

Archaeological approaches to plastics and plastic pollution: A critical overview

Estelle Praet^{1,2} , John Schofield¹  and Raveena M. Tamoria¹

¹Department of Archaeology, The King's Manor, University of York, York, UK and ²Department of Scientific Research, The British Museum, Great Russel Street, London, UK

Perspective

Cite this article: Praet E, Schofield J and Tamoria RM (2024). Archaeological approaches to plastics and plastic pollution: A critical overview. *Cambridge Prisms: Plastics*, 2, e32, 1–11

<https://doi.org/10.1017/plc.2024.22>

Received: 01 April 2024

Revised: 26 May 2024

Accepted: 11 June 2024

Keywords:

contemporary archaeology; Galapagos; garbology; plastics; policy; toxic heritage; microplastics

Corresponding author:

Estelle Praet;

Email: estelle.praet@gmail.com

Abstract

In this overview, we examine some of the ways in which archaeologists have increasingly turned their attention to the contemporary world, focusing not on ancient artefacts but on the material legacies that we ourselves are creating and what they tell us about ourselves, including the impact we are having on planetary and human health. One aspect of this “contemporary archaeology” is the study of modern waste, an area of research often referred to as “garbology.” Originating in the later 1960s, this study of modern waste is typically focused on the plastics that characterise what is now commonly referred to as the Plastic Age, a supposedly more familiar past aligning with both cultural experience and memory. The paper emphasises archaeology’s strong interdisciplinary traditions, particularly in its use of scientific methods, which make it easier for archaeologists to work within interdisciplinary teams and with other stakeholders and with policymakers, these being particularly relevant in studies that focus on the contemporary world. The paper concludes by describing how archaeologists are using these perspectives on the contemporary world to cast their eyes forward to the future.

Impact statement

Archaeologists are used to generating impact, whether through the significance of new data from excavations impacting policy or public perceptions of climate change, or creating well-being benefits related to the cultural participation opportunities that archaeology typically entails. For archaeologies of the contemporary world, and notably for those archaeologists working with plastics, those impacts are proving to be equally, if not more evident. Taking an archaeological perspective on plastic items, investigating them as artefacts, can create meaningful object itineraries that help understand the journeys plastics have taken from source to sink and how human behaviours have shaped and influenced these journeys. Archaeology’s deep-time perspective contributes to new insight into heritage futures and the likely legacies of this toxic heritage on planetary and human health. Landscape archaeology takes a broader view on impacts, along coastlines for example, documenting how plastics can compromise visual integrity as well as the impact on, for example, Indigenous communities who inhabit these areas. In a more conventional sense, plastic items can also act as chronological markers, for example as techno fossils within stratigraphic sequences, markers to phases across a Plastic Age whose future trajectory is far from certain but which archaeology can help to predict.

Introduction

Archaeology is no longer just about looking at the stuff of the past – the traditional view that you were an archaeologist only if you did archaeology by digging the earth (Flannery, 1982; Shanks and McGuire, 1996). Archaeology also has the capacity to offer important insights to understand, contextualise and solve current global challenges from migration to environmental change (Huvila *et al.*, 2022). It is the discipline of resilient things, of stuff that remains, which reflects an important affinity with this “new” era – that some refer to as the Anthropocene (Pétursdóttir, 2017), and within it, the Plastic Age. Climate change to which plastics’ life cycle contributes (Ford *et al.*, 2022) has become the biggest challenge facing our planet. Plastic litter accumulates in the oceans and on beaches, becoming one of our most significant archaeological legacies (Holtorf, 2024) and undoubtedly the most impactful contemporary material culture deposited in the archaeological records of this Plastic Age.

Characterised as a “wicked problem” (after Rittel and Webber, 1973; see Schofield, 2024 for its application through archaeology and cultural heritage) with expectations to double within the next 20 years (Lebreton and Andrady, 2019), plastic pollution poses serious and unprecedented threats to human health and environmental security. This paper provides an illustration of the broad range of theories, methods and tools that archaeology offers in studying plastics and plastic

© The Author(s), 2024. Published by Cambridge University Press. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

 Cambridge Prisms

 CAMBRIDGE UNIVERSITY PRESS

pollution. Archaeologists and heritage practitioners are uniquely poised to enrich plastic pollution discourse by contributing evidence-based knowledge gained via archaeological research and investigation, thus providing valuable contributions and perspectives. While Zimmerman's research looks at archaeology of homelessness, his assertion is also appropriate to plastic pollution – that archaeology's applicability to the present stems from three key elements: studying material culture, building accurate narratives about the past based on what is found and using the narratives to suggest changes relating to social concerns (Zimmerman, 2013). Similarly, Praet (2024) outlines several ways archaeologists approach plastics, either as cultural artefacts, studying their journeys from production to waste or examining them through the lens of how plastics affect diverse landscapes and create new geographies. Equally, Wooten (2023) argues that historical archaeology provides a potential methodology to collect modern environmental data that contributes to meaningful solutions to the global climate crisis. All these methods provide the necessary and substantial scientific output required for effective and well-rounded policy-making and governance.

Archaeologies of the contemporary world

The contemporary world and the material traces that characterise it became topics of interest within archaeology in the late 1960s. The motivation with this early work was initially to study modern material culture among contemporary hunter–gatherer communities as a means to better understand the human behaviours of Palaeolithic peoples (e.g. Binford, 1978; see also Yellen, 1977). These studies led to the first publications to discuss the merits and the theoretical foundations of a more contemporary archaeology (e.g. Rathje, 1979), being the study of modern material culture for what it tells us, specifically, about the contemporary world: the archaeology of us (Gould and Schiffer, 1981). This emphasis on archaeology as an approach to investigating the contemporary world then developed further after 2000, to match the reflective mood of the new millennium (e.g. Graves-Brown, 2000; Buchli and Lucas, 2001a). All of these developments are summarised in Harrison and Schofield's (2010) overview, which describes how these approaches share an interest for the complexities of a globalised, overwhelming and challenging material culture and how this material culture both shapes and characterises the world.

As described, and building on earlier work, archaeologists started to formally consider the “contemporary past” as an object of study in its own right in the early 2000s. The potential of modern material culture as a source of information and an archaeological object of interest was notably explored in “*Matter, Materiality and Modern Culture*” (Graves-Brown, 2000). Several volumes followed, emphasising the contribution of contemporary archaeology. For example, as a discipline that contributes to building memory and resilience through ethical means (*Archaeologies of the contemporary past* by Buchli and Lucas, 2001a) and contemporary archaeologies as a diversity of practices acting as a way to “marry archaeology in the modern world and archaeology of the modern world” (Holtorf and Piccini 2009: 16). In a sense, these publications and the projects whose descriptions they contain were building on the awareness that archaeology is situated and political (Gonzalez-Ruibal, 2008) and advocated for its relevance in contemporary context. In *After Modernity* (2010), Harrison and Schofield defined an archaeology of the contemporary past corresponding to the Late Modern period that distinguishes itself by increased communicative technologies and electronic media, a globalised technology

impacting production and consumption, mass migration, new modes of capitalism and more leisure time. Reflecting on the challenges of an archaeology *of* and *in* the present, and the need for multidisciplinary perspectives, Graves-Brown *et al.* (2013) preferred to use “archaeology of the contemporary world” while recognising its relevance for the world's future. A recurrent theme in archaeologies of the contemporary past is their ubiquity and inclusivity. Never had any field of archaeology tried so hard to broaden the discipline by including more specialists, reiterating that “we are all archaeologists now” because we all have something to say about our contemporary and (allegedly familiar) material culture (Harrison and Schofield, 2010; Holtorf, 2015: 217).

Several academic traditions have contributed to providing a different perspective on contemporary archaeologies. While contemporary archaeology is seen as an extension of historical archaeology in North America and Australia, for example, the Latin American perspective has emphasised the discipline's importance for recovery notably after disaster and conflict (González-Ruibal, 2018). The British/Nordic tradition has focused on the concepts of landscapes and esthetics, using surveys more than excavations while objects and their histories were key to the mainland European perspective (González-Ruibal, 2018). Looking at the recent past has also allowed more collaborative approaches in archaeology and heritage management, notably in Australia with the involvement of Indigenous peoples defining their relationship with their surrounding heritage and environment whether recent or not (e.g. Ross *et al.*, 2010; Brady, 2016; Jackson, 2023).

In brief, the last two decades have contributed to refining this new field of study and distinguishing it from ethnoarchaeology, archaeological ethnography, and historical archaeology despite the thematic and methodological overlaps between those disciplines (see Harrison and Breithoff, 2017 for a thorough discussion of these areas of overlap). An annual conference was established in 2003, Contemporary and Historical Archaeology in Theory, or CHAT, resulting in numerous edited conference proceedings (e.g. McAtackney *et al.*, 2007), while a dedicated journal (the *Journal of Contemporary Archaeology*) launched in 2013. Yet, the discipline has faced critique, sometimes described as not being proper archaeology. Its detractors worry about the limited or absent time-depth of the research focus, an argument often used to criticise historical archaeology compared to the universally valued archaeological research of a remote and exotic past (Gilardenghi, 2021). These critiques emerge from a consideration of the discipline of archaeology as excavation-based, failing to realise also the archaeological significance of the “surface assemblage” (Harrison, 2011). In this work, we use contemporary archaeologies as a framework building both on the creativity and diversity of their applications, their ability to foster interdisciplinary approaches and their relevance for current and future challenges notably that of plastic pollution. But before considering the issue of plastic pollution, we provide an overview of the intersections that exist involving archaeology and modern material culture.

Archaeology and modern material culture

Material culture (i.e. things and objects that humans and non-humans interact with¹) has always been central to the study of archaeology. While archaeologists have always worked with

¹It is beyond the scope of this paper to offer a thorough review of material culture studies. There are several resources available to understand its development including Hicks and Beaudry (2010) and Knappett (2005).

artefacts, the Material-Culture turn (i.e. the shift to materials occurring in the 1980s in British archaeology and anthropology following a revival of interest for materials across different disciplines, as detailed by Hicks, 2010) opened the potential of material culture for other, and notably social scientists (Schiffer, 2017: Chapter 29). However, in spite of their central position within archaeology, the role and importance of material culture have shifted over time, from providing ways to identify cultural groups (for Culture Historians) to becoming a source of information about people's behaviours, even including contemporary material culture.

Processual archaeologists were the first to consider contemporary material culture as being of interest to answering archaeological questions. Following and contrasting the approach of Culture Historians associating shifts in artefact typology and style with cultural changes (e.g. the Neolithic "revolution" proposed by Childe, 1935), processual archaeology developed an interest in cultural processes through the extensive use of models and systems thinking (e.g. Binford, 1962, 1965). Processual archaeology also explored contemporary ethnographic examples as a way to infer past practices and behaviours (Renfrew 2011: Chapter 12). This interest in ethno-archaeology was fully explored in the study of Millie's Camp (Canada) as an archaeological site. In this study, Bonnichsen (1973) analysed a contemporary camp from an archaeological perspective and inferred behaviours and practices from the material record, following its abandonment. The conclusions were then tested against information shared by Millie, a former camp occupant (Bonnichsen, 1973). Taking a case study from the recent past, this study allowed archaeologists to test inferences and biases existing in archaeological interpretations.

Building on processual archaeology, behavioural archaeology focused on the relationship between material culture and human behaviours (Schiffer, 2002, 2010), including modes of inferring about past/present practices through past/present material culture (Reid *et al.*, 1975). Through different strategies (Reid *et al.*, 1975), behavioural archaeology mostly explored past and modern material culture as a source of information about people. Several projects were developed in the late 1960s and 1970s that combined those methods to investigate modern material culture, the most emblematic of which was the Garbage Project developed by William Rathje.

This project regarded modern garbage as a source of interest for archaeologists and a way to acquire information about the consumption patterns of contemporary society. Rathje contributed to the development of Garbology, a term introduced and put into practice by the journalist A.J. Weberman (1980), who analyzed garbage from his idol Bob Dylan and then from various other famous individuals. Rathje's Garbage Project developed this idea, promoting the scientific and systematic application of archaeological methods, such as surveys and typologies, to study contemporary waste (e.g. and notably Rathje and Murphy, 2001). In the US, between 1973 and 2005, the Garbage Project analysed 192.2 tons of garbage from 20,416 households in seven areas, 45.3 tons of refuse from 19 landfills, and four open dumps in 15 cities (Rathje, 2011). Through their research, Rathje's teams noted paper as being the most voluminous category within landfills, realizing however the significance of plastics whose proportions changed little between fresh household garbage and landfill due to their non-biodegradability despite advertised promises. This contemporary archaeology project therefore produced new information around consumption levels, food waste and reactions to shortages (Reno, 2013). The Garbage Project emerged in an era concerned with social and environmental issues (Reno, 2013), which makes it still

very relevant today. The legacy of the project is still visible with several approaches using waste as a method to understand social practices (Höglberg, 2017), reconstruct narratives of illegal migrations (De León, 2015), and of object journeys (Schofield *et al.*, 2020), and as an engagement tool in marketing research (Damron-Martinez and Jackson, 2017).

In the mid-1980s, post-processualism brought the focus on the meaning and symbolism of material culture and how this shaped human social practices (Trigger, 2006: Chapter 8; for a review on the development of post-processualism see Preucel, 1995). Post processualists looked at material culture *per se* and not as an interpretative tool (see Hicks, 2010), recognising the agency of objects (Jones and Boivin, 2010). From that perspective, post-processualists in the UK started to use contemporary material culture to reflect on social meaning and values. Research on the design of beer cans in Sweden versus Britain (Shanks and Tilley, 1992) and the wearing of bow ties in a pet food factory (Hodder, 1987) led to the understanding of modern material culture within social practices (summarised in Harrison and Schofield, 2010: 187–188). This approach slowly expanded the potential meaning and relevance of modern material culture while recognising its complexity. The use of material culture as a prism into culture, behaviour or society, had reached its limits, often reproducing an object-subject dualism, with the object informing about different aspects of the subject's life. Several frameworks were since proposed to study material culture, questioning researchers positionality thanks to indigenous and feminist archaeologies (Hicks, 2010), developing object-centred approaches (e.g. Olsen, 2010), investigating object agency (Gosden, 2005), and recognising how objects are entangled in relationships with different actors through Actor Network Theory (ANT) (Latour, 1996, 2005). Building on archaeological reflections on posthumanism (de-centering of the human, see Fernández-Götz *et al.*, 2021) and New Materialisms (a recognition that materials are central for archaeologists but considering them in a non-reductionist manner, see Witmore, 2014: 205), archaeologists considered ways to apply these frameworks to the archaeological record (e.g. Fowler and Harris, 2015) including of the contemporary era (e.g. Yaneva, 2013).

Those expanding perspectives were facilitated by the consideration for modern and contemporary material culture, particularly in anthropology and sociology (e.g. Hawkins *et al.*, 2015 for an analysis of bottled water), but also in archaeology (Erny and Caraher, 2020; Letelier Cosmelli and Goldschmidt Levinsky, 2021). From that perspective, much of modern material culture became archaeological objects of research and even archaeological sites including a Ford Transit van (Bailey *et al.*, 2009), a computer hard drive (Perry and Morgan, 2015), and video games (Newell *et al.*, 2022). Among those studies, some focused on new synthetic materials, such as plastics (e.g. in the form of leisure items such as vinyl records and toys), and offered avenues to explore different concepts, such as that of nature/culture as a holistic framework for investigation, extending beyond the conventional dualism, and to recognise the actions of both human and nonhuman actors. The entanglement of plastics with humans and non-humans alike, and its contribution to new geological forms make these distinctions even less relevant for contemporary assemblages. The focus on modern material culture therefore inscribes itself in those approaches, opening interpretations beyond an anthropocentric and western lens. This focus on modern material culture developed alongside an interest for modern societies in their integrity that naturally became a topic of interest for (contemporary) archaeologists. The specificity of modern material culture entangled in global,

colonial, and complex networks requires tailored archaeological frameworks to explore how they contribute to shaping our societies culturally, socially, politically, and economically. In this paper, we emphasise the framework of object itineraries that we consider particularly helpful to understand plastics as global artefacts (see for example, the global journey of a flip flop by Knowles, 2015). The following section will present how object itineraries are particularly suited for the study of plastics as artefacts characteristic of the Plastic Age.

Object itineraries

The interest in artefacts, and their complex histories, led to the development of the *chaîne opératoire* due to the theories of anthropologist Marcel Mauss (1936) and the contributions of archaeologist Leroi-Gourhan (1964) to account for the sequence of actions necessary for an artefact's production. (see Lewis and Arntz, 2020 for a review of the term's genesis, present uses and potential developments). This concept offered a very systematic way of reconstructing the different steps included in the making of an object. It offered possibilities to inform on the technology of societies (Martinón-Torres, 2002) and was first predominantly used by French academics for lithics studies (Sellet, 1993). The *chaîne opératoire* mostly focused on objects by reconstructing production steps, starting with the procurement of raw material and ending with the discard of the artefact (Sellet, 1993). However, the framework and its focus on technology were deemed too rigid to understand other aspects of artefact production (Bar-Yosef and Van Peer, 2009), which were central to the development of alternatives inferring behaviours from the material record. For example, Schiffer (1975) developed the behavioural chain analysis, considered in some ways very similar to the *chaîne opératoire* (Sellet, 1993; Martinón-Torres, 2002; Lewis and Arntz, 2020), aiming to reconstruct a sequence of activities and testing how these correspond to the archaeological record. In his development of behavioural archaeology, Schiffer (2002, 2010) was interested in cultural and noncultural processes, including taphonomic factors, to reconstruct materials' life histories and understand the record the archaeologists are faced with (Schiffer, 1975). Both the *chaîne opératoire* and the behavioural chain analysis have since informed studies using the *chaîne opératoire* to reconstruct with more precision the steps of artefact production, use, and discard for a wide range of materials (e.g. Driscoll, 2009; Drieu *et al.*, 2020). Since then, the concept has evolved to be more inclusive of social practices and its reconstruction has built upon multidisciplinary works, facilitated by the rise in material science studies (Lewis and Arntz, 2020). While the social and cultural aspects of material culture are therefore considered in more recent applications of the *chaîne opératoire* (Lewis and Arntz, 2020), it was their absence that led archaeologists, particularly post-processualists, to look for approaches focusing on the social life of objects such as object biography and life histories.

The consideration for the sociality of material culture naturally led archaeologists to focus on how the social nature of objects was expressed through interactions with humans and how their lives paralleled our own. Two concepts were developed building on an analogy with human life: object biographies and life histories. First coined by the anthropologist Kopytoff (1986), object biographies were seen as a way to ask the same questions about objects (or, as he called them, *things*) and people, including their origin, cultural meaning, and the changes throughout their lives. A *thing* could have multiple biographies whether social, economic, or technical

but all would be culturally constituted (Kopytoff, 1986). The potential of the framework was then explored for archaeological artefacts in Gosden and Marshall's (1999) landmark publication. These authors considered object biographies as an accumulation of histories and relationships with people crystallising in the present significance of the objects. Biographies facilitated the consideration of shifting and changing meanings and perceptions during the life of an artefact (Hahn and Weiss, 2013). Life histories, already considered as a part of behavioural archaeology (Schiffer, 1975), aimed at understanding and reconstructing the trajectory that artefacts had taken, adopting a social (e.g. Holtorf, 1998; Crown, 2007) or technological lens (e.g. Sáenz-Samper and Martinón-Torres, 2017; Plaza Calonge *et al.*, 2022). While the focus on morphological and/or functional changes had been central to use-life approaches developed by processualists (Tringham, 1995), life histories also considered the social interactions in which objects and monuments were and still are entangled (e.g. Holtorf, 1998), and the meaning they hold (Gosden and Marshall, 1999). The concept allowed for an object's life to be told independently from its maker(s) or owner(s), a vision particularly helpful when multiple hands contribute to the existence of clay pots (Crown, 2007) and to consider the role of past monuments for subsequent societies (Holtorf, 1998).

Limitations of both concepts were quickly identified, and scholars attempted to clarify both frameworks to make them more nuanced. Despite the success of object biographies for almost 25 years in archaeology (Mytum, 2003/2004; Pearson and Connah, 2013; Jones *et al.*, 2016; Guzzo Falci *et al.*, 2020), concerns regarding its limitations were also raised. For example, limitations of object biographies include the ontology (dualism subject/object), the linearity of the reconstructed biography and the start and end point of an object's life (see Hahn and Weiss, 2013; Bauer, 2019). The risks posed by the linear nature of object biographies was already identified by Joy (2009), who advocated for a relational biography focusing on the set of relationships an object was entangled in. Scholars using life histories identified similar issues, particularly the determination of start (birth) and end (death) points (see Holtorf, 1998 for the death of megalithic monuments). To acknowledge this, Holtorf (2002) distinguished between short and long life histories, the former including an object's life until it is buried, whereas the latter extends to include interactions that led the object to reach the present time. The development of the long life histories framework enabled Holtorf (2002) to situate material culture in the present while recognising its extension into the past and the future and evaluate the evolution of its meaning through time. Despite those attempts, the development of a new framework, object itineraries, allowed archaeologists to move away from the problematic analogy with human life at the core of object biographies and life histories.

First proposed by Rosemary Joyce (2012a, 2012b), object itineraries are defined as "routes by which things circulate in and out of places where they come to rest or are active" (Joyce, 2015: 29). Central to the volume edited by Joyce and Gillespie (2015a), the potential of object itineraries as an alternative to object biographies was explored for archaeological artefacts, fully considering the modalities of circulation of the objects. Going beyond the tension between relational and narrative biographies, itineraries connect objects to their representations (Joyce and Gillespie, 2015b) and the engagement they have with researchers and with the public (Joyce, 2015). Since then, the concept has gained interest in archaeology (e.g. Joyce, 2017) including examples from museum (e.g. McGill and St. Germain, 2021) and heritage studies (e.g. Bauer, 2021),

creative writing (e.g. Nisbet, 2021), and even marketing research (e.g. Santana and Botelho, 2019). The framework has been seen as having several advantages over object biographies (see Bauer, 2019), for example mapping out how the stops and journeys of an object can be interconnected (Nisbet, 2021) and working on different temporal scales, from human life span to geology (Joyce, 2015). Object itineraries also allow us to consider the ethical and political implications of material culture (Bauer, 2019). In that perspective, the potential of object itineraries is key to moving beyond the limitations that life histories and biographies could not overcome. Itineraries offer space to consider a network of processes and relationships that go beyond the temporal, human and geographical scales usually considered. For plastics, this is particularly important because of their persistence, plasticity, ubiquity, untraceability, and “globalised unlocality” (Davis, 2022: 5). This framework suits plastics particularly well, breaking away from the technical focus of *chaîne opératoire*, the linearity of biographies, and the analogy with human life. This constitutes a framework that is well suited to the archaeological investigation of plastics as artefacts embodying the Plastic Age.

The Plastic Age

Like many categories of artefacts from earlier periods, plastics are abundant, ubiquitous, and pervasive within the contemporary world, and this has been increasingly the case since about 1950 when plastics started to become widely used, not least in food packaging. Yet, it is the persistence and the impact of their presence that separates plastics from other materials of earlier periods. Their ubiquity and the way they affect people unequally emphasise the colonial dynamics in which plastics are entangled, from production to disposal (Liboiron, 2021; Davis, 2022). By being global, colonial, political and persistent, they embody anthropic impacts on the environment, a key characteristic of the Anthropocene. While recently dismissed by the International Union of Geological Sciences (IUGS) as a geological epoch (Witze 2024), the Anthropocene remains a relevant concept for scholars from a wide range of disciplines interested in exploring the distinct nature of human impact since the 1950s. While we recognise the key role that plastics played in defining and studying the Anthropocene (e.g. Zalasiewicz *et al.*, 2016), we here prefer the term Plastic Age, as a more archaeologically oriented term.

The term Plastic Age, first mentioned as the title of an American novel written by Percy Marks in 1924, has become a term adopted by different scholars (Thompson *et al.*, 2009; Porta, 2021; Kramm and Völker, 2023), to mirror the periodisation of earlier periods such as the Stone Age, the Bronze Age and the Iron Age. Similarly to the Anthropocene, debates have arisen regarding the starting point of the Plastic Age. The invention of synthetic plastics in the early twentieth century, and their increasing importance served to suggest a starting date for the Plastic Age after the First World War (e.g. Sklar, 1970). Yet, the consumption of plastics increased drastically after the Second World War to meet the demands of post-war societies rushing into mass consumerism (Meikle, 1992; Strasser, 2000). This period also coincides with the diversification of plastics’ chemical signatures (Geyer, 2020), hence making 1950 a most commonly accepted starting date for the Plastic Age, as stated above. A few variants were also proposed including the Plasticene (Ross, 2018; Haram *et al.*, 2020), starting in 1907 (corresponding to the invention of Bakelite as the first fully synthetic plastic) with an intensification since 1950 (Rangel-Buitrago, Neal and Williams,

2022), and the Plastics Age (Sparke, 1993 in Hawkins, 2018). Following the use of the singular for other periods, and as stated above, we here refer to the Plastic Age (as in Godin *et al.* 2024) while recognising diversity within its scope. The Plastic Age emphasises the key role of plastics as material culture shaping practices of our contemporary societies, mirroring archaeological periods centred on the material properties and technology of artefacts (Graves-Brown, 2014). Aside from being a material culture that most people interact with daily, plastics are becoming historical, entering museum collections subject to conservation treatments, and yet also forming a “toxic heritage” (after Kryder-Reid and May, 2024).

The history of synthetic plastics highlights how they have acquired socio-economic values and importance. In that sense, they have become what archaeologists consider artefacts, shaping new social practices (Hawkins, 2018) and holding cultural meaning (Ingold, 2000). Emblematic of our contemporary world, plastics were praised and hated equally. In the first instance, plastics were seen as cheap substitutes for other materials (Bensaude-Vincent, 2013), offering a way to protect natural resources while paving the way for democratisation of several products. There followed a tangible excitement to explore the potential of plastics’ materiality in art and design, preceding an ecological consciousness of plastics’ impacts and persistence (Bryning, 2024). Plastics were also of interest to scholars studying modern material culture including archaeologists, notably as a symbol embodying consumer culture, supermodernity and destruction (in the sense defined by González-Ruibal, 2018). For example, the plasticity of plastics, and their mutable qualities, created new socio-economic dynamics and markets (Hawkins *et al.*, 2015; Dey, 2021), but also reinforced and reproduced some immutabilities including exposure to waste (Dey, 2021).

Plastic artefacts enter the archaeological record and can even become part of the geology. Corcoran *et al.* (2013) were the first to identify a hybrid artefact (in the sense given by Liebmann, 2015) in Hawaii, which they called *plastiglomerate*. Since then, different ways in which plastic can be the locus of nature/culture hybridisation have been identified (see Rangel-Buitrago, Neal and Williams, 2022 for a review of the ways plastics are included in the geology). The “Plastic Geological Cycle” is a term proposed by Rangel-Buitrago, Neal and Williams (2022) to explain the processes and pathways by which plastics, especially micro- and nano-particles, are incorporated into the Earth’s geosphere and potentially impact the natural rock cycle. The existence of anthrosols (i.e. a mix of litter with organic and/or mineral matter) and *plastisols* (i.e. plastic mixed with organic and/or mineral matter) (Rangel-Buitrago, Neal and Williams, 2022) highlight how plastics can also enter the archaeological record and indicate layers of occupation.

Archaeologies of plastics and plastic pollution

With the long-standing interest of archaeologists in the waste generated by human societies, plastic litter and pollution have become the focus of several studies. The accumulation of plastics was identified on the Iron Age heritage site of Castell Henllys (Wales) where the sites of two reconstructed Iron Age houses were excavated by Mytum and Meek (2020). Plastics were considered as artefacts informing on the site’s visitors’ behaviours (Mytum and Meek, 2020). Building on the potential of material culture to inform behaviours, an archaeological framework was used to correlate the accumulation of plastics in rivers with littering behaviours

(Carpenter and Wolverson, 2017). Taking a landscape approach, surveys of drift matter including plastics yielded insight into the human relationship to this material culture and how it is perceived locally (Pétursdóttir, 2017, 2020). Using plastic waste collected on beaches of Galapagos (Ecuador), Schofield *et al.* (2020) organised a narrative workshop to reconstruct the journeys that those plastic artefacts had taken before reaching the archipelago's shores. Sampling of plastic bags in the town of Santa Cruz, Galapagos was also undertaken to approach disposal practices over time (Schofield *et al.*, 2021a). These latter two were related studies that provided the groundwork and the opportunity for further projects using marine plastic litter as the basis for online and in-person narrative workshops in Galapagos and the wider Pacific region (Praet *et al.*, 2023a; Praet *et al.*, 2023b). Prior to these projects, the potential of researching marine debris as an archaeological object of study was already identified by Arnshav (2014), who encouraged the development of marine garbology. Sometimes, access to physical artefacts is challenging as was the case during the COVID-19 lockdowns. From that perspective, social media representations and content analysis also offer an archive of plastic use and disposal, which can be investigated archaeologically, the artefacts in this case being represented through online records such as photographs or descriptions. Using evidence from social media, Schofield *et al.* (2021b) studied Personal Protective Equipment (PPE) such as face masks and gloves from an archaeological perspective to develop policy recommendations. In their MetroVancouver project, Camp and Muckle (2022) documented artwork, structures and artefacts associated with the pandemic through pedestrian surveys, digital recording and online meetings. These projects under the COVID-19 pandemic emphasise the relevance of contemporary archaeology to document waste associated with specific events and contribute to recommending solutions.

Archaeological approaches are not limited to plastic waste and can also include perspectives on plastic production sites (e.g. Caraher, 2024) and the use of plastics as products (e.g. in art see Bryning, 2024) sometimes reused as building material to maintain heritage building traditions (e.g. in the case of the Flipflop, a dhow made of former plastic flip flops, see Müller *et al.*, 2024). Plastic production sites can become part of a toxic heritage, one facilitated by industrialisation and waste disposal, and that has shaped our current landscapes (e.g. Shackel, 2023). The extraction of natural plastics can also contribute to the development of toxic landscapes, for example, with the addition of chemicals to process rubber in Amazonia (Alves Muniz, 2023). In addition, archaeological theory can approach plastic from different angles, questioning the role of the discipline in addressing this current environmental crisis. A recent reflection by Wooten (2023) offered to focus on plastics archaeologically as a basis for activism and public outreach, leading to reflections on behaviour and the current climate crisis. This refreshing approach used archaeology as a situated practice, while Praet (2024) looked at plastic pollution as an object of study and of concern for archaeologists, respectively, exploring the potential of its materiality, suggesting different techniques and acknowledging its impacts on heritage and archaeological sites.

While there are many ways to consider an archaeology of plastics or plastic pollution as a subfield of contemporary archaeologies, transdisciplinary approaches are particularly welcome and are probably essential to approach the related wicked problems of climate change and environmental pollution (see Bernstein, 2015). For example, some scholars have become interested in the accumulation of plastics over time in sedimentary records (Brandon

et al., 2019; Simon-Sánchez *et al.*, 2022), while others have explored the information available on plastic objects (Falk-Andersson *et al.*, 2021), notably on PET bottles (Ryan, 2020; Ryan *et al.*, 2021). Other studies have focused on plastic litter weathering and degradation, notably with the Lego Lost at Sea project (Turner *et al.*, 2020). While a thorough discussion of ways to look at plastics archaeologically is provided by Praet (2024), the *Routledge Handbook of Archaeology and Plastics* (Godin *et al.*, 2024) is the first work exploring the diversity of archaeological approaches to plastics and plastic pollution globally, in both a geographic and thematic sense.

Plastic waste as toxic heritage

Waste is a ubiquitous material of post-industrial landscapes, one that is entangled in social, economic and/or political relationships (Baird, 2022). Studying plastics archaeologically requires consideration of plastic waste and how it can become and/or threaten heritage. Considering plastics as heritage questions the value(s) contemporary societies assign to them as products but also as waste. While there is no doubt that some plastic products can be seen as highly valued heritage as they hold social, cultural and economic meaning, the discussion here focuses on plastic waste exclusively. In their socio-archaeological approach to the International Space Station (ISS), Walsh *et al.* (2022) identified that waste could either be seen as: (a) not valuable and therefore burnt or (b) valued and therefore removed from the ISS and brought back to earth. The limited capacity of vessels going back to earth from the ISS required a careful selection of the objects, hence the need to focus only on those items given value and importance (Walsh *et al.*, 2022). Inspired by forensic science, Walsh *et al.* (2022) used the concept of chain of custody, considering the whole process of inventorying, handling, documenting and disposing of objects with accountable actors for every step. This specific example contrasts with the lack of accountability characterising most plastic waste, being considered untraceable (see Davis, 2022). While accountability varies greatly for plastic waste, the value assigned to it is key to how contemporary societies perceive and act towards it.

Recent discussions have highlighted that plastic waste can also contribute to heritage making, either by being reused to maintain heritage practices or by shaping new waste landscapes valued for their extraordinary nature (see Godin *et al.*, 2024). The former can be exemplified by Müller *et al.* (2024) in their illustration of recycled plastic flip flops used as raw material to build a traditional boat with nontraditional material, using indigenous knowledge. From that perspective, plastic waste allows heritage-making to survive and indigenous knowledge to be passed on. Considering plastic waste as heritage is a position notably argued for by Holtorf (2023: 119) who considers that plastic trash “forms a kind of distributed World Heritage Site”. Plastic waste as a heritage site contrasts with its “globalized unlocality” (Davis, 2022: 5), constant transformation and degradation, and the geographical scale of the issue.

With archaeological theory and practice being heavily influenced by posthumanism, nonhumans are now immersed within definitions of heritage. From that perspective, considering marine plastic litter and plastic waste in general as entangled in heritage making is meaningful, as it shapes new relationships with humans and nonhumans alike. Heritage can no longer be perceived as a restriction from the human touch (see Harrison, 2021). Plastic's

overwhelming presence and degradation into fragments that become entangled with nature make it difficult and almost irrelevant to differentiate nature/culture in most places around the world. The concept of plastic naturecultures was proposed by De Wolff (2017) to address the specificities of plastic-species encounters and the plastisphere. Plastic nature cultures could then become a type of heritage, nonetheless recognising the threat that these interactions pose and the toxic nature of such heritage.

The threat that plastics pose to the environment, wildlife and human health turns it into an almost hazardous material or heritage. In that sense, plastic waste belongs to a category of heritage that has recently been gathered under the concept of toxic heritage (Kryder-Reid and May 2024). The toxicity of heritage is not related to its content but rather to its management and the narratives built on it (Wollentz *et al.*, 2020). In that perspective, plastic can be considered toxic and toxic heritage more because of its (mis)management than the toxic additives and substances allowing its plasticity. Plastic is also very changeable, a property characterising toxic waste and toxic heritage, according to Wollentz *et al.* (2020). Plastics have also been labelled ghost heritage (notably by Harrison, 2021). The concept of ghost heritage, as haunting unmanaged disposals (Harrison, 2021: 38), is an interesting way to approach plastics, particularly to explore the shifts of plastic pollution from an overwhelmingly visible issue on polluted beaches to the invisible ingestion of micro- and nano-plastics by humans and nonhumans. Depending on the beholder, the context and the degradation, plastics can be overwhelmingly visible, such as in Kamilo Beach, Hawaii, one of the most polluted beaches on earth, or invisible to most humans, such as plastics in deeply buried archaeological sediments (Rotchell *et al.* 2024).

Considering plastic waste as heritage is also anchored in the legacy that it is leaving for future societies, one that already represents the Anthropocene and the Plastic Age. However considering plastic waste as legacy and heritage must be done cautiously. The danger in perceiving waste as heritage, even if toxic, also echoes worries about reifying waste and waste fetishism (see Gille, 2010, 2013). The legacy of plastic waste is also unequal, often following colonial dynamics imposed upon Indigenous peoples and lands (Liboiron, 2021). Exports of plastic waste have reinforced those colonial dynamics with Global South communities exposed to the hazards that plastic waste provokes. From that perspective, an intersectional approach (after Crenshaw, 1991) helps understand how waste affects people unequally depending on gender, age, class, origin, occupation, and economic possibilities among others. Plastic may represent an important material for women waste pickers from marginalized communities in the Global South relying on this work (Wittmer, 2021) while women from WEIRD (Western, Educated, Industrialised, Rich and Democratic) societies have economic possibilities, allowing them to avoid plastics in their eco-friendly lifestyle.

Independently from the unequal distribution of its legacy, waste remains relational and connected (Baird, 2022), which makes the use of object itineraries particularly relevant to discuss plastic waste. Baird (2022) even proposes to see waste as a teaching tool, one that moves our consideration of waste from nostalgia to repair by considering the social, economic, and environmental problems at its core. Projects based on plastic waste as artefacts can inspire discussions about respect for the environment and the role of human behaviour contributing to the issue (e.g. Holtorf, 2023 for his analysis of the Lego Lost at Sea project). Contemporary archaeology is interested not only in the material culture of us, and here, we are focusing on plastics, but also in the activities, relationships,

and perceptions we develop with and towards these objects. Using an archaeological framework turns archaeology into a situated and thus vital practice.

Plastics, archaeology and contributions to policy

As we discussed previously, archaeologists routinely now study the contemporary world with a view to the future, while archaeology has also become highly interdisciplinary and creative in the ways it attempts to build an understanding of the world, emphasising the relationships that humans have with their world including the things and the non-humans that they share it with. From that perspective, archaeology can contribute to shaping policy and evaluate decision-making, notably by contributing to activism and contextualising plastic pollution as a societal problem centered around material culture.

Archaeology can be viewed as an important tool for activism (see Wooten 2023) through the data and understandings that it can generate. Activist groups can shape governance initiatives, as well as pushing for policies and programs that are focused on solutions towards recycling, reuse, and reduction of waste (O'Neil, 2019). As described earlier, there is a growing injustice and inequity stemming from plastic pollution, where some communities are taking on more of the burden of plastic pollution than others. Plastic pollution disproportionately harms the human right to a clean and healthy environment, and for many vulnerable communities including indigenous peoples and the many waste pickers who recycle and repurpose plastic waste, they are experiencing systemic environmental injustices (Vandenburg and Ota, 2022). Inequitable impacts of plastic pollution do not start in the ocean and can be observed at all stages of the plastic lifecycle, extending across social, political, and economic planes and are disproportionate, for example, for people of colour and low income (Vandenburg and Ota, 2022). This asymmetry of power over plastics production and pollution governance has excluded a diversity of actors across the full range of plastics and alternative forms of knowledge and world views (to dominant Eurocentric scientific disciplines), producing harmful outcomes for already at-risk communities (O'Neil, 2019; Vandenburg and Ota, 2022). Contemporary archaeological work enables deeper consideration of inequalities and injustice in the past and functions to remind us of struggles that continue into the present day and the future (Kiddey and Graves-Brown, 2015).

The plastic crisis is a complex societal problem and transcends all borders. Undoubtedly, problems related to plastic pollution cannot be solved solely by the waste management sector or changes through consumer choices and cannot be solved as quickly as we may hope. Given the scale and magnitude of climate change and other environmental challenges, researchers have emphasised the value of interdisciplinary or transdisciplinary research, including the social sciences and humanities, to evaluate issues and search for realistic scenarios and solutions (Rick and Sandweiss, 2020). Policymakers are required to analyse the problems, make decisions and implement changes (Detombe, 2015). Archaeology in the context of interdisciplinary approaches will be key to finding overarching laws and policy solutions fitting the scope of the problem. The plastic pollution crisis is placing the planet in peril. Plastics contribute to climate change through greenhouse gas emissions, from production to disposal, and the pollution will be exacerbated by climatic events (Ford *et al.*, 2022). Archaeologists as members of a community of interdisciplinary researchers now have an important role to play because of their unique insight into understanding behaviours

through material culture, their ability to work across scales (from local to global) and in all environments, and their deep-time perspective. Therefore, by conveying their findings in holistic and equitable applications of scientific, social, and economic perspectives to understand the Plastic Age and its related challenges, they can be a part of shaping important policies, regulations, and legislative frameworks at all levels.

Plastics: An archaeological view into the deep future

In this paper, we have discussed how, over the past 60 years, archaeology has transitioned from a study of only the ancient past to a dynamic and future-oriented study of the contemporary world, incorporating those ancient traces that have proved resilient and form a part of our world, alongside the traces that we ourselves are creating in our everyday actions. This transition has rendered archaeology not only socially relevant, in the sense that it is a record of our own contributions and impacts upon the world and how and why they matter, but as a subject central to future thinking and to better understanding the implications of our behaviours on the years, centuries, and millennia that lie ahead. Archaeology is, arguably, uniquely placed to explore, think about, and critically examine alternative futures. However, it is important also to restate a point made earlier: that archaeology has long been an interdisciplinary field of study, not only working with scientists and social scientists, to get more from the evidence recovered, but also working in a transdisciplinary way, to analyse public reaction, influence policy and demonstrate impact. What archaeological work on plastics has proven is that this collaborative approach is not optional but essential for archaeology to continue to have influence.

As people living in the early to mid twenty-first century, we can predict many alternative futures. Some of our views are shaped by science fiction, each story representing a time many centuries or even multiple millennia from now. Rather than fiction, perhaps we should consider these to be some of those “alternative futures”. As we continue to try to better understand the past, we can also use the archaeological evidence at our disposal, alongside models generated for example through economics and climate science, to directly and critically address those futures by determining which elements are the most likely to occur, what might cause them to occur or rule them out, and when we might expect them to become a reality. Finding solutions to the current wicked problems of climate change and environmental pollution is one area in which these two archaeological perspectives (past- and future-oriented) can converge. Taking archaeology into new and challenging situations like these, alongside new environments such as deep oceans and space, presents additional opportunities to think about human pasts, present and future.

But where we perhaps need to focus most of all is in demonstrating how our archaeological evidence can cause people to think about their own part in this grand narrative, about time and our place within the many stories of the changing planet on which we live and upon which we depend. Archaeology is ultimately about people and it is the individual actions of people that have created the traces that constitute the palimpsest of the contemporary world. How we act today, as a society but also as individuals within society, will similarly determine the shape of future worlds. This philosophical approach, this way of thinking, is something that, as archaeologists, we understand. Plastics, as archaeological materials, are central to reading, thinking through and ultimately, hopefully, understanding the implications of the deep entanglements of

people and things in the contemporary world, and they are also therefore vital to how we might try to untangle things sufficiently to create futures in which life continues to thrive.

Open peer review. To view the open peer review materials for this article, please visit <http://doi.org/10.1017/plc.2024.22>.

Acknowledgements. The authors would like to thank the editors for inviting them to contribute to Cambridge Prisms with this review evaluating the contribution of archaeology to the study of plastics and plastic pollution. An early version of this paper was written as the introduction to EP’s PhD thesis submitted to the University of York in January 2024. The authors would like to thank two anonymous reviewers for their comments and suggestions that contributed to improving this paper.

Author contribution statement. Estelle Praet: conceptualization; writing – original draft; writing – review and editing John Schofield: structure; writing – original draft; writing – review and editing Raveena M. Tamoria: writing – original draft; writing – review and editing.

Financial support. EP’s research, as part of her PhD, was supported by the Arts & Humanities Research Council [grant number AH/R012733/1] through the White Rose College of the Arts & Humanities.

Competing interest. The authors declare no conflict of interest.

References

- Alves Muniz TS (2023) Case study 6: Rubber as (toxic) heritage: Amazonian knowledge and the rubber industry. In Kryder-Reid E and May S (eds.), *Toxic Heritage: Legacies, Futures, and Environmental Injustice*. London: Routledge, pp. 256–260.
- Arnshav M (2014) The freedom of the seas : Untapping the archaeological potential of marine debris. *Journal of Maritime Archaeology* 9(1), 1–25. <https://doi.org/10.1007/sl>.
- Bailey G et al. (2009) Transit, transition: Excavating J641 VUJ. *Cambridge Archaeological Journal* 19(1), 1–28. <https://doi.org/10.1017/S0959774309000018>.
- Baird M (2022) Waste sits in places: Post-extractive landscapes as heritage. In Pettenati G (ed.), *Landscape as Heritage: International Critical Perspectives*. London: Routledge, pp. 204–215. <https://doi.org/10.4324/9781003195238-18>.
- Bar-Yosef O and Van Peer P (2009) The Chaîne Opératoire approach in middle Paleolithic archaeology. *Current Anthropology* 50, 1, 103–131. <https://doi.org/10.1086/592234>.
- Bauer AA (2019) Itinerant objects. *Annual Review of Anthropology* 48, 1, 335–352. <https://doi.org/10.1146/annurev-anthro-102218-011111>.
- Bauer AA (2021) Itineraries, iconoclasm, and the pragmatics of heritage. *Journal of Social Archaeology* 21(1), 3–27. <https://doi.org/10.1177/1469605320969097>.
- Bensaude-Vincent B (2013) Plastics, materials and dreams of dematerialization. In Gabrys J, Hawkins G and Michael M (eds.) *Accumulation: The Material Politics of Plastic* London: Routledge, pp. 17–29.
- Bernstein JH (2015) Transdisciplinarity: A review of its origins, development, and current issues. *Journal of Research Practice* 11, 1.
- Binford LR (1962) Archaeology as anthropology. *American Antiquity* 28(2), 217–225.
- Binford LR (1965) Archaeological systematics and the study of culture process. *American Antiquity* 31(2), 203–210.
- Binford LR (1978) Dimensional analysis of behavior and site structure: Learning from an Eskimo hunting stand. *American Antiquity* 43(3), 330–361. <https://doi.org/10.2307/279390>.
- Bonnichsen R (1973) Millie’s Camp: An experiment in archaeology. *World Archaeology*, 4(3), 277–291.
- Brady LM (2016) Contemporary indigenous relationships to archaeological features: Agency, affect, and the social significance of rock art. *Heritage & Society* 9(1, 2), 3–24. <https://doi.org/10.1080/2159032X.2016.1246153>.
- Brandon JA, Jones W and Ohman MD (2019) Multidecadal increase in plastic particles in coastal ocean sediments. *Science Advances* 5, 9, eaax0587. <https://doi.org/10.1126/sciadv.aax0587>.

- Bryning E** (2024) From transformative potential to existential crisis: The practice of art/archaeology in the plastic age. In Godin G, Pétursdóttir Þ, Praet E and Schofield J (eds), *The Handbook of Archaeology and Plastics*. London: Routledge.
- Buchli V and Lucas G** (2001a) *Archaeologies of the Contemporary Past*. London: Routledge.
- Buchli V and Lucas G** (2001b) *The Archaeology of Alienation: A Late Twentieth-Century British Council House*. London: Routledge.
- Camp SL and Muckle R** (2022) Reflections on archaeological research on a pandemic amid a pandemic. *Conservation and Management of Archaeological Sites* 24(4–6), 182–190. DOI: [10.1080/13505033.2023.2283965](https://doi.org/10.1080/13505033.2023.2283965).
- Caraheer W** (2024). The archaeology of oil production. In Godin G, Pétursdóttir Þ, Praet E and Schofield J (eds), *The Handbook of Archaeology and Plastics*, London: Routledge.
- Carpenter E and Wolverton S** (2017) Plastic litter in streams: The behavioral archaeology of a pervasive environmental problem. *Applied Geography* 84, 93–101. <https://doi.org/10.1016/j.apgeog.2017.04.010>.
- Childe VG** (1935) Changing methods and aims in prehistory: Presidential address for 1935. *Proceedings of the Prehistoric Society* 1, 1–15. <https://doi.org/10.1017/S0079497X00022155>.
- Corcoran PL, Moore CJ and Jazvac K** (2013) An anthropogenic marker horizon in the future rock record. *GSA Today* 6(4–8). <https://doi.org/10.1130/GSAT-G198A.1.4>.
- Crenshaw K** (1991) Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, 43(6), 1241–1299. <https://doi.org/10.2307/1229039>.
- Crown PL** (2007) Life histories of pots and potters: Situating the individual in archaeology. *American Antiquity* 72(4), 677–690. <https://doi.org/10.2307/25470440>.
- Damron-Martinez D and Jackson KL** (2017) Connecting consumer behavior with marketing research through garbology. *Marketing Education Review* 27(3), 151–160. <https://doi.org/10.1080/10528008.2017.1312458>.
- Davis H** (2022) *Plastic Matter*. Durham: Duke University Press.
- De León J** (2015) *The Land of Open Graves: Living and Dying on the Migrant Trail*. Oakland: University of California Press.
- De Tombe D** (ed.) (2015) *Handling Societal Complexity: A Study of the Theory of the Methodology of Societal Complexity and the COMPRAM Methodology*. Berlin: Springer.
- De Wolff K** (2017) Plastic Naturecultures: Multispecies ethnography and the dangers of separating living from nonliving bodies. *Body & Society* 23(3), 23–47. <https://doi.org/10.1177/1357034X17715074>.
- Dey T** (2021) Plastic Mut(e)ability: Limited promises of plasticity. *Worldwide Waste* 67(1), 1–11.
- Drieu L, Lepère C, and Regert M** (2020) The missing step of pottery chaîne opératoire: Considering post-firing treatments on ceramic vessels using macro- and microscopic observation and molecular analysis. *Journal of Archaeological Method and Theory* 27(2), 302–326. <https://doi.org/10.1007/s10816-019-09428-8>.
- Driscoll K** (2009) Exploring the Chaîne Opératoires in Irish quartz lithic traditions: Current research. *Internet Archaeology* 26. <https://doi.org/10.11141/ia.26.12>.
- Erny G and Caraheer W** (2020) The kingdom of Chelmis: Architecture, material culture, and the modern landscape of the Western Argolid. *Journal of Field Archaeology* 45(3), 209–221. <https://doi.org/10.1080/00934690.2019.1704990>.
- Falk-Andersson J et al.** (2021) Methods for determining the geographical origin and age of beach litter: Challenges and opportunities. *Marine Pollution Bulletin* 172, 112901. <https://doi.org/10.1016/j.marpolbul.2021.112901>.
- Fernández-Götz M et al.** (2021) Posthumanism in archaeology: An introduction. *Cambridge Archaeological Journal* 31(3), 455–459. <https://doi.org/10.1017/S0959774321000135>.
- Ford H V, Jones N H, Davies A J, Godley B J, Jambeck J R, Napper I E, Suckling C C, Williams G J, Woodall L C and Koldewey H J** (2022) The Fundamental Links between Climate Change and Marine Plastic Pollution. *Science of The Total Environment* 806: 150392. <https://doi.org/10.1016/j.scitotenv.2021.150392>.
- Flannery KV** (1982) The Golden Marshalltown: A parable for the archaeology of the 1980s. *American Anthropologist* 84, 265–279.
- Fowler C and Harris OJ** (2015) Enduring relations: Exploring a paradox of new materialism. *Journal of Material Culture* 20(2), 127–148. <https://doi.org/10.1177/1359183515577176>.
- Gilardenghi E** (2021) “Caminante no hay camino, se hace arqueología al andar”: reflexiones en torno a una arqueología política. *Revista del Museo de Antropología* 14(1), 21–34.
- Gille Z** (2010) Actor networks, modes of production, and waste regimes: Reassembling the macro-social. *Environment and Planning A: Economy and Space* 42(5), 1049–1064. <https://doi.org/10.1068/a42122>.
- Gille Z** (2013) Is there an substance of dreams: Plastics matter? A response to Myra Hird. *Social Epistemology Review and Reply Collective* 2(4), 1–6.
- Godin G, Pétursdóttir Þ, Praet E and Schofield J** (2024). *The Handbook of Archaeology and Plastics*. London: Routledge.
- González-Ruibal A** (2008) Time to destroy. *Current Anthropology* 49(2), 247–279. <https://doi.org/10.1086/526099>.
- González-Ruibal A** (2018) Beyond the Anthropocene: Defining the age of destruction. *Norwegian Archaeological Review* 51(1–2), 10–21. <https://doi.org/10.1080/00293652.2018.1544169>.
- Gosden C** (2005) What do objects want? *Journal of Archaeological Method and Theory* 12(3), 193–211. <https://doi.org/10.1007/s10816-005-6928-x>.
- Gosden C and Marshall Y** (1999) The cultural biography of objects. *World Archaeology* 31(2), 169–178.
- Gould RA and Schiffer MB** (eds) (1981) *Modern Material Culture: The Archaeology of us*. New York: Academic.
- Graves-Brown P** (2000) *Matter, Materiality and Modern Culture*. London: Routledge.
- Graves-Brown P** (2014) When was the Anthropocene? (and why?) *Journal of Contemporary Archaeology* 1, 77–81.
- Graves-Brown P, Harrison R and Piccini A** (2013) *The Oxford Handbook of the Archaeology of the Contemporary World*. Oxford: Oxford University Press.
- Guzzo Falci C et al.** (2020) The biographies of bodily ornaments from indigenous settlements of the Dominican Republic (AD 800–1600). *Latin American Antiquity* 31(1), 180–201.
- Hahn HP and Weiss H** (2013) Introduction: Biographies, travels and itineraries of things. In Hahn HP and Weiss H (eds), *Mobility, Meaning and Transformations of Things: Shifting Contexts of Material Culture through Time and Space*. Oxford: Oxbow Books, pp. 1–14.
- Haram LE et al.** (2020) A Plasticene Lexicon. *Marine Pollution Bulletin* 150, 110714. <https://doi.org/10.1016/j.marpolbul.2019.110714>.
- Harrison R and Breithoff E** (2017) Archaeologies of the contemporary world. *Annual Review of Anthropology* 46, 203–221.
- Harrison R and Schofield J** (2010) *After Modernity: Archaeological Approaches to the Contemporary Past*. Oxford University Press.
- Harrison, R** (2011) Surface Assemblages. Towards an Archaeology in and of the Present. *Archaeological Dialogues* 18(2), 141–61. <https://doi.org/10.1017/S1380203811000195>.
- Harrison R** (2021) Legacies: Rethinking the futures of heritage and waste in the Anthropocene. In Bangstad TR and Pétursdóttir Þ (eds), *Heritage Ecologies*. London: Routledge, pp. 31–48.
- Hawkins G** (2018) Plastic and presentism: The time of disposability. *Journal of Contemporary Archaeology* 5(1), 91–102.
- Hawkins G, Potter E and Race K** (2015) *Plastic Water: The Social and Material Life of Bottled Water*. Cambridge, MA: The MIT Press. <https://doi.org/10.7551/mitpress/9780262029414.001.0001>.
- Hicks D** (2010) The material-cultural turn: Event and effect. In Hicks D and Beaudry MC (eds), *The Oxford Handbook of Material Culture Studies*. Oxford: Oxford University Press, pp. 24–98.
- Hicks D and Beaudry M C** (2010) Introduction: Material Culture Studies: A Reactionary View. In *The Oxford Handbook of Material Culture Studies*, edited by D Hicks and M C Beaudry. Oxford University Press. <https://doi.org/10.1093/oxfordhdb/9780199218714.013.0001>.
- Hodder I** (1987) *The Archaeology of Contextual Meanings*. Cambridge: Cambridge University Press.
- Högberg A** (2017) Waste, very much a social practice. In Sosna D and Brunclíková L (eds), *Archaeologies of Waste: Encounters with the Unwanted*. Oxford: Oxbow, pp. 59–64.

- Holtorf CJ** (1998) The life-histories of megaliths in Mecklenburg-Vorpommern (Germany). *World Archaeology* 30(1), 23–38. <https://doi.org/10.1080/00438243.1998.9980395>.
- Holtorf C** (2015) Are We All Archaeologists Now? *Journal of Contemporary Archaeology* 2(2): 217–19.
- Holtorf CJ** (2002) Notes on the life history of a pot sherd. *Journal of Material Culture* 7, 1. <https://doi.org/10.1177/1359183502007001305>.
- Holtorf CJ** (2023) Towards a world heritage for the Anthropocene. In Shepherd N (ed.), *Rethinking Heritage in Precarious Times: Coloniality, Climate Change, and Covid-19*. London: Routledge, pp. 111–126.
- Holtorf CJ** (2024) The climate heritage paradox: How rethinking archaeological heritage can address global challenges of climate change. *World Archaeology*. <https://doi.org/10.1080/00438243.2024.2320122>.
- Holtorf CJ and Piccini A** (2009) *Contemporary Archaeologies: Excavating Now*. Lausanne: Peter Lang.
- Huvila I et al.** (2022) Archaeological practices and societal challenges. *Open Archaeology* 8(1), 296–305 <https://doi.org/10.1515/opar-2022-0242>.
- Ingold T** (2000) *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill*. London: Routledge.
- Jackson S** (2023) Caring for waterscapes in the Anthropocene: Heritage-making at Budj Bim, Victoria, Australia. *Environment and History* 29(4), 591–611. <https://doi.org/10.3197/096734022X16384451127393>.
- Jones AM and Boivin N** (2010) The malice of inanimate objects: Material agency. In Hicks D and Beaudry MC (eds), *The Oxford Handbook of Material Culture Studies*. Oxford: Oxford University Press, pp. 333–351.
- Jones AM, Díaz-Guardamino M, and Crellin RJ** (2016) From artefact biographies to “multiple objects”: A new analysis of the decorated plaques of the Irish Sea region. *Norwegian Archaeological Review* 49(2), 113–133. <https://doi.org/10.1080/00293652.2016.1227359>.
- Joy J** (2009) Reinvigorating object biography: Reproducing the drama of object lives. *World Archaeology* 41(4), 540–556. <https://doi.org/10.1080/00438240903345530>.
- Joyce RA** (2012a) Life with things: Archaeology and materiality. In Shankland D (ed.), *Archaeology and Anthropology: Past, Present and Future*, London: Routledge, pp. 119–132.
- Joyce RA** (2012b) When is authentic? Situating authenticity in the itineraries of objects. In Geurds A and Van Broekhoven L (eds), *Creating Authenticity: Authentication Processes in Ethnographic Museums*. Leiden: Sidestone Press, pp. 39–57.
- Joyce RA** (2015) Things in motion: Itineraries of Ulua marble vases. In *Things in Motion: Object Itineraries in Anthropological Practice*, Joyce RA and Gillespie SD (eds), Santa Fe: School for Advanced Research Press, pp.21–38.
- Joyce RA** (2017) *Painted Pottery of Honduras: Object Lives and Itineraries*. Leiden: Brill.
- Joyce RA and Gillespie SD** (2015a) *Things in Motion: Object Itineraries in Anthropological Practice*. Santa Fe: School for Advanced Research Press.
- Joyce RA and Gillespie SD** (2015b) Making things out of objects that move. In Joyce RA and Gillespie SD (eds), *Things in Motion: Object Itineraries in Anthropological Practice*. Santa Fe: School for Advanced Research Press, pp. 3–19.
- Kiddey R and Graves-Brown P** (2015) Reclaiming the streets: The role of archaeology in deconstructing the myths of contemporary society. *Archaeological Review from Cambridge* 38(2), 135–147.
- Knowles C** (2015) The Flip-Flop Trail and Fragile Globalization’. *SAGE Journals* 32(7–8). <https://journals.sagepub.com/doi/abs/10.1177/0263276415576217>.
- Knappett C** (2005) *Thinking Through Material Culture: An Interdisciplinary Perspective*. Philadelphia: University of Pennsylvania Press. <https://doi.org/10.9783/9780812202496>.
- Kopytoff I** (1986) The cultural biography of things: Commoditization as process. In Appadurai A (ed.), *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge: Cambridge University Press, pp. 64–92.
- Kramm J and Völker C** (2023) *Living in the Plastic Age*. DE: Campus Verlag GmbH.
- Kryder-Reid E and May S** (eds) (2024) *Toxic Heritage: Legacies, Futures, and Environmental Injustice*. Oxon: Routledge.
- Latour B** (1996) On actor-network theory. A few clarifications plus more than a few complications. *Soziale Welt* 47, 369–381. <https://doi.org/10.22394/0869-5377-2017-1-173-197>.
- Latour B** (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press. <https://doi.org/10.1093/oso/9780199256044.001.0001>.
- Lebreton L and Andrady A** (2019) Future scenarios of global plastic waste generation and disposal. *Palgrave Communications* 5(1), 1–11. <https://doi.org/10.1057/s41599-018-0212-7>.
- Leroi-Gourhan A** (1964) *Le geste et la parole: technique et langage*. Paris: Albin Michel.
- Letelier Cosmelli J and Goldschmidt Levinsky D** (2021) Objects as battlefields in the struggle for civil rights: The archaeology and analysis of contemporary material culture and heritage in Chile. *AP (Madrid)* 11. <https://doi.org/10.23914/ap.v11i10.288>.
- Lewis M and Arntz M** (2020) The Chaîne Opératoire: Past, present and future. *Archaeological Review from Cambridge* 35(1), 6–16.
- Liboiron M** (2021) *Pollution Is Colonialism*. Durham: Duke University Press.
- Liebmann M** (2015) The Mickey mouse kachina and other “double objects”: Hybridity in the material culture of colonial encounters. *Journal of Social Archaeology* 15(3), 319–341. <https://doi.org/10.1177/1469605315574792>.
- Martinón-Torres M** (2002) Chaîne Opératoire: The concept and its applications within the study of technology. *Gallaecia* 21, 29–43.
- Mauss M** (1936) Les techniques du corps. *Journal de Psychologie*, XXXII, 3–4.
- McAtackney L, Palus M and Piccini A** eds (2007) *Contemporary and Historical Archaeology in Theory: Papers from the 2003 and 2004 CHAT Conferences*. Oxford: British Archaeological Reports S1677.
- McGill D and St Germain J** (2021) Nazi science, wartime collections, and an American museum: An object itinerary of the *Anthropologie symbol. International Journal of Cultural Property* 28, 1, 87–106. <https://doi.org/10.1017/S0940739121000096>.
- Meikle JL** (1992) Into the fourth kingdom: Representations of plastic materials, 1920–1950. *Journal of Design History* 5(3), 173–182.
- Müller C, Béguerie V and Faber R.** (2024) The Flipflop: The recycled plastic boat on a mission to ‘close the loop’ on plastic waste. In Godin G, Pétursdóttir Þ, Praet E and Schofield J (eds), *The Handbook of Archaeology and Plastics*, London: Routledge.
- Mytum H** (2003/2004) Artefact biography as an approach to material culture: Irish gravestones as a material form of genealogy. *The Journal of Irish Archaeology* 12/13, 111–127.
- Mytum H and Meek J** (2020) The Iron age in the plastic age: Anthropocene signatures at castell Henllys. *Antiquity* 95(379), 198–214.
- Newell PA, Aycock J, and Biittner KM** (2022) Still entombed after all these years: The continuing twists and turns of a maze game. *Internet Archaeology* 59. <https://doi.org/10.11141/ia.59.3>.
- Nisbet G** (2021) A wall of stuff: Object itinerary as a framework for writing the souvenir. *Text* 25, 61. <https://doi.org/10.52086/001c.23492>.
- Olsen B** (2010) In *Defense of Things: Archaeology and the Ontology of Objects*. Lanham: AltaMira Press.
- O’Neill K** (2019) *Waste*. New York: John Wiley & Sons.
- Pearson D and Connah G** (2013) Retrieving the cultural biography of a gun. *Journal of Conflict Archaeology* 8(1), 41–73. <https://doi.org/10.1179/1574077312Z.00000000017>.
- Perry S and Morgan C** (2015) Materializing media archaeologies: The MAD-P hard drive excavation. *Journal of Contemporary Archaeology* 2(1), 94–104. <https://doi.org/10.1558/jca.v2i1.27083>.
- Pétursdóttir Þ** (2017) Climate change? Archaeology and Anthropocene. *Archaeological Dialogues* 24(2), 175–205. <https://doi.org/10.1017/S1380203817000216>.
- Pétursdóttir Þ** (2020) Anticipated futures? Knowing the heritage of drift matter. *International Journal of Heritage Studies* 26(1), 87–103. <https://doi.org/10.1080/13527258.2019.1620835>.
- Plaza Calonge MT, Figueroa Larre V and Martinón-Torres M** (2022) Technology, life histories and circulation of gold objects during the middle period (AD 400–1000): A perspective from the Atacama Desert, Chile. *Archaeological and Anthropological Sciences*, 14(5), 89. <https://doi.org/10.1007/s12520-022-01549-8>.
- Porta R** (2021) Anthropocene, the plastic age and future perspectives. *FEBS Open Bio* 11(4), 948–953. <https://doi.org/10.1002/2211-5463.13122>.
- Praet E et al.** (2023a) Bottle with a message: The role of story writing as an engagement tool to explore children’s perceptions of marine plastic litter.

- Marine Pollution Bulletin* **186**, 114457. <https://doi.org/10.1016/j.marpolbul.2022.114457>.
- Praet E et al.** (2023b) Waste journeys: Using object itineraries to investigate marine plastic in Galapagos. *Journal of Contemporary Archaeology* **10**(1), 81–109. <https://doi.org/10.1558/jca.25844>.
- Praet E** (2024) Plastic pollution: Archaeological perspective on an anthropocene climate emergency. *World Archaeology*. <https://doi.org/10.1080/00438243.2024.2320123>.
- Preucel RW** (1995) The postprocessual condition. *Journal of Archaeological Research* **3**(2), 147–175. <https://doi.org/10.1007/BF02231436>.
- Rangel-Buitrago N, Neal W and Williams A** (2022) The Plasticene: Time and rocks. *Marine Pollution Bulletin* **185**, 114358. <https://doi.org/10.1016/j.marpolbul.2022.114358>.
- Rathje WL** (1979) Modern material culture studies. In Schiffer MB (ed.), *Advances in Archaeological Method and Theory*. New York: Academic Press, pp. 1–37.
- Rathje WL** (2011) Archaeological intervention in the past, present and future tense. *Archaeological Dialogues*, **18**(2), 176–180.
- Rathje WL and Murphy C** (2001) *Rubbish! The Archaeology of Garbage*. Tucson: The University of Arizona Press.
- Reid, JJ, Schiffer, MB and Rathje, WL** (1975) Behavioral archaeology: Four strategies. *American Anthropologist* **77**(4), 864–869.
- Renfrew C** (2011) *Before Civilization: The Radiocarbon Revolution and Prehistoric Europe*. London: Pimlico.
- Reno J** (2013) Waste. In Graves-Brown P, Harrison R and Piccini A (eds), *The Oxford Handbook of the Archaeology of the Contemporary World*. Oxford: Oxford University Press, pp. 261–273.
- Rick TC and Sandweiss DH** (2020) Archaeology, climate, and global change in the age of humans. *Proceedings of the National Academy of Sciences* **117**(15), 8250–8253.
- Rittel H and Webber M** (1973) Dilemmas in a General Theory of Planning. *Policy Sciences* **4**(2), 155–169.
- Ross N** (2018) The “Plasticene” epoch? *Elements* **14**(5), 291. <https://doi.org/10.2138/gselements.14.5.291>.
- Ross A et al.** (2010) Archaeology, cultural landscapes, and indigenous knowledge in Australian cultural heritage management legislation and practice. *Heritage Management* **3**(1), 73–96. <https://doi.org/10.1179/hma.2010.3.1.73>.
- Rotchell JM et al.** (2024) The contamination of in situ archaeological remains: A pilot analysis of microplastics in sediment samples using μ FTIR. *Science of the Total Environment* **914**: 169941. <https://doi.org/10.1016/j.scitotenv.2024.169941>.
- Ryan PG** (2020) Land or sea? What bottles tell us about the origins of beach litter in Kenya. *Waste Management* **116**, 49–57. <https://doi.org/10.1016/j.wasman.2020.07.044>.
- Ryan PG et al.** (2021) Message in a bottle: Assessing the sources and origins of beach litter to tackle marine pollution. *Environmental Pollution* **288**, 117729. <https://doi.org/10.1016/j.envpol.2021.117729>.
- Sáenz-Samper J and Martínón-Torres M** (2017) Depletion gilding, innovation and life-histories: The changing colours of Nahuange metalwork. *Antiquity* **91**(359), 1253–1267. <https://doi.org/10.15184/aqy.2017.97>.
- Santana J and Botelho D** (2019) “If it comes from Juazeiro, it’s blessed!” Liquid and solid attachment in systems of object itineraries of pilgrimages. *Journal of Marketing Management* **35**(5–6), 514–539. <https://doi.org/10.1080/0267257X.2019.1592210>.
- Schiffer MB** (1975) Behavioral chain analysis: Activities, organization, and the use of space. *Fieldiana. Anthropology* **65**, 103–119.
- Schiffer MB** (2002) *Behavioral Archeology*. New York: Percheron Press.
- Schiffer MB** (2010) *Behavioral Archaeology: Principles and Practice*. London: Routledge.
- Schiffer MB** (2017) *Archaeology’s Footprints in the Modern World*. Salt Lake City: The University of Utah Press.
- Schofield J** (2024) *Wicked Problems for Archaeologists: Heritage as Transformative Practice*. Oxford: Oxford University Press.
- Schofield J et al.** (2020) Object narratives as a methodology for mitigating marine plastic pollution: Multidisciplinary investigations in Galápagos. *Antiquity* **94**(373), 228–244. <https://doi.org/10.15184/aqy.2019.232>.
- Schofield J, et al.** (2021a) Contemporary archaeology as a framework for investigating the impact of disposable plastic bags on environmental pollution in Galápagos. *Journal of Contemporary Archaeology* **7**(2), 276–306. <https://doi.org/10.1558/jca.41134>.
- Schofield J, et al.** (2021b) “COVID waste” and social media as method: An archaeology of personal protective equipment and its contribution to policy. *Antiquity*, **95**(380), 435–449. <https://doi.org/10.15184/aqy.2021.18>.
- Sellet F** (1993) *Chaîne Opératoire: The concept and its applications*. *Lithic Technology*, **1 & 2**.
- Shackel PA** (2023) The toxic anthracite = toxic heritage. In Kryder-Reid E and May S (eds), *Toxic Heritage: Legacies, Futures, and Environmental Injustice*. London: Routledge, pp. 266–77.
- Shanks M and Tilley C** (1992) *Reconstructing Archaeology: Theory and Practice*. London: Routledge.
- Shanks M and McGuire RH** (1996) The craft of archaeology. *American Antiquity* **61**(1), 75–88.
- Simon-Sánchez L et al.** (2022) Can a sediment Core reveal the plastic age? Microplastic preservation in a coastal sedimentary record. *Environmental Science & Technology* **56**(23), 16780–16788. <https://doi.org/10.1021/acs.est.2c04264>.
- Sklar R** (1970) *The Plastic Age (1917–1930)*. New York: G. Braziller.
- Strasser S** (2000) *Waste and Want: A Social History of Trash*. New York: Henry Holt and Company.
- Thompson RC et al.** (2009) Our plastic age. *Philosophical Transactions of the Royal Society B: Biological Sciences* **364**(1526), 1973–1976. <https://doi.org/10.1098/rstb.2009.0054>.
- Trigger BG** (2006) *A History of Archaeological Thought*. Cambridge: Cambridge University Press.
- Tringham R** (1995) Archaeological houses, households, housework and the home. In Benjamin D and Stea D (eds), *The Home: Words, Interpretations, Meanings, and Environments*. Aldershot: Avebury Press, pp. 79–107.
- Turner A, Arnold R, and Williams T** (2020) Weathering and persistence of plastic in the marine environment: Lessons from LEGO. *Environmental Pollution* **262**, 1–7. <https://doi.org/10.1016/j.envpol.2020.114299>.
- Vandenberg J and Ota Y** (2022) *Towards an Equitable Approach to Marine Plastic Pollution*. Ocean Nexus Center. Available at <https://oceanexus.uw.edu/2022/11/21/equity-marine-plastic-pollution-report/> (accessed 29 March 2024).
- Walsh JSP, Gorman AC, and Castaño P** (2022) Postorbital discard and chain of custody: The processing of artifacts returning to earth from the international Space Station. *Acta Astronautica* **195**, 513–531. <https://doi.org/10.1016/j.actaastro.2022.03.035>.
- Weberman AJ** (1980) *My Life in Garbology*. New York: Stonehill.
- Witmore C** (2014) Archaeology and the new materialisms. *Journal of Contemporary Archaeology*, **1**(2), 203–246. <https://doi.org/10.1558/jca.v1i2.16661>.
- Wittmer J** (2021) “We live and we do this work”: Women waste pickers’ experiences of wellbeing in Ahmedabad, India. *World Development* **140**, 105253. <https://doi.org/10.1016/j.worlddev.2020.105253>.
- Witze A** (2024) It’s final: The anthropocene is not an epoch, despite protest over vote. *Nature News*. <https://doi.org/10.1038/d41586-024-00868-1>.
- Wollentz G et al.** (2020) Toxic heritage: Uncertain and unsafe. In Harrison R et al. (eds.), *Heritage Futures: Comparative Approaches to Natural and Cultural Heritage Practices*. London: UCL Press, pp. 294–312.
- Wooten KJ** (2023) The shape of things: Archaeology, environmentalism, and plastic. *Historical Archaeology* **57**, 489–503. <https://doi.org/10.1007/s41636-023-00449-5>.
- Yaneva A** (2013) Actor-network-theory approaches to the archaeology of contemporary architecture. In Graves-Brown P, Harrison R and Piccini A (eds), *The Oxford Handbook of the Archaeology of the Contemporary World*. Oxford: Oxford University Press, pp. 121–134.
- Yellen JE** (1977) *Archaeological Approaches to the Present*. London: Academic Press.
- Zalasiewicz J et al.** (2016) The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene. *Anthropocene* **13**, 4–17. <https://doi.org/10.1016/j.ancene.2016.01.002>.
- Zimmerman L J** (2013) Archaeology’s applicability to the present: Material culture, accurate narratives, and social concerns. *Archaeological Review from Cambridge* **28**(1), 1–15.