

Archaeological Approaches to Plastics and Plastic Pollution: A Critical Overview

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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 and social 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.

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10.1017/plc.2024.22

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30

31 **Keywords**

32 Contemporary Archaeology, Galapagos, Garbology, Plastics, Policy, Toxic Heritage,
33 Microplastics

34

35 **Impact Statement**

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

53

54

55

56 Introduction

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

70

71 Characterised as a “wicked problem” (after Rittel and Webber 1973; see Schofield
72 2024 for its application through archaeology and cultural heritage) with expectations
73 to double within the next 20 years (Lebreton and Andrady, 2019), plastic pollution
74 poses serious and unprecedented threats to human health and environmental
75 security. This paper provides an illustration of the broad range of theories, methods
76 and tools that archaeology offers in studying plastics and plastic pollution.
77 Archaeologists and heritage practitioners are uniquely poised to enrich plastic pollution
78 discourse by contributing evidence-based knowledge gained via archaeological
79 research and investigation, thus providing valuable contributions and perspectives.
80 While Zimmerman’s research looks at archaeology of homelessness, his assertion is
81 also appropriate to plastic pollution - that archaeology’s applicability to the present
82 stems from three key elements: studying material culture, building accurate narratives
83 about the past based on what is found, and using the narratives to suggest changes
84 relating to social concerns (Zimmerman, 2013). Similarly, Praet (2024) outlines several
85 ways archaeologists approach plastics, either as cultural artefacts, studying their
86 journeys from production to waste, or examining them through the lens of how plastics
87 affect diverse landscapes and create new geographies. Equally, Wooten (2023)

88 argues that historical archaeology provides a potential methodology to collect modern
89 environmental data that contributes to meaningful solutions to the global climate crisis.
90 All these methods provide the necessary and substantial scientific output required in
91 effective and well-rounded policy making and governance.

92 Archaeologies of the Contemporary World

93 The contemporary world and the material traces that characterise it, became topics of
94 interest within archaeology in the late 1960s. The motivation with this early work was
95 initially to study modern material culture amongst contemporary hunter-gatherer
96 communities as a means to better understand the human behaviours of Palaeolithic
97 peoples (e.g. Binford 1978; see also Yellen 1977). These studies led to the first
98 publications to discuss the merits and the theoretical foundations of a more
99 contemporary archaeology (e.g. Rathje 1979), being the study of modern material
100 culture for what it tells us, specifically, about the contemporary world: the archaeology
101 of us (Gould and Schiffer 1981). This emphasis on archaeology as an approach to
102 investigating the contemporary world then developed further after 2000, to match the
103 reflective mood of the new millennium (e.g. Graves-Brown, 2000; Buchli and Lucas,
104 2001). All of these developments are summarised in Harrison and Schofield's (2010)
105 overview which describes how these approaches share an interest for the complexities
106 of a globalised, overwhelming and challenging material culture and how this material
107 culture both shapes and characterises the world.

108

109 As described, and building on earlier work, archaeologists started to formally
110 consider the "contemporary past" as an object of study in its own right, in the early
111 2000s. The potential of modern material culture as a source of information and an
112 archaeological object of interest was notably explored in "*Matter, Materiality and*
113 *Modern Culture*" (Graves-Brown, 2000). Several volumes followed, emphasising the
114 contribution of contemporary archaeology. For example: as a discipline that
115 contributes to building memory and resilience through ethical means (*Archaeologies*
116 *of the contemporary past*" by Buchli and Lucas, 2001); and contemporary
117 archaeologies as a diversity of practices acting as a way to "marry archaeology in the
118 modern world and archaeology of the modern world" (Holtorf and Piccini 2009: 16). In
119 a sense, these publications and the projects whose descriptions they contain, were

120 building on the awareness that archaeology is situated and political (Gonzalez-Ruibal,
121 2008), and advocated for its relevance in contemporary context. In *After Modernity*
122 (2010), Harrison and Schofield defined an archaeology of the contemporary past
123 corresponding to the Late Modern period that distinguishes itself by increased
124 communicative technologies and electronic media, a globalised technology impacting
125 production and consumption, mass migration, new modes of capitalism and more
126 leisure time. Reflecting on the challenges of an archaeology *of* and *in* the present, and
127 the need for multidisciplinary perspectives, Graves-Brown *et al.* (2013) preferred to
128 use “archaeology of the contemporary world”, while recognising its relevance for the
129 world’s future. A recurrent theme in archaeologies of the contemporary past is their
130 ubiquity and inclusivity. Never had any field of archaeology tried so hard to broaden
131 the discipline by including more specialists, reiterating that “we are all archaeologists
132 now” because we all have something to say about our contemporary and (allegedly
133 familiar) material culture (Harrison and Schofield, 2010; Holtorf, 2015: 217).

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

146

147 In brief, the last two decades have contributed to refining this new field of study
148 and distinguishing it from ethnoarchaeology, archaeological ethnography, and
149 historical archaeology despite the thematic and methodological overlaps between
150 those disciplines (see Harrison and Breithoff, 2017 for a thorough discussion of these
151 areas of overlap). An annual conference was established in 2003, Contemporary and
152 Historical Archaeology in Theory, or CHAT, resulting in numerous edited conference
153 proceedings (e.g. McAtackney, Palus and Piccini, 2007), while a dedicated journal

154 (the *Journal of Contemporary Archaeology*) launched in 2013. Yet, the discipline has
155 faced critique, sometimes described as not being proper archaeology. Its detractors
156 worry about the limited or absent time-depth of the research focus, an argument often
157 used to criticise historical archaeology compared to the universally-valued
158 archaeological research of a remote and exotic past (Gilardenghi, 2021). These
159 critiques emerge from a consideration of the discipline of archaeology as excavation-
160 based, failing to realise also the archaeological significance of the 'surface
161 assemblage' (Harrison, 2011). In this work, we use contemporary archaeologies as a
162 framework building both on the creativity and diversity of their applications, their ability
163 to foster interdisciplinary approaches and their relevance for current and future
164 challenges notably that of plastic pollution. But before considering the issue of plastic
165 pollution, we provide an overview of the intersections that exist involving archaeology
166 and modern material culture.

167

168 Archaeology and modern material culture

169 Material culture (i.e. things and objects that humans and non-humans interact with¹)
170 has always been central to the study of archaeology. While archaeologists have
171 always worked with artefacts, the Material-Culture turn (i.e. the shift to materials
172 occurring in the 1980s in British archaeology and anthropology following a revival of
173 interest for materials across different disciplines as detailed by Hicks 2010) opened
174 the potential of material culture for other, and notably social scientists (Schiffer, 2017:
175 Chapter 29). However, in spite of their central position within archaeology, the role and
176 importance of material culture have shifted over time, from providing ways to identify
177 cultural groups (for Culture Historians) to becoming a source of information about
178 people's behaviours, even including contemporary material culture.

179

180 Processual archaeologists were the first to consider contemporary material
181 culture as being of interest to answering archaeological questions. Following and
182 contrasting the approach of Culture Historians associating shifts in artefact typology
183 and style with cultural changes (e.g. the Neolithic 'revolution' proposed by Childe,

¹ It 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).

184 1935), processual archaeology developed an interest in cultural processes through
185 the extensive use of models and systems thinking (e.g. Binford, 1962; 1965).
186 Processual archaeology also explored contemporary ethnographic examples as a way
187 to infer past practices and behaviours (Renfrew 2011: Chapter 12). This interest in
188 ethno-archaeology was fully explored in the study of Millie's Camp (Canada) as an
189 archaeological site. In this study, Bonnichsen (1973) analysed a contemporary camp
190 from an archaeological perspective and inferred behaviours and practices from the
191 material record, following its abandonment. The conclusions were then tested against
192 information shared by Millie, a former camp occupant (Bonnichsen, 1973). Taking a
193 case study from the recent past, this study allowed archaeologists to test inferences
194 and biases existing in archaeological interpretations.

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

204 This project regarded modern garbage as a source of interest for archaeologists
205 and a way to acquire information about consumption patterns of contemporary society.
206 Rathje contributed to the development of Garbology, a term introduced and put into
207 practice by the journalist A.J. Weberman (1980) who analysed garbage from his idol
208 Bob Dylan and then from various other famous individuals. Rathje's Garbage Project
209 developed this idea, promoting the scientific and systematic application of
210 archaeological methods, such as surveys and typologies, to study contemporary
211 waste (e.g. and notably Rathje and Murphy, 2001). In the US, between 1973 and 2005,
212 the Garbage Project analysed 192.2 tons of garbage from 20,416 households in seven
213 areas and 45.3 tons of refuse from 19 landfills and four open dumps in 15 cities
214 (Rathje, 2011). Through their research, Rathje's teams noted paper as being the most
215 voluminous category within landfills, realising however the significance of plastics
216 whose proportions changed little between fresh household garbage and landfill due to
217 their non-biodegradability despite advertised promises. This contemporary

218 archaeology project therefore produced new information around consumption levels,
219 food waste, and reactions to shortages (Reno, 2013). The Garbage Project emerged
220 in an era concerned with social and environmental issues (Reno, 2013), which makes
221 it still very relevant today. The legacy of the project is still visible with several
222 approaches using waste as a method to understand social practices (Högberg, 2017),
223 re-construct narratives of illegal migrations (De León, 2015) and of object journeys
224 (Schofield *et al.*, 2020), and as an engagement tool in marketing research (Damron-
225 Martinez and Jackson, 2017).

226

227 In the mid-1980s, post-processualism brought the focus on the meaning and
228 symbolism of material culture and how this shaped human social practices (Trigger,
229 2006: Chapter 8; for a review on the development of post-processualism see Preucel,
230 1995). They looked at material culture *per se* and not as an interpretative tool (see
231 Hicks 2010), recognising the agency of objects (Jones and Boivin, 2010). From that
232 perspective, post-processualists in the UK started to use contemporary material
233 culture to reflect on social meaning and values. Research on the design of beer cans
234 in Sweden versus Britain (Shanks and Tilley, 1992) and the wearing of bow ties in a
235 pet food factory (Hodder, 1987) led to the understanding of modern material culture
236 within social practices (summarised in Harrison and Schofield, 2010: 187-188). This
237 approach slowly expanded the potential meaning and relevance of modern material
238 culture, while recognising its complexity. The use of material culture as a prism into
239 culture, behaviour, or society, had reached its limits, often reproducing an object-
240 subject dualism, with the object informing about different aspects of the subject's life.
241 Several frameworks were since proposed to study material culture, questioning
242 researchers positionality thanks to indigenous and feminist archaeologies (Hicks
243 2010), developing object-centred approaches (e.g. Olsen, 2010), investigating object
244 agency (Gosden, 2005), and recognising how objects are entangled in relationships
245 with different actors through Actor Network Theory (ANT) (Latour, 1996, 2005).
246 Building on archaeological reflections on posthumanism (de-centering of the human,
247 see Fernández-Götz *et al.*, 2021) and New Materialisms (a recognition that materials
248 are central for archaeologists but considering them in a non-reductionist manner, see
249 Witmore, 2014: 205), archaeologists considered ways to apply these frameworks to
250 the archaeological record (e.g. Fowler and Harris, 2015) including of the contemporary
251 era (e.g. Yaneva, 2013).

252

253 Those expanding perspectives were facilitated by the consideration for modern
254 and contemporary material culture, particularly in anthropology and sociology (e.g.
255 Hawkins, Potter and Race, 2015 for an analysis of bottled water), but also in
256 archaeology (Erny and Caraher, 2020; Letelier Cosmelli and Goldschmidt Levinsky,
257 2021). From that perspective, much of modern material culture became archaeological
258 objects of research and even archaeological sites including a Ford Transit van (Bailey
259 *et al.*, 2009), a computer hard drive (Perry and Morgan, 2015) and video games
260 (Newell *et al.*, 2009). Among those studies, some focused on new synthetic materials,
261 such as plastics (e.g. in the form of leisure items such as vinyl records and toys), and
262 offered avenues to explore different concepts, such as that of nature/culture as a
263 holistic framework for investigation, extending beyond the conventional dualism, and
264 to recognise the actions of both human and nonhuman actors. The entanglement of
265 plastics with humans and non-humans alike, and its contribution to new geological
266 forms make these distinctions even less relevant for contemporary assemblages. The
267 focus on modern material culture therefore inscribes itself in those approaches,
268 opening interpretations beyond an anthropocentric and western lens. This focus on
269 modern material culture developed alongside an interest for modern societies in their
270 integrity that naturally became a topic of interest for (contemporary) archaeologists.
271 The specificity of modern material culture entangled in global, colonial and complex
272 networks requires tailored archaeological frameworks to explore how they contribute
273 to shaping our societies culturally, socially, politically and economically. In this paper,
274 we emphasise the framework of object itineraries that we consider particularly helpful
275 to understand plastics as global artefacts (see for example the global journey of a flip
276 flop by Knowles 2015). The following section will present how object itineraries are
277 particularly suited for the study of plastics as artefacts characteristic of the Plastic Age.
278

279 Object itineraries

280 The interest in artefacts, and their complex histories, led to the development of the
281 chaîne opératoire due to the theories of anthropologist Marcel Mauss (1936) and the
282 contributions of archaeologist Leroi-Gourhan (1964) to account for the sequence of
283 actions necessary for an artefact's production. (See Lewis and Arntz, 2020 for a review

284 of the term's genesis, present uses and potential developments.) This concept offered
285 a very systematic way of re-constructing the different steps included in the making of
286 an object. It offered possibilities to inform on the technology of societies (Martín-
287 Torres, 2002), and was first predominantly used by French academics for lithics
288 studies (Sellet, 1993). The chaîne opératoire mostly focused on objects by
289 reconstructing production steps, starting with the procurement of raw material and
290 ending with the discard of the artefact (Sellet, 1993). However, the framework and its
291 focus on technology were deemed too rigid to understand other aspects of artefact
292 production (Bar-Yosef and Van Peer, 2009), which were central to the development
293 of alternatives inferring behaviours from the material record. For example, Schiffer
294 (1975) developed the behavioural chain analysis, considered in some ways very
295 similar to the chaîne opératoire (Sellet, 1993; Martín-Torres, 2002; Lewis and Arntz,
296 2020), aiming to reconstruct a sequence of activities and testing how these correspond
297 to the archaeological record. In his development of behavioural archaeology, Schiffer
298 (2002; 2010) was interested in cultural and non-cultural processes, including
299 taphonomic factors, to reconstruct materials' life histories and understand the record
300 the archaeologists are faced with (Schiffer, 1975). Both the chaîne opératoire and the
301 behavioural chain analysis have since informed studies using the chaîne opératoire to
302 reconstruct with more precision the steps of artefact production, use and discard for a
303 wide range of materials (e.g. Driscoll, 2009; Drieu, Lepère and Regert, 2020). Since
304 then, the concept has evolved to be more inclusive of social practices and its
305 reconstruction has built upon multidisciplinary works, facilitated by the rise in material
306 science studies (Lewis and Arntz, 2020). While the social and cultural aspects of
307 material culture are therefore considered in more recent applications of the chaîne
308 opératoire (Lewis and Arntz, 2020), it was their absence that led archaeologists,
309 particularly post-processualists, to look for approaches focusing on the social life of
310 objects such as object biography and life histories.

311

312 The consideration for the sociality of material culture naturally led
313 archaeologists to focus on how the social nature of objects was expressed through
314 interactions with humans, and how their lives paralleled our own. Two concepts were
315 developed building on an analogy with human life: object biographies and life histories.
316 First coined by the anthropologist Kopytoff (1986), object biographies were seen as a
317 way to ask the same questions about objects (or, as he called them, *things*) and

318 people, including their origin, cultural meaning, and the changes throughout their lives.
319 A *thing* could have multiple biographies whether social, economic, or technical but all
320 would be culturally constituted (Kopytoff, 1986). The potential of the framework was
321 then explored for archaeological artefacts in Gosden and Marshall's (1999) landmark
322 publication. These authors considered object biographies as an accumulation of
323 histories and relationships with people crystallising in the present significance of the
324 objects. Biographies facilitated the consideration of shifting and changing meanings
325 and perceptions during the life of an artefact (Hahn and Weiss, 2013). Life histories,
326 already considered as a part of behavioural archaeology (Schiffer, 1975), aimed at
327 understanding and reconstructing the trajectory that artefacts had taken, adopting a
328 social (e.g. Holtorf, 1998; Crown, 2007) or technological lens (e.g. Sáenz-Samper and
329 Martín-Torres, 2017; Plaza Calonge, Figueroa Larre and Martín-Torres, 2022).
330 While the focus on morphological and/or functional changes had been central to use-
331 life approaches developed by processualists (Tringham, 1995), life histories also
332 considered the social interactions in which objects and monuments were and still are
333 entangled (e.g. Holtorf, 1998), and the meaning they hold (Gosden and Marshall,
334 1999). The concept allowed for an object's life to be told independently from its
335 maker(s) or owner(s), a vision particularly helpful when multiple hands contribute to
336 the existence of clay pots (Crown, 2007) and to consider the role of past monuments
337 for subsequent societies (Holtorf, 1998).

338

339 Limitations of both concepts were quickly identified and scholars attempted to
340 clarify both frameworks to make them more nuanced. Despite the success of object
341 biographies for almost 25 years in archaeology (Mytum, 2003/2004; Pearson and
342 Connah, 2013; Jones, Díaz-Guardamino and Crellin, 2016; Guzzo Falci *et al.*, 2020),
343 concerns regarding its limitations were also raised. For example, limitations of object
344 biographies include the ontology (dualism subject/object), the linearity of the
345 reconstructed biography, and the start and end point of an object's life (see Hahn and
346 Weiss, 2013; Bauer, 2019). The risks posed by the linear nature of object biographies
347 was already identified by Joy (2009) who advocated for a relational biography focusing
348 on the set of relationships an object was entangled in. Scholars using life histories
349 identified similar issues, particularly the determination of start (birth) and end (death)
350 points (see Holtorf, 1998 for the death of megalithic monuments). To acknowledge
351 this, Holtorf (2002) distinguished between short and long life histories, the former

352 including an object's life until it is buried whereas the latter extends to include
353 interactions that led the object to reach the present time. The development of the long
354 life histories framework enabled Holtorf (2002) to situate material culture in the present
355 while recognising its extension into the past and the future, and evaluate the evolution
356 of its meaning through time. Despite those attempts, the development of a new
357 framework, object itineraries, allowed archaeologists to move away from the
358 problematic analogy with human life at the core of object biographies and life histories.
359

360 First proposed by Rosemary Joyce (2012a, 2012b), object itineraries are
361 defined as “routes by which things circulate in and out of places where they come to
362 rest or are active” (Joyce, 2015: 29). Central to the volume edited by Joyce and
363 Gillespie (2015a), the potential of object itineraries as an alternative to object
364 biographies was explored for archaeological artefacts, fully considering the modalities
365 of circulation of the objects. Going beyond the tension between relational and narrative
366 biographies, itineraries connect objects to their representations (Joyce and Gillespie,
367 2015b) and the engagement they have with researchers and with the public (Joyce,
368 2015). Since then, the concept has gained interest in archaeology (e.g. Joyce, 2017)
369 including examples from museum (McGill and St. Germain, 2021) and heritage studies
370 (Bauer, 2021), creative writing (e.g. Nisbet, 2021) and even marketing research (e.g.
371 Santana and Botelho, 2019). The framework has been seen as having several
372 advantages over object biographies (see Bauer, 2019), for example mapping out how
373 the stops and journeys of an object can be interconnected (Nisbet, 2021) and working
374 on different temporal scales, from human life span to geology (Joyce, 2015). Object
375 itineraries also allow us to consider the ethical and political implications of material
376 culture (Bauer, 2019). In that perspective, the potential of object itineraries is key to
377 moving beyond the limitations that life histories and biographies could not overcome.
378 Itineraries offer space to consider a network of processes and relationships that go
379 beyond the temporal, human, and geographical scales usually considered. For
380 plastics, this is particularly important because of their persistence, plasticity, ubiquity,
381 untraceability, and “globalised unlocality” (Davis, 2022: 5). This framework suits
382 plastics particularly well, breaking away from the technical focus of *chaîne opératoire*,
383 the linearity of biographies and the analogy with human life. This constitutes a
384 framework that is well suited to the archaeological investigation of plastics as artefacts
385 embodying the Plastic Age.

386 The Plastic Age

387 Like many categories of artefacts from earlier periods, plastics are abundant,
388 ubiquitous, and pervasive within the contemporary world and this has been
389 increasingly the case since about 1950 when plastics started to become widely used,
390 not least in food packaging. Yet, it is the persistence and the impact of their presence
391 that separates plastics from other materials of earlier periods. Their ubiquity and the
392 way they affect people unequally emphasises the colonial dynamics in which plastics
393 are entangled, from production to disposal (Liboiron, 2021; Davis, 2022). By being
394 global, colonial, political, and persistent, they embody anthropic impacts on the
395 environment, a key characteristic of the Anthropocene. While recently dismissed by
396 the International Union of Geological Sciences (IUGS) as a geological epoch (Witze
397 2024), the Anthropocene remains a relevant concept for scholars from a wide range
398 of disciplines interested in exploring the distinct nature of human impact since the
399 1950s. While we recognise the key role that plastics played in defining and studying
400 the Anthropocene (e.g. Zalasiewicz *et al.*, 2016), we here prefer the term Plastic Age,
401 as a more archaeologically-oriented term.

402

403 The term Plastic Age, first mentioned as the title of an American novel written
404 by Percy Marks in 1924, has become a term adopted by different scholars (Thompson
405 *et al.*, 2009; Porta, 2021; Kramm and Völker, 2023), to mirror the periodisation of
406 earlier periods such as the Stone Age, the Bronze Age, and the Iron Age. Similarly to
407 the Anthropocene, debates have arisen regarding the starting point of the Plastic Age.
408 The invention of synthetic plastics in the early twentieth century, and their increasing
409 importance, served to suggest a starting date for the Plastic Age after the First World
410 War (e.g. Sklar, 1970). Yet, the consumption of plastics increased drastically after the
411 Second World War to meet the demands of post-war societies rushing into mass
412 consumerism (Meikle, 1992; Strasser, 2000). This period also coincides with the
413 diversification of plastics' chemical signatures (Geyer, 2020), hence making 1950 a
414 most commonly accepted starting date for the Plastic Age, as stated above. A few
415 variants were also proposed including the Plasticene (Ross, 2018; Haram *et al.*, 2020),
416 starting in 1907 (corresponding to the invention of the Bakelite as the first fully
417 synthetic plastic) with an intensification since 1950 (Rangel-Buitrago, Neal and
418 Williams, 2022), and the Plastics Age (Sparke, 1993 in Hawkins, 2018). Following the

419 use of the singular for other periods, we here refer to the Plastic Age (as in Godin et
420 al., in press) while recognising diversity within its scope. The Plastic Age emphasises
421 the key role of plastics as material culture shaping practices of our contemporary
422 societies, mirroring archaeological periods centred on the material properties and
423 technology of artefacts (Graves-Brown, 2014). Aside from being a material culture that
424 most people interact with daily, plastics are becoming historical, entering museum
425 collections subject to conservation treatments, and yet also forming a ‘toxic heritage’
426 (after Kryder-Reid and May 2024).

427

428 The history of synthetic plastics highlights how they have acquired socio-
429 economic values and importance. In that sense, they have become what
430 archaeologists consider artefacts, shaping new social practices (Hawkins, 2018) and
431 holding cultural meaning (Ingold, 2000). Emblematic of our contemporary world,
432 plastics were praised and hated equally. In the first instance, plastics were seen as
433 cheap substitutes for other materials (Bensaude-Vincent, 2013), offering a way to
434 protect natural resources while paving the way for democratisation of several products.
435 There followed a tangible excitement to explore the potential of plastics’ materiality in
436 art and design, preceding an ecological consciousness of plastics’ impacts and
437 persistence (Bryning, 2024). Plastics were also of interest to scholars studying modern
438 material culture including archaeologists, notably as a symbol embodying consumer
439 culture, supermodernity, and destruction (in the sense defined by González-Ruibal,
440 2018). For example, the plasticity of plastics, and their mutable qualities, created new
441 socio-economic dynamics and markets (Hawkins, Potter and Race, 2015; Dey, 2021),
442 but also reinforced and reproduced some immutabilities including social hierarchies
443 and exposure to waste (Dey, 2021).

444

445 Plastic artefacts enter the archaeological record and can even become part of
446 the geology. Corcoran, Moore and Jazvac (2013) were the first to identify a hybrid
447 artefact (in the sense given by Liebmann, 2015) in Hawaii which they called
448 plastiglomerate. Since then, different ways in which plastic can be the locus of
449 nature/culture hybridisation have been identified (see Rangel-Buitrago, Neal and
450 Williams, 2022 for a review of the ways plastics are included in the geology). The
451 “Plastic Geological Cycle” is a term proposed by Rangel-Buitrago, Neal and Williams
452 (2022) to explain the processes and pathways by which plastics, especially micro- and

453 nano-particles, are incorporated into the Earth's geosphere and potentially impact the
454 natural rock cycle. The existence of anthrosols (i.e. a mix of litter with organic and/or
455 mineral matter) and plastisols (i.e. plastic mixed with organic and/or mineral matter)
456 (Rangel-Buitrago, Neal and Williams, 2022) highlight how plastics can also enter the
457 archaeological record and indicate layers of occupation.

458

459 Archaeologies of plastics and plastic pollution

460 Since the Garbage Project first explored modern waste including plastics,
461 archaeologists have been keen on exploring plastics from different angles, sometimes
462 as part of interdisciplinary projects. Whether it is by considering plastics as artefacts,
463 heritage, or legacy, and focusing on mega, macro, micro or nanoplastics,
464 archaeologists have studied plastics' presence in a wide range of contexts.

465

466 With the long-standing interest of archaeologists in the waste generated by
467 human societies, plastic litter and pollution have become the focus of several studies.
468 The accumulation of plastics was identified on the Iron Age heritage site of Castell
469 Henllys (Wales) where the sites of two reconstructed Iron Age houses were excavated
470 by Mytum and Meek (2020). Plastics were considered as artefacts informing on the
471 site's visitors' behaviours (Mytum and Meek, 2020). Building on the potential of
472 material culture to inform behaviours, an archaeological framework was used to
473 correlate the accumulation of plastics in rivers with littering behaviours (Carpenter and
474 Wolverton, 2017). Taking a landscape approach, surveys of drift matter including
475 plastics yielded insight into the human relationship to this material culture and how it
476 is perceived locally (Pétursdóttir, 2017, 2020). Using plastic waste collected on
477 beaches of Galapagos (Ecuador), Schofield et al. (2020) organised a narrative
478 workshop to reconstruct the journeys that those plastic artefacts had taken before
479 reaching the archipelago's shores. Sampling of plastic bags in the town of Santa Cruz,
480 Galapagos was also undertaken to approach disposal practices over time (Schofield
481 *et al.*, 2021a). These latter two were related studies that provided the groundwork and
482 the opportunity for further projects using marine plastic litter as the basis for online and
483 in-person narrative workshops in Galapagos and its wider region (Praet *et al.*, 2023a;
484 Praet *et al.*, 2023b). Prior to these projects, the potential of researching marine debris

485 as an archaeological object of study was already identified by Arnshav (2014) who
486 encouraged the development of marine garbology. Sometimes, access to physical
487 artefacts is challenging as was the case during the COVID-19 lockdowns. From that
488 perspective, social media representations and content analysis also offer an archive
489 of plastic use and disposal which can be investigated archaeologically, the artefacts
490 in this case being represented through online records such as photographs or
491 descriptions. Using evidence from social media, Schofield *et al.* (2021b) studied
492 Personal Protective Equipment (PPE) such as face masks and gloves from an
493 archaeological perspective to develop policy recommendations. In their
494 MetroVancouver project, Camp and Muckle (2022) documented artwork, structures
495 and artefacts associated with the pandemic through pedestrian surveys, digital
496 recording and online meetings. These projects under the COVID-19 pandemic
497 emphasize the relevance of contemporary archaeology to document waste, rapid
498 events and contribute to recommending solutions.

499

500 Archaeological approaches are not limited to plastic waste and can also include
501 perspectives on plastic production sites (e.g. Caraher, in press) and the use of plastics
502 as products (e.g. in art see Bryning, in press) sometimes re-used as building material
503 to maintain heritage building traditions (e.g. in the case of the Flipflop, a dhow made
504 of former plastic flip flops, see Müller *et al.*, in press). Plastic production sites can
505 become part of a toxic heritage, one facilitated by industrialisation and waste disposal,
506 and that has shaped our current landscapes (e.g. Shackel, 2023). The extraction of
507 natural plastics can also contribute to the development of toxic landscapes, for
508 example with the addition of chemicals to process rubber in Amazonia (Alves Muniz,
509 2023). In addition, archaeological theory can approach plastic from different angles,
510 questioning the role of the discipline in addressing this current environmental crisis. A
511 recent reflection by Wooten (2023) offered to focus on plastics archaeologically as a
512 basis for activism and public outreach, leading to reflections on behaviour and the
513 current climate crisis. This refreshing approach used archaeology as a situated
514 practice, while Praet (2024) looked at plastic pollution as an object of study and of
515 concern for archaeologists, respectively exploring the potential of its materiality
516 suggesting different techniques, and acknowledging its impacts on heritage and
517 archaeological sites.

518

519 While there are many ways to consider an archaeology of plastics or plastic
520 pollution, as a subfield of contemporary archaeologies, transdisciplinary approaches
521 are particularly welcome and are probably essential to approach the related wicked
522 problems of climate change and environmental pollution (see Bernstein, 2015). For
523 example, some scholars have become interested in the accumulation of plastics over
524 time in sedimentary records (Brandon, Jones and Ohman, 2019; Simon-Sánchez *et*
525 *al.*, 2022) while others have explored the information available on plastic objects (Falk-
526 Andersson *et al.*, 2021), notably on PET bottles (Ryan, 2020; Ryan *et al.*, 2021). Other
527 studies have focused on plastic litter weathering and degradation, notably with the
528 Lego Lost at Sea project (Turner, Arnold and Williams, 2020). While a thorough
529 discussion of ways to look at plastics archaeologically is provided by Praet (2024), the
530 forthcoming *Routledge Handbook of Archaeology and Plastics* (Godin *et al.*, in press)
531 will be the first work exploring the diversity of archaeological approaches to plastics
532 and plastic pollution globally, in both a geographic and thematic sense.

533 Plastic waste as toxic heritage

534 Waste is a ubiquitous material of post-industrial landscapes, one that is entangled in
535 social, economic, and/or political relationships (Baird, 2022). Studying plastics
536 archaeologically requires consideration of plastic waste and how it can become and/or
537 threaten heritage. Considering plastics as heritage questions the value(s)
538 contemporary societies assign to them as products but also as waste. While there is
539 no doubt that some plastic products can be seen as highly valued heritage as they
540 hold social, cultural, and economic meaning, the discussion here focuses on plastic
541 waste exclusively. The value of waste has often been a topic of debate from which
542 plastics do not escape. In their socio-archaeological approach to the International
543 Space Station (ISS), Walsh, Gorman, and Castaño (2022) identified that waste could
544 either be seen as: a) not valuable and therefore burnt, or b) valued and therefore
545 removed from the ISS and brought back to earth. The limited capacity of vessels going
546 back to earth from the ISS required a careful selection of the objects, hence the need
547 to focus only on those items given value and importance (Walsh, Gorman, and
548 Castaño, 2022). Inspired by forensic science, Walsh, Gorman, and Castaño (2022)
549 used the concept of chain of custody, considering the whole process of inventorying,
550 handling, documenting, and disposing of objects with accountable actors for every

551 step. This specific example contrasts with the lack of accountability characterising
552 most plastic waste, being considered untraceable (see Davis, 2022). While
553 accountability varies greatly for plastic waste, the value assigned to it is key to how
554 contemporary societies perceive and act towards it.

555

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

567

568 With archaeological theory and practice now being heavily influenced by
569 posthumanism, nonhumans are now immersed within definitions of heritage. From that
570 perspective, considering marine plastic litter and plastic waste in general as entangled
571 in heritage making is meaningful, as it shapes new relationships with humans and
572 nonhumans alike. Heritage can no longer be perceived as a restriction from the human
573 touch (see Harrison, 2021). Plastic’s overwhelming presence and degradation into
574 fragments that become entangled with nature makes it difficult and almost irrelevant
575 to differentiate nature/culture in most places around the world. The concept of plastic
576 naturecultures was proposed by De Wolff (2017) to address the specificities of plastic-
577 species encounters and the plastisphere. Plastic naturecultures could then become a
578 type of heritage, nonetheless recognising the threat that these interactions pose and
579 the toxic nature of such heritage.

580

581 The threat that plastics pose to the environment, wildlife, and human health
582 turns it into an almost hazardous material or heritage. In that sense, plastic waste
583 belongs to a category of heritage that has recently been gathered under the concept
584 of toxic heritage (Kryder-Reid and May 2024). The toxicity of heritage is not related to

585 its content but rather to its management and to the narratives built on it (Wollentz *et*
586 *al.*, 2020). In that perspective, plastic can be considered toxic and toxic heritage more
587 because of its (mis)management than the toxic additives and substances allowing its
588 plasticity. Plastic is also very changeable, a property characterising toxic waste and
589 toxic heritage according to Wollentz *et al.* (2020). Plastics have also been labelled
590 ghost heritage (notably by Harrison, 2021). The concept of ghost heritage, as haunting
591 unmanaged disposals (Harrison, 2021: 38), is an interesting way to approach plastics,
592 particularly to explore the shifts of plastic pollution from an overwhelmingly visible
593 issue on polluted beaches to the invisible ingestion of micro- and nanoplastics by
594 humans and nonhumans. Depending on the beholder, the context, and the
595 degradation, plastics can be overwhelmingly visible, such as in Kamilo Beach, Hawaii,
596 one of the most polluted beaches on earth, or invisible to most humans, such as
597 plastics in deeply buried archaeological sediments (Rotchell *et al.* 2024).

598

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

615

616 Independently from the unequal distribution of its legacy, waste remains
617 relational and connected (Baird, 2022) which makes the use of object itineraries
618 particularly relevant to discuss plastic waste. Baird (2022) even proposes to see waste

619 as a teaching tool, one that moves our consideration of waste from nostalgia to repair
620 by considering the social, economic, and environmental problems at its core. Projects
621 based on plastic waste as artefacts can inspire discussions about respect for the
622 environment and the role of human behaviour contributing to the issue (e.g. Holtorf,
623 2023 for his analysis of the Lego Lost at Sea project). Contemporary archaeology is
624 interested not only in the material culture of us, and here we are focusing on plastics,
625 but also in the activities, relationships, and perceptions we develop with and towards
626 these objects. Using an archaeological framework turns archaeology into a situated
627 and thus vital practice.

628

629 Plastics, archaeology and contributions to policy

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

638 Archaeology can be viewed as an important tool for activism (and see Wooten 2023)
639 through the data and understandings that it can generate. Activist groups can shape
640 governance initiatives, as well pushing for policies and programs that are focused on
641 solutions towards recycling, reuse, and reduction of waste production (O'Neil, 2019).
642 As described earlier, there is a growing injustice and inequity stemming from plastic
643 pollution, where some communities are taking on more of the burden of plastic
644 pollution than others. Plastic pollution disproportionately harms the human right to a
645 clean and healthy environment and for many vulnerable communities including
646 indigenous peoples and the many waste pickers who recycle and repurpose plastic
647 waste, they are experiencing systemic environmental injustices (Vandenburg and Ota,
648 2022). Inequitable impacts of plastic pollution do not start in the ocean and can be
649 observed at all stages of the plastic lifecycle, extending across social, political,

650 economic planes and are disproportionate, for example, for people of colour and low
651 income (Vandenburg and Ota, 2022). This asymmetry of power over plastics
652 production and pollution governance has excluded a diversity of actors across the full
653 range of plastics and alternative forms of knowledge and world views (to dominant
654 Eurocentric scientific disciplines), producing harmful outcomes for already at-risk
655 communities (O’Neil, 2019; Vandenburg and Ota, 2022). Contemporary
656 archaeological work enables deeper consideration of inequalities and injustice in the
657 past and functions to remind us of struggles that continue into the present day, and
658 the future (Kiddey and Graves-Brown, 2015).

659 The plastic crisis is a complex societal problem and transcends all borders.
660 Undoubtedly problems related to plastic pollution cannot be solved solely by the waste
661 management sector or changes through consumer choices and cannot be solved as
662 quickly as we may hope. Given the scale and magnitude of climate change and other
663 environmental challenges, researchers have emphasised the value of interdisciplinary
664 or transdisciplinary research, including the social sciences and humanities, to evaluate
665 issues and search for realistic scenarios and solutions (Rick and Sandweiss, 2020).
666 Policymakers have the task to give directions to the world, in order to analyse the
667 problems, make decisions and implement changes (Detombe, 2015). Archaeology in
668 the context of interdisciplinary approaches will be key to finding overarching laws and
669 policy solutions fitting the scope of the problem. The plastic pollution crisis is placing
670 the planet in peril. As referred to earlier, plastics contribute to climate change through
671 greenhouse gas emissions, from production to disposal, and the pollution will be
672 exacerbated by climatic events (Ford et al. 2022). Archaeologists as members of a
673 team of interdisciplinary researchers now have an important role to play because of
674 their unique insight into understanding behaviours through material culture, their ability
675 to work across scales (from local to global) and in all environments, and their deep-
676 time perspective. Therefore conveying their findings in holistic and equitable
677 applications of scientific, social and economic perspectives to understand the Plastics
678 Age and its related challenges, they can be a part of shaping important policies,
679 regulations and legislative frameworks at all levels.

680 Plastics: an archaeological view into the deep future

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

697

698 As people living in the early to mid twenty-first century, we can predict many
699 alternative futures. Some of our views are shaped by science-fiction, each story
700 representing a time many centuries or even multiple millennia from now. Rather than
701 fiction, perhaps we should consider these to be some of those 'alternative futures'. As
702 we continue to try to better understand the past, we can also use the archaeological
703 evidence at our disposal, alongside models generated for example through economics
704 and climate science, to directly and critically address those futures, by determining
705 which elements are the most likely to occur, what might cause them to occur or rule
706 them out, and when we might expect them to become a reality. Finding solutions to
707 the current wicked problems of climate change and environmental pollution is one area
708 in which these two archaeological perspectives (past- and future-oriented) can
709 converge. Taking archaeology into new and challenging situations like these,

710 alongside new environments such as deep oceans and space, presents additional
711 opportunities to think about human pasts, present and futures.

712

713 But where we perhaps need to focus most of all, is in demonstrating how our
714 archaeological evidence can cause people to think about their own part in this grand
715 narrative, about time and our place within the many stories of the changing planet on
716 which we live and upon which we depend. Archaeology is ultimately about people and
717 it is the individual actions of people that have created the traces that constitute the
718 palimpsest of the contemporary world. How we act today, as a society but also as
719 individuals within society, will similarly determine the shape of future worlds. This
720 philosophical approach, this way of thinking, is something that, as archaeologists, we
721 understand. Plastics, as archaeological materials, are central, to reading, thinking
722 through and ultimately, hopefully, understanding the implications of the deep
723 entanglements of people and things in the contemporary world, and they are also
724 therefore vital to how we might try to untangle things sufficiently to create futures in
725 which life continues to thrive.

726

727 **Acknowledgments**

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

734

735 **Author contribution statement**

736 **Estelle Praet:** conceptualization; writing – original draft; writing – review and editing

737 **John Schofield:** structure; writing – original draft; writing – review and editing

738 **Raveena M. Tamoria:** writing – original draft; writing – review and editing

739

740 **Financial support**

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

744

745 **Conflict of interest**

746 The authors declare no conflict of interest.

747

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