some habitats while creating others. More than just a passive stratigraphic record of past events, it has active effects of its own (Edgeworth 2018).

The archaeosphere can be held to encompass not only the material remains of the past as seen from the present, but also the archaeology of the future in the process of formation now. It grows upward through the dumping and building-up of deposits and extends downward through the cutting of shafts, tunnels, mines, quarries, and other large-scale voids. It spreads outward as people

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(and the residues and traces that accumulate wherever they go) move into previously uninhabited and unexploited areas. With the use of hand-digging tools ceding to the deployment of more powerful earth-moving machines, rates of accumulation increase dramatically. Mining and quarrying for mineral extraction, for instance, produce vast amounts of soil and rock from deep strata to be redistributed on the surface, ultimately finding its way into shallow subsurface archaeological layers, while at the same time creating voids that serve as basins for the deposition of landfill and other material (Denizen 2013, Edgeworth 2017). These stratigraphic formation processes can be observed taking place all around us. Human activities are transforming the near-surface stratigraphy of the planet more today than ever before, adding cumulatively to the already substantial human signature in the archaeological and geological records.

A recent study estimated that the weight of the global mass of human-made material, at 1.1 teratonnes, is overtaking the weight of global living biomass and growing exponentially, doubling roughly every 20 years (Elhacham et al. 2020). Most of this material ends up, sooner or later, in the accumulating archaeosphere layer. However, such estimates tend to leave out material significantly modified by humans yet not entirely artificial, including most archaeological strata. Another study, taking at least some of this neglected human-modified material into account, estimated the mass of the functioning technosphere and its material residue in the archaeosphere together to weigh a more realistic but still conservative 30 teratonnes (Zalasiewicz et al. 2017).

One hundred years ago, the geologist Robert Sherlock noted that anthropogenic deposits were up to 10 m deep below the historic core of London (Sherlock 1922), and it was partly on that basis that he developed the idea of humans as geological agents. He was following the lead of Eduard Suess, who in the 1850s recorded similar depths of what he called the Schuttdecke or "rubble blanket" under Vienna (Suess 1862). Three-dimensional mapping of urban archaeosphere deposits in cities such as Pisa (Bini et al. 2018), Rome (Luberti 2018), and São Paulo in Brazil (Peloggia et al. 2017) follows in that tradition. Although of great value, these geoarchaeological studies provide snapshots in time, offering static representations of what are actually dynamic growth forms. The missing fourth dimension of temporal process needs to be added. One way to do so would be to map at intervals spanning generations. Thus the anthropogenic ground mapped by Suess in Vienna has grown many times over during the last 170 years (see the Anthropocene Surge project website: **https://anthropocene-vienna.univie.ac.at/**). Its overall shape, size, volume, weight, and extent today are greater by far than what they were back then. By comparing then with now, the rates of lateral spread and vertical growth of human-modified ground can be partially apprehended.

Ways in which archaeological strata accumulate present a useful model for conceptualizing how seemingly insignificant effects of multiple local events compound over time to produce global impacts, enabling a more multiscalar understanding of the Anthropocene to develop (Catlin 2016). Planetary-scale environmental change is brought about by global accumulation of localized changes (Turner et al. 1990). As one author cogently puts it, "The Anthropocene begins to emerge when we consider human-environmental activity at a local level, compounded by thousands of years, affecting vast areas of interlocking landscapes" (Periman 2006, p. 562).

THE MATERIAL CHALLENGE

Such time-transgressive, multiscalar, shape-shifting stratigraphic evidence resists insertion into temporal frameworks that divide evidence into before and after periods on either side of globally synchronous timelines (Bauer & Ellis 2018). It presents a considerable material challenge to the concept of the Anthropocene, prompting researchers to change frameworks of thought to accommodate the evidence (rather than fit the evidence around an imposed conceptual timeline). It challenges not only chronostratigraphic timeframes, but also the established categories of

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geological classification into which the stratigraphic evidence for the Anthropocene is currently placed.

At present, stratigraphic codes of geology are based mainly on strata formed through sedimentary processes on the seafloor millions of years ago. But much archaeological evidence is formed through nonsedimentary processes (Harris 1989, 2014). The traces and residues of human earth-cutting and earth-moving actions do not fit easily into those conceptual schemes. Formed mainly on land rather than on the seabed, often incorporating elements of intelligent design, archaeological stratification (though similar in many respects to nonhuman geological stratification) exhibits characteristics that are unprecedented in the earlier rock record.

Trying to squeeze such evidence into ill-fitting geological categories might lead one to suppose, for example, that systems of metro tunnels and shafts can be treated as "burrows" (Zalasiewicz et al. 2014a). Of course, in a limited sense they are indeed burrows, but they are much more than that. Leaving aside the obvious difference in scale, metros display some remarkable characteristics that burrows do not. Extraction of quantities of excavated material from deep strata and its mechanical transport against the force of gravity to the surface constitute a form of geological uplift for which there is no precedent in prehuman layers. This is followed by the importing of large quantities of manufactured material into deep strata, such as bricks or concrete to form tunnel linings. Tunnels are typically laid out with a degree of precision of line and complexity of design that does not occur naturally outside of the humanly engineered world. It is important that established geological categories are adapted to accommodate these new configurations of evidence because, as a recent study by Williams et al. (2020) shows, underground metros throughout the world provide a useful stratigraphic signal of rapid urban population growth and energy consumption during the Anthropocene. Or at least they do if the start of the Anthropocene is not specified in the mid-twentieth century, thereby excluding most early metro development. The signal provided by metros is spread out over 170 years (and is continuing to spread through time and space) and cannot be pinned down to a single date.

Archaeological strata are distinct from earlier geological strata in containing an abundance of artifacts and human-manufactured materials (pottery, glass, bricks, concrete, metal alloys, plastics, etc.), sometimes referred to by geologists as "technofossils" (Zalasiewicz et al. 2014b). These can be regarded as trace fossils of human activity and used for correlation and dating purposes. However, it is important to recognize the differences between technofossils and the fossils of natural organisms (Harris 1989). Unlike natural organisms whose remains may be fossilized and preserved in strata, technofossils are not subject to natural selection pressures, or at least not directly. Instead, the development of artifact form over time is socially mediated, with cultural selection processes at work, leading to substantial differences in patterns of distribution and development. Even the fossilization of technofossils may be the outcome of human technological procedures—such as the firing of bricks and tiles or pottery in kilns—rather than natural events. Intention, design, learning, and transmission of ideas, among other factors, are involved. Furthermore, the entry into stratigraphic contexts of technofossils (and plant and animal remains, including human bodies) is facilitated in part by cultural practices of deliberate burial, giving rise to biostratigraphic patterns unknown in the earlier geological record. Geology—a natural science—is being challenged by the material evidence here to develop or adapt its methodologies to account for cultural as well as natural factors and, arguably, to make more use of archaeological methods that are already honed to deal with such geologically unprecedented material.

Recent and contemporary archaeological contexts of rubbish deposition such as landfills (Rathje & Murphy 1992) contain an incredible diversity of technofossils, along with the remains of domesticated creatures such as factory-bred chickens in large quantities (Bennett et al. 2018). Landfilled quarries can be kilometers across and hundreds of meters deep and yet have cuts and

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fills just like posthole and pit features of much smaller size. The almost fractal quality of archaeological evidence (Whitridge 2016) should be noted. The fact that similar stratigraphic configurations manifest on different scales in the material record makes archaeological methods such as the Harris matrix (Harris 1989) extremely useful. Designed for dealing with detailed stratigraphic sequences on relatively small scales, the method can be upscaled and applied on larger scales as well to deal with cuts, fills, linings, and voids of giant landfilled quarries, underground metros, and other mega-scale anthropogenic features (Harris 2014).

Because features cut by humans (or their machines) have not been formed through traditional sedimentary processes, they do not comfortably fit into any existing geological category of deposit, apart from the outlying category of "artificial ground" (Price et al. 2011, Edgeworth 2014). But the word artificial does not adequately describe the mixed character of human-modified ground. With the exception of heavily engineered structures and surfaces such as concrete floors or tarmac surfaces, such ground is almost never entirely artificial. It is formed through a dynamic mixture of human, biological, and geomorphological processes (Schiffer 1996). In landfills, for example, soil bacteria are actively engaged in processes of decomposition of human waste, and the rationale for landfilling is predicated on the participation of such microorganisms. Generally speaking, domesticated species of animals and plants play a large part in the formation of human-modified ground, as do nonhuman material flows such as the transport of sediment by rivers, inextricably entangled with the effects of human agency (Hodder 2012).

Surveys of artificial ground tend to overlook the greater mass and extent of human-modified ground where human and natural forces have combined. Taken as part of the stratigraphic basis of the Anthropocene, however, the traces of nature–human entanglements evident in strata (which fall outside the categories of both artificial ground and natural geology, yet are recognized and recorded as archaeological evidence) have the power to radically transform notions of the anthropos and the Anthropocene, putting into question the assumptions of human exceptionalism deeply embedded therein (Pilaar Birch 2018).

Even the encompassing conceptual geological category of strata is radically challenged. Notwithstanding the early insights of Suess and Sherlock, many geologists are unwilling to accept as geological strata anything not formed entirely by natural agencies. It is commonly held that if the material is not sedimentary then it cannot be strata (Finney & Edwards 2016). Yet one of the most central and generally accepted principles of the Anthropocene concept is that humans are geological agents. If that is so, then their capacity to produce and transform strata—and the status of strata thus produced as intrinsically geological—must logically be acknowledged.

Geology is not the only field that is facing material challenges to its conceptual frameworks. Archaeology too is challenged by its own evidence base in several important respects, in particular by the fact that archaeological evidence is manifesting in areas, domains, and scales where it was not found previously. Older archaeological formations are emerging in regions once thought to be mainly pristine natural environments such as Amazonia (see the next section) or are revealed by melting ice as the climate warms (hence the advent of the new field of glacial archaeology; see Dixon et al. 2014). Later formations are to be found in areas of human operation that have only recently opened up, such as the digital realm (Parikka 2012, Perry & Morgan 2015) and orbital space (Gorman 2005, 2014). Archaeological features and artifacts are no longer just human scaled; they are manifesting on nano and mega scales too (Edgeworth 2010).

As archaeology struggles to keep up with the widening spatial and scalar scope of its stratigraphic and material culture subject matter (Smith et al. 2020), it is prompted by the same material to widen its temporal range to include the present and future as well as the past. It has always seemed strange, and at odds with stratigraphic evidence, to impose an arbitrary point in time at which material ceases to be archaeological, and this notion is radically undermined in

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any case by the new subfield of the archaeology of the contemporary past (Harrison & Schofield 2010, Graves-Brown et al. 2013, González-Ruibal 2018a). Archaeologists traditionally think of artifacts and sites in terms of the past, but they are now being pushed by the evidence itself to explore presents and futures too (Holtorf & Högberg 2016). Witmore (2014) and Harrison & Sterling (2020) characterize archaeology as a future-oriented discipline. Crossland (2014) points out that traces of the human past provide the grounds for new imaginaries of the future.

CULTURAL–NATURAL ENTANGLEMENTS

Archaeological evidence itself is no great respecter of disciplinary boundaries. It manifests in one form or another in the fields of investigation of a host of other disciplines, including geology, river studies, ecology, Earth system science, and so on. In some cases, it has been there all along, buried in stratigraphic evidence, largely unnoticed or perhaps seen as insignificant. When hidden under later supposedly natural accretions or growths, it emerges from the ground up, shattering the illusions of a pristine nature that helped to keep it concealed.

An influential and groundbreaking study in river geomorphology serves to illustrate this point. Streams near the mid-Atlantic coast of the United States had previously been held as archetypes of natural meandering streams, with little or no human influence involved. But this view was completely overturned through a remarkable discovery (Walter & Merritts 2008).

The moment of discovery occurred while the investigators were wading ankle-deep in a small river. They found it puzzling that the river had vertical banks nearly 5 m high, composed of finely laminated silty clays that looked more like pond sediments than floodplain deposits. Walking 100 m downstream, the investigators found a line of large roughly shaped blocks of limestone crossing the stream, disappearing under both banks. They identified these materials as the remains of a dam, built for the purpose of powering mills, and realized that the "floodplain" deposits through which the channel was so deeply incised were, in fact, ponded sediments that had built up against the dam (Walter 2011).

The discovery had radical implications for understanding not just this stretch of the river but the whole river system. Subsequent research showed that it had multiple dams like this positioned at regular intervals along its main course and tributaries. Each abandoned dam had ponded sediment built up against it, creating a historic fill terrace, so that the course of the river became a stepped succession of fill terraces through which present meandering channels are incised. Other streams in the same region had been similarly stepped through the construction of dams, tens of thousands of dams in all.

Evidence of what the rivers were like before any dam construction began survives below all that accumulated sediment. Those earlier rivers were very different, taking the form of braided channels running through wetlands (Walter & Merritts 2008). The postcolonial dams altered patterns of sedimentation so radically that the watercourses underwent massive transformation to a different kind of river entirely.

How did the thousands of dams and their effects on the development of rivers and sediment accumulation go unnoticed by previous investigators? How was it possible for the historic fill terraces to be mistaken for natural floodplain formations? Even though the dams were mostly buried and out of sight, there were plenty of other clues to their existence, ranging from historic maps to living memories of mills to the evidence of the sediments themselves. These were overlooked because of the assumption that this environment was largely natural and pristine.

The Walter & Merritts (2008) study reveals the extent to which human constructions such as dams have become an integral part of what were assumed to be entirely natural stratigraphic formation processes. To properly understand the transformation undergone by rivers, researchers

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must account for the role of archaeological structures in the form of buried dams in shaping sediment accumulation.

Elsewhere in the world, major human-induced transformations of rivers occurred at much earlier dates. The Yellow River in China has been modified to such an extent from the late Neolithic on (Zhuang & Kidder 2014, Kidder & Zhuang 2015) that even river avulsions and catastrophic floods cannot be regarded simply as natural events.

Archaeological evidence is emerging to challenge entrenched and previously unquestioned assumptions about other supposedly natural environments. Vast areas of Amazonia were, until recently, thought to be pristine, virgin forest. Archaeological evidence that counters this view has come to light only now that remote sensing can penetrate the thick forest canopy and deforestation has removed so many trees. Discoveries of ancient roads, houses, ceremonial mounds, settlements, ditched enclosures, and anthropogenic soils known as terra preta are overturning the myth of the natural rainforest. Large parts of the forest have clearly been managed by indigenous peoples for millennia—in terms of growing domesticated crops and engaging in forms of agroforestry—and, in some places, supported high population densities in pre-Columbian times (Roosevelt 2013, de Souza et al. 2018).

In northern Bolivia, the earthwork remains of thousands of forest islands have been found, which rise above the surrounding savannah and stay above water in times of flood. These remains contain evidence of domesticated crops such as squash and cassava from as far back as 10,000 years ago, much earlier than was previously thought possible (Lombardo et al. 2020). In northwestern Brazil, hundreds of large geometric ditched enclosures up to 300 m in diameter and with enclosing ditches up to 11 m wide and 4 m deep were recently discovered in deforested areas once thought to have been virgin forest (Watling et al. 2017). In areas of Amazonia that are still forest, domesticated varieties of trees are found in the greatest profusion in the vicinity of pre-Columbian archaeological sites, and biodiversity seems to increase in areas where there are accumulations of terra preta or dark earth. This evidence suggests that the present state of the forest with all its immense biodiversity is at least in part an outcome of human–wild interactions in the past (de Oliveira et al. 2020).

The Anthropocene concept is sustained by perceptions of environments such as the Amazon rainforest as being entirely natural, at least until recent human interventions associated with the proposed new epoch. It implicates the idea that the Earth system was in a natural state up to a certain recent point in time and that it transitioned more or less instantaneously into a human-dominated state (Steffen et al. 2016). This temporal version of the nature/culture dichotomy, placing the conceptual division in time as well as in space, pervades the Anthropocene idea. Archaeological evidence indicates something different (Stephens et al. 2019, 2020). It suggests that human and natural forces have been deeply entangled for considerable periods of time, with no sudden shift in state from natural to cultural. Recent intensification of human impacts in the form of the Great Acceleration (Steffen et al. 2015) is undeniable, but the idea that the transition to a human age occurred in the mid-twentieth century is highly questionable.

IMPLICATIONS OF ARCHAEOLOGICAL EVIDENCE FOR THE ANTHROPOCENE

The most important implication of archaeological evidence for the Anthropocene is that it needs to be reconfigured as a more loosely-defined time-transgressive event, biozone, or episode of Earth history instead of as a chronostratigraphic time unit. This reconfiguration would focus attention on the processes of Earth system transformation, in which humans are playing a significant role (Braje 2018, Simonetti 2019), rather than on the date of onset. Instead of an instantaneous transition from a natural state to a cultural state, there would be greater concern

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with root causes and with interactions between natural and cultural forces that are spread over time, without losing the main focus on recent and contemporary changes. The Great Acceleration could then be more accurately understood as an intensification or acceleration of existing trends rather than as a sudden change of state of the Earth system.

Such a shift would bring the geological concept of the Anthropocene more into alignment with current thinking in the social sciences and humanities (Horn & Bergthaller 2020, Clark & Szerszynski 2021) and encourage greater interdisciplinary collaboration. Treating the Anthropocene as time-transgressive would give greater credence to stratigraphic evidence and human-modified strata in particular, which has been largely neglected up to now because of its diachronous character. The imperative to specify a precise moment of onset would no longer be prioritized over what strata themselves tell us. The empirical ground of stratigraphic evidence would be accorded primacy over the requirements of time charts or other conceptual schemes. As Clark & Szerszynski (2021) argue, planetary thought implies thinking with and through the Earth. Earth is best thought of as a participant rather than a subject of the Anthropocene debate.

This involves an acknowledgement that the substantial body of human-modified ground, far from being just a passive record, is an active part of the Earth system, with effects on (and interactions with) the hydrosphere, biosphere, and atmosphere (Edgeworth 2018). For example, tens of thousands of coastal landfills worldwide are subject to erosion and inundation by rising seas caused by climate change, releasing large amounts of buried plastic into rivers and oceans (Brand et al. 2018), with consequent effects on marine wildlife. At the same time, landfills produce quantities of methane, increasing the levels of greenhouse gases in the atmosphere, thereby contributing in small measure to global warming.

Not all human residues or transformations of the Earth's surface have dire consequences, however. Boivin & Crowther (2021) give many examples from the archaeological record of past solutions to environmental problems that could usefully be applied today.

Last but not least, the anthropos itself—the notion of the human implicit in the Anthropocene term—is problematized by archaeological evidence. Human impacts on physical strata and on the Earth system as a whole are inextricably mixed with the impacts of domesticated species, human-modified rivers, and other geomorphological and biological forces (Olivier 2020). The seemingly clear and unequivocal boundary drawn around the category of the human is largely illusory. And the same goes, as González-Ruibal (2018b) argues, for the assumption of a homogenous and undifferentiated humanity within. Archaeological evidence points to differences between cultures and communities as much as similarities, highlighting inequalities and divisions, unequal access to resources, and wide variation in status and wealth as reflected in material culture patterning. Woodfill (2019) suggests that the Anthropocene term conflates the atmosphere-polluting and climate-changing activities of modern industrial society in the West with those of all humanity, pointing out that archaeological evidence presents a much more variegated and uneven picture. Taking such evidence into account, Bauer & Bhan (2018) redefine the anthropos as a heterogeneous assemblage of people, other living creatures, and dynamic materials, which combine in various ways to act in response to different environmental challenges. With such a broadening out of the concept of the human, the term Anthropocene arguably seems more appropriate than when defined in terms of human exceptionalism or human domination over nature. Archaeology matters, according to Barrett (2021), because of the insights it offers into "different forms of humanness."

Will the Anthropocene be formalized as a new geological epoch beginning in the mid-twentieth century? Going against the grain of opinion of most members of the Anthropocene Working Group, I predict that this will not happen. Stratigraphic indications of diachronous beginnings are just too substantial to be discounted out of hand. Instead, there are signs that time-transgressive archaeological evidence, manifesting in multiple fields, is already helping to

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transform the very idea of the Anthropocene. Thus soil scientists Certini & Scalenghe (2021), who 10 years ago sought to tie anthropogenic soils to a timeline of 2,000 years before present, now use the same evidence to argue that "soil is the best testifier of the diachronous dawn of the Anthropocene." Expect other authors to take a similar change in tack. Prompted by the sheer diachroneity of the stratigraphy itself, the relevant geological commissions and working groups are more likely in the end—after due consideration of all the evidence—to informally designate the Anthropocene as a time-transgressive event, independent of the International Chronostratigraphic Chart and without a specified starting date.

CONCLUSION

Archaeological evidence has an important contribution to make to the Anthropocene debate. It comprises an extremely rich source of stratigraphic data about human–environment relations on multiple scales over the last ~10,000 years, including modern and contemporary periods (Boyd 2018), and gives crucial time depth to any understanding of landscape modification and human-induced Earth system change. Knowledge of the past gained through archaeological investigation of material remains can be mobilized to shape a better understanding of the Anthropocene (Rick & Sandweiss 2020, Boivin & Crowther 2021). But a common misunderstanding is that archaeological evidence relates only to the past and can tell us only about events and processes that happened before the modern period. This assumption is mistaken. Stratigraphic sequences of the archaeosphere have never stopped forming and are still very much in the process of formation. Indeed, the rate of accumulation and spread of archaeosphere strata in the last 70 years has increased so dramatically that this material could itself be used as the major stratigraphic signal of the Great Acceleration.

Some archaeologists have counseled more restraint and less hubris in making the case for archaeology's potential role in debates about climate change and other environmental issues (Lane 2015). Thus Skeates (2012) pleads that archaeology is only a small field, relative to larger and better-funded disciplines such as geography, without the same political weight. But this review has not been just about archaeology as an academic discipline, narrowly defined. It has also been about archaeology's evidence base of human-modified ground in the archaeosphere, which has its own independent existence. And the archaeosphere is truly vast—a hyperobject, no less—with powers to shape and influence that belie its status as a mere stratigraphic record. Archaeological evidence is bringing itself to the attention of the multidisciplinary research community, whether archaeologists actively argue its case or not.

Speaking from a geographical and land ecology perspective, leaders of the ArchaeoGLOBE project (which collated and mapped findings on land use over the last 10,000 years from more than 250 archaeologists worldwide; see **https://dataverse.harvard.edu/dataverse/ArchaeoGLOBE**) recently stated that archaeological knowledge is increasingly becoming "a crucial instrument for understanding humanity's cumulative effect on ecology and the Earth system, including global changes in climate and biodiversity" (Stephens et al. 2020).

As the rapidly expanding material residue of human activity gathers pace in accumulating and spreading over stretches of land, riverbed, lakebed, and seafloor, it inevitably transforms the habitats of numerous plant and animal species. How could it merely provide a material record of past events and nothing more? How could it not have active effects and impacts of its own on the wider environment and on the Earth system of which it is a part?

At the same time that this expansion of human-modified material is taking place, earlier archaeological evidence emerges from the ground to surprise and transform entrenched ideas about supposedly untouched areas. In some cases, this evidence may have been hidden from view by

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dense forest or accumulated sediment or by ice that is now melting as the result of climate change, and it comes to light when those occluding layers are removed (or by remote sensing). Yet nothing masks or buries such evidence quite as deeply as the widespread myth of a near-pristine nature held to have been in existence prior to the proposed Anthropocene epoch, structuring modes of thought in terms of the nature/culture dichotomy and shaping perceptions of landscapes accordingly. When evidence is buried by ideas, it is much more difficult to bring to the surface than if it were buried under more solid material. Only a radical questioning of deeply held assumptions and a rethinking of basic frameworks can bring it fully into the open, which makes its potential impact all the more powerful when it does emerge into view.

In conclusion, archaeological evidence provides both substantive stratigraphic support and a significant material challenge to the developing concept of the Anthropocene. It is pivotal to the now pressing task of reconfiguring the Anthropocene as a time-transgressive event, episode, biozone, or transformation, providing a common ground for a more interdisciplinary and process-based understanding of human-influenced Earth system change.

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