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Critical Geoarchaeology: From Depositional Processes to the Sociopolitics of Earthen Life

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Abstract

In the last several decades, geoarchaeological research and practice have moved well beyond their foundational concerns for site formation processes and the stratigraphic integrity of artifact associations, developing significant orientations toward archaeological and social theory. This review focuses on four overlapping research emphases that have explicitly extended the reach of geoarchaeological research within the broader social sciences and humanities, including (*a*) interpretive, symbolic, and social approaches in geoarchaeological research; (*b*) articulations with recent developments in posthumanist and new materialist scholarship; (*c*) the application of geoarchaeological investigations to historical ecology and political ecology research programs; and (*d*), building on the latter, critical engagements with ongoing transdisciplinary scholarship on the Anthropocene. Taken together, these different orientations offer new possibilities for geoarchaeological research to inform anthropological concerns for social and environmental production and the ways that archaeological and geological fields of practice and discourse contribute to shaping social, political, and environmental conditions today.

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INTRODUCTION

Geoarchaeology—the practice of using techniques rooted in the geosciences to address archaeological research questions—has long-established foci on site-formation processes, geochronology, and the reconstruction of paleoenvironmental contexts as objects of scholarly investigation (e.g., Courty et al. 1989, Goldberg & Macphail 2006, Nicoll et al. 2021, Rapp & Hill 2006, Waters 1992). Such topics of inquiry have been so fundamental to the specialty that some scholars have suggested that all archaeology is essentially “geoarchaeology,” given the degree to which any archaeological interpretation is premised on assumptions or explicit inferences about the formation and preservation of the excavated archaeological record (cf. Maher 2017, Renfrew 1976). While geoarchaeological research justifiably and necessarily maintains emphases on understanding environmental factors that have contributed to shaping the formation, preservation, and contemporary distribution of the archaeological record at multiple spatial scales (e.g., Araujo et al. 2020, Bauer et al. 2004, Goff et al. 2021, Mallol & Mentzer 2017), in recent decades there has also been an increasing effort to establish stronger links between geoarchaeology and other interpretive and theoretical concerns of archaeology, anthropology, and the broader social sciences and humanities within which these disciplines are situated (e.g., Maher 2017). These efforts have generally taken several different forms of theoretical engagement that serve as the basis of this review. More specifically, here I focus on four overlapping research orientations that have explicitly extended the reach of geoarchaeological work beyond its more conventional topics: (a) interpretive, symbolic, and social approaches in geoarchaeological research; (b) articulations with recent developments in posthumanist and new materialist scholarship; (c) the application of geoarchaeological investigations to historical ecology and political ecology research programs; and (d) critical engagement with ongoing interdisciplinary scholarship on the Anthropocene.

Taken together, these different orientations offer new possibilities for geoarchaeological research to inform anthropological attention to social and environmental production and to contribute to broader conversations in the humanities and social sciences. However, these opportunities also come with challenges and pitfalls. The embrace of some strands of new materialist and posthumanist thought, for instance, has significant shortcomings in how this scholarship addresses concerns for power, inequalities, and political responsibility (e.g., Bauer & Bhan 2018, Harman 2009, Van Dyke 2015). Moreover, (geo)artifact classification schemes, typologies, and temporal systematics are not neutral analytical devices (e.g., Agbe-Davies 2016, Finney & Edwards 2016). Thus, to be clear, these new research orientations need not seamlessly articulate with each other. Yet collectively they enable geoarchaeological research to emphasize the social and cultural significance of earthen materials and substances in relationship to human–environment dynamics and histories at multiple temporal and spatial scales. Given the contemporary context of ongoing concerns for global environmental change (e.g., Crutzen 2002), such geoarchaeological research is thus well positioned to contribute to transdisciplinary conversations about social and environmental production, emphasizing, for instance, resilience and sustainability (e.g., Crumley et al. 2015, French et al. 2017) while also pushing beyond these interests to critically interrogate the ontologies and ideological bases in which conservation policies and discourses are rooted.

INTERPRETIVE, SYMBOLIC, AND SOCIAL APPROACHES IN GEOARCHAEOLOGY

Defined in a broad sense as the practice of using techniques based in the geosciences to address archaeological research questions (e.g., Goldberg & Macphail 2006), the subdiscipline of geoarchaeology has long contributed to anthropological archaeology in ways that go beyond foundational considerations of site-formation processes, geochronology, and the reconstruction

of paleoenvironmental contexts. Indeed, to the degree that geoarchaeological research has been used to reconstruct past cultural activities and practices (e.g., manuring agricultural fields, ritual modifications of materials), it has long represented an important set of methods to an anthropological archaeology at multiple research scales (e.g., Courty et al. 1989, Lee et al. 2014, Love 2012, Macphail 1989, Maher 2017, Mentzer et al. 2017). By some definitions, most artifact compositional analyses and material provenience assessments fall under the rubric of geoarchaeology, given the degree that these analyses frequently rely on techniques deployed in the geosciences. A range of geochemical mass spectrometry methods and other compositional evaluations (e.g., EDAX, ICPMS, NAA, XRF, XRD) are often considered to be within the tool kit of the discipline (cf., Goldberg & Macphail 2006, Rapp & Hill 2006, Shackley 2011), especially when coupled with other geologically informed observations (e.g., petrographic analysis). Such studies of artifact chemistry and composition (e.g., ceramic petrography) have provided rich data to evaluate production practices and have frequently been used to inform anthropological models of political economy, exchange relationships, craft production, and social communities of practice (cf. Grávalos et al. 2022, Nath et al. 2014, Roddick 2015, Roddick & Cuynet 2021, Tite 1999). Thus, to be clear, the application of geoarchaeology to a theoretically informed anthropological archaeology is not a wholly new development. Nevertheless, there have been increasing efforts to establish stronger links between geoarchaeology and more recent theoretical developments in archaeology, anthropology, and the broader social sciences and humanities.

One major emphasis to frame geoarchaeological research in light of broader theoretical developments in the field of archaeology has underscored the research domain's potential to enhance interpretations of culturally meaningful practices, materials, and places in the past. Although it is not always explicitly acknowledged, these approaches have generally followed postprocessual concerns that archaeological research should contextually evaluate cultural significance over generalizing laws and processes of human behavior (e.g., Hodder 1986, 1999). Some scholars have recently framed these new orientations in geoarchaeology as “behavioral” geoarchaeology and others as “social” geoarchaeology (cf. Jusseret 2010, Love 2012, Roddick 2015, Roos & Wells 2017). Regardless of such different designations and genealogies, these approaches share an interest in highlighting how specific techniques of geoarchaeological research, such as careful stratigraphic delineation, soil chemistry, micromorphological analyses, or petrographic analyses of artifacts (e.g., ceramics), can amplify assessments of the cultural and social significance of deposits and materials in specific cultural and historical contexts. For instance, Roos & Wells's (2017) concern to advance a “behavioral geoarchaeology” shows commitment to amplifying interpretations of “ritual” and “sacred” activities and practices, such as how Fulton et al. (2017) deploy chemical signatures of anthrosols to identify the location of ritual practices in plazas and open spaces in first-millennium Mesoamerican contexts (see also Contreras 2017).

In a similar manner, multiple recent geoarchaeological studies have illustrated how the fine-grained analyses of soils and sediments may reveal hitherto unrecognized dimensions of ritual practices, the symbolic attributes of things, and the cultural values associated with particular substances (cf. Adams & Fladd 2017; Boivin 2000, 2004, 2008; Contreras 2017; Maher 2019; Roos & Wells 2017; Sherwood & Kidder 2011). For example, Boivin's (2000) ethno-archaeological study of the use of different soils and sediments to plaster house floors and features according to physical properties (color, texture, etc.) and cultural values (sacrality, purity) within a Hindu cosmology in contemporary Rajasthan demonstrates how geoarchaeological analyses might be better attuned to the cultural and social significance (e.g., of caste and gender) of the substances they study. Kidder & Sherwood's (2017) micromorphological assessment of earthen monuments from the southeastern United States exemplifies this point well. For instance, their detailed analyses of multiple mounds and strata illustrate that mound building involved “the purposeful selection of soils and sediments

for specific color, texture, or engineering properties” and that the patterned organization of these different substances through ritual practices was instrumental to the constitution and communication of social relationships (Kidder & Sherwood 2017, p. 1077; see also Adams & Fladd 2017, Sherwood et al. 2013, Sherwood & Kidder 2011).

One can find many examples of how the field of geoarchaeology has productively moved beyond its long-standing foci on site formation, chronology, and environmental contexts and into more interpretive archaeological research programs. In some cases, these approaches have also sought to critically challenge modernist ontologies, a concern that is now reaching the broader discipline of geology as well (e.g., Bobbette & Donovan 2018). Roddick (2015), for example, suggests how geoarchaeological observations might help inform interpretations of Indigenous ontologies with respect to earthen materials and substances (Roddick 2015). In advancing an argument for a “social geoarchaeology,” Roddick (2015) considers how the Quechua concepts of *camay* and *huaca* might be used to help understand the itineraries of geocultural objects in the Lake Titicaca basin that are documented, in part, through petrographic and compositional analyses. By evaluating the choice of ceramic tempering agents and their cultural places of origin within broader social and cultural landscapes, Roddick suggests that geoarchaeological research can trace the biographies of materials and substances and “potentially highlight developing cultural logics and aesthetic orders, such as the relational ontology seen in the Andes” (Roddick 2015, p. 144). Such concerns for recognizing different ontologies through the (geo)archaeological record has also opened space for taking seriously the politics of knowledge production (e.g., Cipolla 2018). Yet despite recognizing the limits of the modernist program to characterize environmental phenomena as either “natural” or “cultural” (e.g., see Latour 1993 on purification), practicing geoarchaeologists have remained relatively silent on this topic. Their silence might be unsurprising, in part, because of the strong modernist commitments of geology as a discipline (e.g., Bobbette & Donovan 2018; see also Kourampas 2012, p. 209). However, it is also worth noting that (geo)archaeologists should be attuned to issues around appropriating and reifying Indigenous ontologies (e.g., Sundberg 2014, Todd 2016).

GEOARCHAEOLOGY AND POSTHUMANIST AND NEW MATERIALIST HISTORIOGRAPHIES

As geoarchaeological research has increasingly engaged anthropological and social theory, it has also begun to address a corpus of scholarship emanating from across the social sciences and humanities that is frequently glossed as posthumanist and new materialist theory. Although these designations mask a range of variable theoretical orientations (cf. Alt & Pauketat 2019, Barad 2007, Bennett 2010, Cipolla 2018, Latour 2005, Van Dyke 2015, Webmoor & Witmore 2008), they generally discount human subjects’ privileged capacities for agency and instead call attention to how humans are embedded within networks or webs of relationships with other things, substances, and forces that also give shape to social actions, practices, conditions, and histories (cf. Coole & Frost 2010, Ingold 2007, Latour 2005, Whatmore 2002). These approaches generally embrace relational ontologies over essentialist or substance ontologies (see Bauer 2018c, Bauer & Kosiba 2016). As such, they are amenable to process-based philosophies that foreground interactions and consider the nature of being as fundamentally dynamic. Moreover, they often evoke the concept of an assemblage—i.e., temporary configurations of heterogeneous elements that produce emergent outcomes (e.g., Bennett 2010, DeLanda 2006, Deleuze & Guattari 1987). For instance, as process-based metaphysics has been applied to soils (cf. Bennett 2010, Kourampas 2012, Meulemans 2020), some geoarchaeologists have explicitly embraced a “symmetrical” archaeology rooted in a Latourian actor–network framework and called for the evaluation of sediments

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and soils “as things-in-themselves, rather than mere records of human agency and environmental forcings” (Kourampas 2012, p. 213; see also Olsen et al. 2012, Webmoor & Witmore 2008). Kourampas (2012) argues that doing so will make geoarchaeology’s “stories richer and more congruent with the realities of the inhabited world” (p. 213), a point that finds some resonance in cultural contexts where earthen materials, such as stones, might be considered vibrant or alive (e.g., Cipolla 2018, Povinelli 1995, Roddick 2015).

Such approaches that call attention to the “primary agency” (sensu Hodder 2012) of materials create useful space to consider how the dynamics of things and substances partly gives shape to social and cultural activities. Hodder’s (2012) notion of “entanglement,” by which he names the “double bind” through which humans come to depend “on things that depend on humans” (p. 88), is frequently referenced to discuss the manner through which humans become caught up in attending to the maintenance of things and materials because of their propensity to weather, decay, and break down. For instance, detailed micromorphological analyses have illustrated how humans became invested in the production and maintenance of specific cultural places because the material requirements of things (e.g., through the ongoing weathering and erosion of soils, sediments, and building materials) necessitated regular human attention (cf. Hodder 2012, Maher 2019). Maher (2019), for instance, compellingly demonstrates how micromorphological analyses shed important light on “people-place-thing” relationships over the long term. In the Epipaleolithic context of the Levant, for example, inhabitants carefully maintained fine-textured, laminate floors, likely through regular sweeping, before intentionally caching objects on them and regularly building new surfaces to mark a significant “life event” (Maher 2019, p. 1048).

While some scholars have suggested that geoarchaeology should further embrace the new materialisms in developing its contemporary theoretical relevance (e.g., Prijatelj 2020; see also Jones 2004), other practitioners have directly addressed this scholarship, and specifically the concern for flat ontologies, from a more critical perspective. Bauer & Kosiba (2016), for example, underscore the importance of cultural value systems and perceptions in mediating how geomorphological processes ultimately come to affect human affairs. Borrowing the term from fluvial geomorphology, they refer to a process of “entrainment,” whereby materials that are “caught up” in the flow of human actions have the potential to affect politics and social change as they articulate with historical values and human perceptions. They argue that, in the context of the South Indian Iron Age (1200–300 BCE), the value placed on herd animals and herding resources heightened the social and political consequences of anthropogenic soil erosion, which shifted the distribution of available pasture and contributed to the emergence of social inequalities during the second and first millennium BCE (e.g., Bauer 2015, Bauer & Kosiba 2016). In other words, the ability of soils to shrink, swell, transform, and move dynamically contributed to the configuration of social conditions within this specific cultural context (see also Bauer 2018a).

In a similar vein, some geoarchaeological research has also called attention to “technopolitics,” “resource materialities,” and a concern for the unruly effects of infrastructure, or “landesque capital,” in giving shape to social and environmental conditions on multiple temporal registers (cf. Brite 2018, Hakansson & Widgren 2014, Hecht 2011, Johansen & Bauer 2018, Mitchell 2002, Morehart 2016). “Resource materialities” (sensu Richardson & Weszkalnys 2014), for instance, frame “natural” resources as relational assemblages of knowledge, practices, and dynamic substances rather than simply as “culturally reworked nature” (Richardson & Weszkalnys 2014, p. 8; see also Johansen & Bauer 2018). In these ways, geoarchaeology research has begun to realize its potential to couple analytical concerns for the ways in which objects (e.g., terraces, canals) and substances (e.g., water, soils, sediments) come to be meaningful in specific historical contexts with concerns for how materials’ relational and dynamic properties also affect human social histories. Yet the mediating effects of materials exist in a cultural and semiotic context in which people

recognize significance in material properties; in other words, the social effects of materials are mediated through cultural systems of signification (e.g., Preucel 2020).

While geoarchaeologists could further contribute to new materialist and posthumanist scholarship (cf. Jones 2004, Kourampas 2012), fully embracing the symmetrical project that wholly equates humans and things as actors comes with challenges (e.g., Webmoor & Witmore 2008). Van Dyke, for instance, points to ethical complications with doing so: “Objects cannot suffer, whereas humans can and do” (Van Dyke 2015, p. 19). Moreover, such frameworks risk failing to identify potential asymmetries in how action might be differentially distributed across the human–nonhuman divide, and consequently they have been critiqued for their ability to address power asymmetries and politics (e.g., Bauer & Kosiba 2016; Harman 2009, p. 147). By distributing agency across an assemblage, these frameworks also present challenges (and opportunities) for addressing responsibility for harms when they are untethered to simplistic cause-and-effect understandings of action (e.g., Bauer & Bhan 2018, pp. 26–27, 116–119; Van Dyke 2015). Thus, as Bauer & Kosiba note (2016), “[O]ur object of study should not solely be [the] innumerable relationships between people and things, but also an inquiry into how *only some* of these relationships come to significantly matter to people” (p. 133, emphasis in original). In this regard, however, it is critical to acknowledge that, for some people, what matters is that nonhumans be recognized with the capacities of subjects—for instance, for rocks to “listen” and glaciers to be “benevolent” providers for the health of social environments (e.g., Povinelli 1995, p. 505; Bauer & Bhan 2018, p. 82; see also Bird-David 1999). Allowing the social roles of glaciers or rocks, for example, expands the grounds for addressing convergences of social and environmental justice; it makes it imperative to evaluate how their social roles are being altered in new environmental contexts, and furthermore it permits injured parties to highlight experiences of injustice that need not conform to scientific measures of environmental health or ecosystem services (e.g., Bauer & Bhan 2018, pp. 120–23; Povinelli 1995).

In short, the role of earthen materials in mediating social, political, and cultural histories will depend on the cultural and political contexts in which they are set. Thus, the current interest in relational ontologies and process-oriented philosophies toward dynamic substances and materials has productively allowed geoarchaeologists to call attention to what things physically do to shape social and political histories, but only with equal attentiveness to cultural contexts and differentiated perceptions and understandings of environmental phenomena among humans. Such frameworks open opportunities for explicitly considering the historical process as neither exclusively culturally nor environmentally determined. As such, they could also greatly contribute to geoarchaeologists’ ongoing empirical and theoretical interests in environmental and landscape histories, particularly as global environmental problems come to the forefront of political concerns.

GEOARCHAEOLOGY AND HISTORICAL AND POLITICAL ECOLOGIES

Geoarchaeology’s long-standing attention to environmental dynamics has also enabled practitioners to contribute to historical ecology and, more recently, political ecology scholarship, especially as these frameworks have increasingly engaged academic debates about the significance of the Anthropocene—a proposed new geological epoch of the geological time scale to formally recognize the transformative effects of human activities on Earth’s environmental processes and broader systemic functioning (cf. Crutzen 2002, Crutzen & Stoermer 2000, Waters et al. 2016, Zalasiewicz et al. 2015). Similar to historical ecology paradigms (sensu Balée 2006, Crumley 1994), geoarchaeologists have long called attention to landscapes and landscape histories as long-term products of human–environment interactions (see Butzer 1982, French 2003, Maher 2017, Rosen et al. 2015, Wilkinson 2003, Wilkinson et al. 2010). Archaeologically informed geological research and

multiscalar geoarchaeology on nearly every continent have now provided pervasive documentation of how broadscale Earth surface processes have been partly influenced by human activities for millennia. These include, for instance, the effects of ancient agricultural practices on fluvial regimes and landforms, settlement and land use on pedogenic development and soil nutrition, and herding activities on hillslope processes and valley colluviation (e.g., Alizadeh et al. 2004, Bauer 2014, Beach et al. 2015, Casana 2008, French 2003, Gaggioli et al. 2021, Marshall et al. 2018, Rosen et al. 2015, Shahack-Gross et al. 2003, Walter & Merritts 2008, Wilkinson 2003). In short, geoarchaeological research has underscored the recursive interplay between cultural practices and landform histories, sometimes documenting devastating effects for human populations in the past (e.g., Cordova 2018, Storozum et al. 2018), but also with an eye toward sustainable land use and considerations of contemporary policies in a long-term human–environment perspective (e.g., Buscardo et al. 2021, Crumley et al. 2015, French et al. 2017, Rosen et al. 2015; see also Sassaman 2012).

In contrast to its more long-standing overlap with historical ecology research interests vis-à-vis landscape histories, only recently have geoarchaeologists begun to more explicitly draw on the concerns of scholarship that identifies as political ecology. In general terms, political ecology calls attention to how human–environment relationships are mediated through different modalities of power and forms of social inequalities (cf. Biersack & Greenberg 2006, Blaikie & Brookfield 1987, Robbins 2012). Although lacking a normative framework, political ecology generally began as a concern to consider class, access, and ownership (i.e., the social relations of production of a Marxist-influenced political economy) in existing social science research paradigms focused on the environment (e.g., cultural ecology in the case of anthropology). However, in the wake of poststructuralism and postmodernism, its research emphases diversified greatly to include, for instance, the politics of knowledge production and discourses and representations of nature—to name just a few more recent concerns (cf. Bauer et al. 2007, Biersack & Greenberg 2006, Morehart et al. 2018, Peet & Watts 1996a, Wolf 1972). Although once critiqued for being “politics without ecology” (e.g., Vayda & Walters 1999, p. 168), a considerable corpus of work has now called attention to how such interests articulate with environmental histories and physical paleoenvironmental proxies, including both geological (e.g., soil distributions) and ecological phenomena (e.g., pollen sequences) (e.g., Fairhead & Leach 1996, Hecht et al. 2014). Furthermore, some political ecologists have also embraced more recent new materialist and posthumanist orientations in calling for greater attention to how environmental dynamics participate in the creation of social relationships, practices, and histories (e.g., Sundberg 2011, Whatmore 2002).

Anthropological archaeologists attentive to documenting social relationships, political practices, and environmental histories have thus started to recognize significant synergies with political ecology (e.g., Bauer et al. 2007; Bauer 2018a,b, 2020; Catlin & Bolender 2018; Kosiba & Hunter 2017; Morehart et al. 2018; Morrison 2009). Building on these synergies, some geoarchaeological research has productively highlighted the ways through which geomorphological landscape processes have contributed to social differentiation, marginalization, and unequal vulnerabilities to environmental changes and pollutants (cf. Bauer 2018a,b, 2020; Catlin & Bolender 2018; Morehart 2016; Stewart 2022; Storozum et al. 2020). Catlin & Bolender (2018), for instance, have demonstrated how Norse settlement and land use in Iceland contributed to intensified soil erosion and further differentiated agricultural and pastoral production spaces, while effectively institutionalizing economic inequalities as highland degradation intensified. In short, “While some farmers did well, others were forced to leave failing land and enter service or tenancy,” reinforcing emerging social hierarchies around land ownership, tenancy, and labor (Catlin & Bolender 2018, p. 120). Similar arguments have also been made for the effects of land use during the South Indian Iron Age, where intensified soil erosion related to animal grazing redistributed pastoral resources

of water and vegetation that were significant to the politics of social differentiation (e.g., Bauer 2015, 2018a). Furthermore, geoarchaeological research has also demonstrated unequal vulnerabilities to environmental hazards and natural disasters, such as floods, earthquakes, and droughts in a range of temporal and spatial contexts (e.g., Bauer 2020, Cordova 2018, Gaggioli 2022, Storozum et al. 2020). Gaggioli (2022), for example, has used soil micromorphology to identify soft-sediment deformation structures (SSDS) associated with earthquakes to show how social distinctions articulated with earthquake-resilient architecture from Early Helladic to Roman-period Mediterranean contexts. Such research underscores that even natural disasters are, at root, social products of vulnerabilities (see also Ribot 2014 on vulnerabilities). It also demonstrates the great utility of geoarchaeological research and methods to understanding unequal social relationships and conditions in the past, as well as their long-term environmental effects. Thus, as geoarchaeological research is poised to continue to document long-term human–environment relationships, it is important that scholars do not lose sight of the social and political contexts of specific places, especially as concerns for environmental change continue to be important avenues of inquiry at increasingly global scales.

CRITICAL GEOARCHAEOLOGY OF THE ANTHROPOCENE

In light of the body of research on long-term human–environment relationships, some geoarchaeologists have also begun to critically engage with interdisciplinary scholarship emanating around the concept of the Anthropocene. More specifically, some have argued for recognizing the onset of the Anthropocene much earlier than the mid-twentieth century date that has been advocated by the Anthropocene Working Group of the International Commission on Stratigraphy (e.g., Albert 2015, Certini & Scalenghe 2011, Zhuang & Kidder 2014). Certini & Scalenghe (2011), for instance, have proposed that the widespread development of anthropogenically modified soils (e.g., anthrosols) across large portions of the globe by roughly 2,000 years ago should serve as the geological marker for the start of the new epoch. Others working at the intersections of archaeology and geology have leveraged research to underscore the limits of formalizing a novel Anthropocene epoch altogether (e.g., Bauer et al. 2021; Edgeworth 2021; Gibbard et al. 2022a,b). Gibbard et al. (2022a,b) have argued that the Anthropocene should be treated in geological systematics as an “event,” rather than as a formalized epoch on the geological time scale (see also Bauer et al. 2021). Acknowledging well-founded concerns for the Eurocentrism embedded in much Anthropocene scholarship (e.g., Crossland 2014, Morrison 2015), two of the principal reasons provided by Gibbard et al. (2022b) for considering the Anthropocene as an event (contra an epoch) are related to (a) how the human species is represented on a global scale and (b) how to account for the diachronism of human effects and human-modified deposits in the stratigraphic record. Indeed, as Edgeworth (2018) has cogently noted, human-modified geological deposits are more than just a “record” of the past; they also have ongoing ecological and environmental effects (Edgeworth 2018, 2021; see also Bauer & Bhan 2018, pp. 64–73, on the ecological effects of the “temporality of materiality”). Stewart’s (2022) chemical assessment of soils at postindustrial archaeological sites illustrates that this point takes on even greater significance when such deposits include high levels of toxins that hold the potential to do harm, enacting “slow violence” (sensu Nixon 2011) on some inhabitants over the long term. Unlike formalized epochs in geological systematics, “geological events can recognize the spatial and temporal heterogeneity and diverse social and environmental processes that interact to produce anthropogenic global environmental changes” (Gibbard et al. 2022b, p. 349), thus enabling greater emphasis on socially differentiated effects and contributions to planetary conditions.

Building on this argument, geoarchaeological work may be used to extend critical engagement with prevalent narratives of the Anthropocene for what they both “silence” (sensu Trouillot 1995)

and ideologically reproduce in contemporary discourses around environmental issues and conservation politics. Considering political ecology orientations, for instance, scholars may approach anthropogenic global environmental change with a concern for socially and politically differentiated impacts, effects, and vulnerabilities, rather than focusing on humans as a singular geological force (cf. Bauer & Bhan 2018, Haraway 2016, Malm & Hornborg 2014, Moore 2016, Sayre 2012, Yusoff 2018). In short, much of the geoarchaeological research noted above demonstrates the blind spots of discussing a generalized anthropos with respect to the Anthropocene concept. Even so, archaeologists have increasingly sought to synthesize regional data sets on past landscape changes to meet the demands of global-scale assessments of environmental and Earth-system change. In doing so, they face multiple challenges. There are the practical difficulties of commensurability for data synthesis and modeling, as well as fundamental issues around the ethical complications of big data, including promoting universal ontologies and “scooping up the history of others in the service of our own” (Crossland 2014, p. 125). While archaeologists are beginning to successfully develop methodologies and classification schemes to facilitate data synthesis (e.g., Morrison et al. 2021, Stephens et al. 2019), the equally substantive ethical and political challenges of producing such global narratives have received less scholarly attention within the field.

Yet geoarchaeology is well positioned to call attention to the limits of the modernist program to separate natural and social environments that, at a foundational level, undergird narratives of the Anthropocene. As noted above, geoarchaeological research on nearly every continent has now demonstrated how human activities have contributed to environmental systems and geomorphological processes at multiple scales (e.g., Bauer 2014, Beach et al. 2015, French 2003, French et al. 2017, Marshall et al. 2018, Shahack-Gross et al. 2003, Walter & Merritts 2008, Wilkinson 2003, Zhuang & Kidder 2014), challenging the utility of efforts to locate a clear “anthropocene divide” (sensu Bauer & Ellis 2018) in the Earth’s environmental records for long-term human–environment relationships. While many have suggested that the Anthropocene “seemed like the twilight of the modernist ontological distinction between humans and nature” (Bobbette & Donovan 2018, p. 4; see also Chakrabarty 2009, Latour 2014, Purdy 2015), to the degree that the new periodization is intended to mark a departure from Earth’s natural systemic trajectory (cf. Crutzen 2002, Steffen et al. 2011), it is more difficult to see how the concept wholly challenges an underlying modernist ideology of nature. As Bauer & Bhan (2018) have noted, “If the defining characteristic of modernity is the push to purify the world into two distinct spheres of Nature and Society (e.g., Latour 1993), then the search for the Anthropocene—the spatio-temporal demarcation at which the Earth system departed from its natural trajectory—is the ultimate extension of this project to the globe” (p. 138). Despite this concern, there is at least a growing recognition that geological knowledge and systematics can be viewed as political (e.g., Finney & Edwards 2016), which has also been accompanied by calls to develop an “*a*modern” geology that recognizes more diverse epistemologies in understanding humans’ relationships to earthen materials and substances (Bobbette & Donovan 2018, pp. 14–21, emphasis in original).

Thus, beyond concerns for recognizing ecological resilience and sustainability in the past (e.g., Beach et al. 2015, Buscardo et al. 2021, French et al. 2017), geoarchaeology is well positioned to embrace more critical calls for a “political geology” (Bobbette & Donovan 2018) and to problematize discussions of conservation policies and discourses of natural heritage (cf. Meskell 2011). Indeed, geoarchaeological and archaeological research set within interdisciplinary ecological frameworks has been critical in demonstrating the legacies of past human land use on contemporary environments (e.g., Alizadeh et al. 2004, Casana 2008, Crumley et al. 2015, French et al. 2017, Rosen et al. 2015, Wilkinson 2003), including those that have been (mis)characterized as natural (e.g., Bauer 2018a, Walter & Merritts 2008). As case studies have repeatedly shown the inapplicability of the nature/culture binary in characterizing a range of environments, such work

potentially shifts the terms of conservation policy debates away from an emphasis on what is natural and toward a more explicit concern for which historical and socioenvironmental assemblages are desirable to particular people in particular places (e.g., Bauer & Bhan 2018, p. 111). In this way, geoarchaeological research could productively align with environmental movements and practices that might be more effective “without Nature” (sensu Morton 2013, p. 105) and that recognize the social, political, and environmental implications of defining natural conditions (e.g., Meskell 2011, Neumann 2004).

Although the destabilization of the concept of nature erodes traditional arguments for conservation (e.g., Caro et al. 2012), it forces analyses of how human values and political interests articulate with sociomaterial assemblages. This effect still creates a variety of openings for constituting and mobilizing support for conserving biodiversity, using resources sustainably, and reducing global warming. As Bauer & Bhan (2018) summarize, the move does

not replace Nature with an ‘anything goes’ approach to environmental politics or policy. Rather, it helps to meaningfully re-evaluate the kinds of environmental politics that are urgently needed to redirect debates on conservation and the causes or consequences of global warming toward a historically informed and socially differentiated understanding of environmental change and production. (p. 111, emphasis in original)

Indeed, by challenging the ideology of nature, a new critical geoarchaeology might also disrupt the inherently politicized epistemology that privileges few people to define natural relationships (cf. Latour 2004, 2014) and that preempts “discussion of different conceptual understandings of human–environment relationalities that have important implications for defining, establishing, preserving, or identifying alternative desirable sociomaterial environmental conditions” (Bauer & Bhan 2018, p. 104). Such a move would align well with recent calls to recognize the politics of geological knowledge production more generally (e.g., Bobbette & Donovan 2018).

CONCLUSION: TOWARD A CRITICAL GEOARCHAEOLOGY OF EARTHEN LIFE

Geoarchaeological research and practice have moved considerably toward new strands of archaeological and social theory in the last several decades. Although fundamental aspects of the formation of the archaeological record, such as assessing taphonomy, chronology, and the stratigraphic integrity of artifact associations, will remain essential concerns of geoarchaeological research, scholars working in a range of different temporal and spatial contexts have called attention to how the detailed analyses of soils and sediments, as well as the geological provenancing of artifacts, hold potential to greatly enrich interpretations of the social and cultural significance of earthen materials and substances. For instance, carefully recorded plaster-laminate house floors are no longer conceptualized merely as intact microstratigraphy, but also as important evidence for symbolically significant activities, ritual practices, or even different ontologies of the world. Moreover, attention to the dynamic attributes of earthen substances—the ability of soils to shrink, swell, and move—has enabled geoarchaeologists to contribute to broader debates about the strengths and limitations of posthumanist and new materialist scholarship that frames things and materials as active contributors to the constitution of social life. Coupled with geoarchaeology’s long-standing interest in landscape processes and environmental dynamics, these new orientations enable geoarchaeological research to continue to inform historical ecologies with greater attention to cultural and social significance. In the current academic context of widespread concern for environmental problems and sustainability, geoarchaeological research is thus well positioned to contribute, and arguably lead, ongoing inter- and transdisciplinary efforts to understand human–environment relationships at multiple scales with an attentiveness to shaping socioenvironmental conditions today.

In this regard, there are several critical avenues for the continued expansion of geoarchaeological research. First, geoarchaeology should continue to develop its orientations toward the political. Geoarchaeologists' engagement with the corpus of scholarship emanating under the rubric of political ecology is rather nascent. Yet social relationships, inequalities, and the emergence of political publics are often intricately linked with environmental histories and processes. Geoarchaeological research would do well to further address these intersections. They are crucial for how we understand the historical development of social and environmental conditions and how we might hope to alter them today.

Second, geoarchaeologists should similarly espouse a concern for the relational dynamics of the materials they study with an attentiveness to material temporalities. As reviewed above, many earthen substances are not just a record of the past; they also actively contribute to the ongoing production of social and environmental conditions. Whether it is the recognition that human-created wetlands of thousands of years ago still potentially generate greenhouse gases (e.g., methane) (cf. Bauer & Bhan 2018, Fuller et al. 2011) or the documentation of slow violence wrought by toxin-polluted soil (e.g., Stewart 2022), some phenomena of social concern are rendered legible only through the long-term lens that geoarchaeological research can provide. In this way, geoarchaeology has a critical role to play in documenting the social lives and futurities of earthen matter on multiple temporal registers, generating novel insights on the historical coupling of social and environmental conditions.

Finally, geoarchaeology should further embrace its position to problematize the inherent politics of geological systematics and environmental knowledge. As archaeologists are aware, disciplinary classification schemes are not neutral or universal analytical devices. Geoarchaeologists, for instance, are especially well positioned to question the limits of a modernist formulation of a new Anthropocene epoch. Indeed, as geologists encounter the publics that have emerged around the Anthropocene, they are similarly beginning to recognize a concern for the politics of knowledge production. Here geoarchaeology could be a significant aide to its allied disciplines. As many archaeologists know, historical narratives are powerful in what they affirm and silence, ideologically (re)produce, and constrain and allow in discursive practice. Thus, as geoarchaeological research continues to contribute to interdisciplinary scholarship on environmental change, geoarchaeologists are well situated among scholars to critically evaluate how their work not only illuminates the past, but also gives shape to the present through what it exposes and explicitly or implicitly affirms and silences, including alternative epistemologies for identifying desirable sociomaterial assemblages. In this way, a critical geoarchaeology is essential as scholars collaborate across disciplines with a concern for diverse modes of human social life and their articulations with Earth's past, present, and future.

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LITERATURE CITED

- Adams CE, Fladd SG. 2017. Composition and interpretation of stratified deposits in ancestral Hopi villages at Homol'ovi. *Archaeol. Anthropol. Sci.* 9:1101–14
- Agbe-Davies AS. 2016. *Tobacco, Pipes, and Race in Colonial Virginia: Little Tubes of Mighty Power*. New York: Routledge
- Albert RM. 2015. Anthropocene and early human behavior. *Holocene* 25:1542–52
- Alizadeh A, Kouchoukos N, Wilkinson TJ, Bauer AM, Mashkour M. 2004. Human-environment interactions on the Upper Khuzestan Plains, Southwest Iran: recent investigations. *Paleorient* 30:69–88
- Alt SM, Pauketat TR, eds. 2019. *New Materialisms Ancient Urbanisms*. New York: Routledge
- Araujo AGM, Feathers JK, Hartmann GA, Ladeira FSB, Valezio EV, et al. 2020. Revisiting Alice Boer: site formation processes and dating issues of a supposedly pre-Clovis site in Southeastern Brazil. *Geoarchaeology* 37(1):32–58
- Balée W. 2006. The research program of historical ecology. *Annu. Rev. Anthropol.* 35:75–98
- Barad K. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke Univ. Press
- Bauer AM. 2014. Impacts of mid- to late-Holocene land use on residual hill morphology: a remote sensing and archaeological evaluation of human-related soil erosion in central Karnataka, South India. *Holocene* 24:3–14
- Bauer AM. 2015. *Before Vijayanagara: Prehistoric Landscapes and Politics in the Tungabhadra Basin*. New Delhi: Manohar, Am. Inst. Indian Stud.
- Bauer AM. 2018a. Questioning a posthumanist political ecology: ontologies, environmental materialities, and the political in Iron Age South India. *Archaeol. Pap. Am. Anthropol. Assoc.* 29:157–74
- Bauer AM. 2018b. Remote sensing soils and social geographies of difference: the landscape archaeology of regur from Iron Age through Medieval Period, northern Karnataka, southern India. *J. Field Archaeol.* 43:31–43
- Bauer AM. 2018c. Substances and materials. In *The Encyclopedia of Archaeological Sciences*, 4 vols., ed. SL López Varela. Hoboken, NJ: Wiley. <https://doi.org/10.1002/9781119188230.saseas0561>
- Bauer AM. 2020. Ritualising land and cultivating distinctions: Medieval period donative practices and a political ecology of the Raichur Doab. In *Power, Presence, and Space: South Asian Rituals in Archaeological Context*, ed. H Albery, J-U Hartmann, HP Ray, pp. 233–57. London: Routledge
- Bauer AM, Bhan M. 2018. *Climate Without Nature: A Critical Anthropology of the Anthropocene*. Cambridge, UK: Cambridge Univ. Press
- Bauer AM, Edgeworth M, Edwards LE, Ellis EC, Gibbard P, Merritts DJ. 2021. Anthropocene: epoch or event? *Nature* 597:332
- Bauer AM, Ellis EC. 2018. The Anthropocene divide: obscuring understanding of socio-environmental change. *Curr. Anthropol.* 59:209–27
- Bauer AM, Johansen PG, Bauer RL. 2007. Toward a political ecology in early South India: preliminary considerations of the sociopolitics of land and animal use in the southern Deccan, Neolithic through Early Historic periods. *Asian Perspect.* 46:3–35
- Bauer AM, Kosiba S. 2016. How things act: an archaeology of materials in political life. *J. Soc. Archaeol.* 16:115–41
- Bauer AM, Nicoll K, Park L, Matney T. 2004. Archaeological site distribution by geomorphic setting in the southern lower Cuyahoga River Valley, northeastern Ohio: initial observations from a GIS database. *Geoarchaeology* 19:711–29
- Beach T, Luzzadder-Beach S, Cook D, Dunning N, Kennett DJ, et al. 2015. Ancient Maya impacts on the Earth's surface: an early Anthropocene analog? *Quat. Sci. Rev.* 124:1–30
- Bennett J. 2010. *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke Univ. Press
- Biersack A, Greenberg JB, eds. 2006. *Reimagining Political Ecology*. Durham, NC: Duke Univ. Press

- Bird-David N. 1999. "Animism" revisited: personhood, environment, and relational epistemology. *Curr. Anthropol.* 40(S1):S67–91
- Blaikie P, Brookfield H, eds. 1987. *Land Degradation and Society*. London: Methuen
- Bobbette A, Donovan A, eds. 2018. *Political Geology: Active Stratigraphies and the Making of Life*. Cham, Switz.: Palgrave Macmillan
- Boivin N. 2000. Life rhythms and floor sequences: excavating time in rural Rajasthan and Neolithic Çatalhöyük. *World Archaeol.* 31(3):367–88
- Boivin N. 2004. Geoarchaeology and the goddess Laksmi: Rajasthani insights into geoarchaeological methods and prehistoric soil use. In *Soils, Stones and Symbols: Cultural Perceptions of the Mineral World*, ed. N Boivin, MA Owoc, pp. 165–86. London: UCL Press
- Boivin N. 2008. *Material Cultures, Material Minds: The Impact of Things on Human Thought, Society and Evolution*. Cambridge, UK: Cambridge Univ. Press
- Brite EB. 2018. The hydrosocial empire: the Karakum River and the Soviet conquest of Central Asia in the 20th century. *J. Anthropol. Archaeol.* 52:123–36
- Buscardo E, Forkuor G, Rubino A, Storozum M. 2021. Land and people. *Commun. Earth Environ.* 2:178
- Butzer KW. 1982. *Archaeology as Human Ecology: Method and Theory for a Contextual Approach*. Cambridge, UK: Cambridge Univ. Press
- Caro T, Darwin J, Forrester T, Ledoux-Bloom C, Wells C. 2012. Conservation in the Anthropocene. *Conserv. Biol.* 26:185–88
- Casana J. 2008. Mediterranean valleys revisited: linking soil erosion, land use and climate variability in the Northern Levant. *Geomorphology* 101:429–42
- Catlin KA, Bolender DJ. 2018. Were the Vikings really green? Environmental degradation and social inequality in Iceland's second nature landscape. *Archaeol. Pap. Am. Anthropol. Assoc.* 29:120–33
- Certini G, Scalenghe R. 2011. Anthropogenic soils are the golden spikes for the Anthropocene. *Holocene* 21:1269–74
- Chakrabarty D. 2009. The climate of history: four theses. *Crit. Inq.* 35:197–222
- Cipolla CN. 2018. Earth flows and lively stone. What differences does 'vibrant' matter make? *Archaeol. Dialogues* 25:49–70
- Contreras DA. 2017. (Re)constructing the sacred: landscape geoarchaeology at Chavín de Huántar, Peru. *Archaeol. Anthropol. Sci.* 9:1045–57
- Coole D, Frost S, eds. 2010. *The New Materialisms: Ontology, Agency, and Politics*. Durham, NC: Duke Univ. Press
- Cordova C. 2018. *Geoarchaeology: The Human-Environmental Approach*. New York: I.B. Tauris
- Courty MA, Goldberg P, Macphail R. 1989. *Soils and Micromorphology in Archaeology*. Cambridge, UK: Cambridge Univ. Press
- Crossland Z. 2014. Anthropocene: locating agency, imagining the future. *J. Contemp. Archaeol.* 1:123–28
- Crumley CL. 1994. Historical ecology: a multidimensional ecological orientation. In *Historical Ecology: Cultural Knowledge and Changing Landscapes*, ed. CL Crumley, pp. 1–16. Santa Fe, NM: Sch. Adv. Res. Press
- Crumley CL, Laparidou S, Ramsey M, Rosen AM. 2015. A view from the past to the future: concluding remarks on the 'The Anthropocene in the Longue Durée'. *Holocene* 25(10):1721–23
- Crutzen PJ. 2002. Geology of mankind. *Nature* 415:23
- Crutzen PJ, Stoermer EF. 2000. The Anthropocene. *IGBP Newsl.* 41:17
- DeLanda M. 2006. *A New Philosophy of Society: Assemblage Theory and Social Complexity*. New York: Continuum
- Deleuze G, Guattari F. 1987. *A Thousand Plateaus: Capitalism and Schizophrenia*, transl. B Massumi. London: Athlone
- Edgeworth M. 2018. More than just a record: active ecological effects of archaeological strata. In *Historical Archaeology and Environment*, ed. MA Torres De Souza, DM Costa, pp. 19–40. Cham, Switz.: Springer
- Edgeworth M. 2021. Transgressing time: archaeological evidence in/of the Anthropocene. *Annu. Rev. Anthropol.* 50:93–108
- Fairhead J, Leach M. 1996. *Misreading the African Landscape: Society and Ecology in a Forest-Savanna Mosaic*. Cambridge, UK: Cambridge Univ. Press
- Finney SC, Edwards LE. 2016. The 'Anthropocene' epoch: scientific decision or political statement?. *GSA Today* 26:4–10

- French C. 2003. *Geoarchaeology in Action: Studies in Soil Micromorphology and Landscape Evolution*. London: Routledge
- French C, Sulas F, Petrie C. 2017. Expanding the research parameters of geoarchaeology: case studies from Aksum in Ethiopia and Haryana in India. *Archaeol. Anthropol. Sci.* 9:1613–26
- Fuller DQ, van Etten J, Manning K, Castillo C, Kingwell-Banham E, et al. 2011. The contribution of rice agriculture and livestock pastoralism to prehistoric methane levels: an archaeological assessment. *Holocene* 21:743–59
- Fulton KA, Well CE, Storer DA. 2017. Ritual or residential? An integrated approach to geochemical prospecting for understanding the use of plaza spaces at Palmarejo, Honduras. *Archaeol. Anthropol. Sci.* 9:1059–76
- Gaggioli A. 2022. *Earthquakes and the structuring of Greco-Roman society: the longue durée of human-geological environment relationships in Helike, Greece*. PhD Thesis, Stanford Univ.
- Gaggioli A, Bauer AM, Morrison KD, Lycett MT. 2021. Early water management in South Asia: geochronology and micromorphology of rock pools and small-scale water catchment features in Karnataka, India. *Geoarchaeology* 36:780–88
- Gibbard P, Walker M, Bauer A, Edgeworth M, Edwards L, et al. 2022a. The Anthropocene as an event, not an epoch. *J. Quat. Sci.* 37:395–99
- Gibbard PL, Bauer AM, Edgeworth M, Ruddiman WF, Gill JL, et al. 2022b. A practical solution: the Anthropocene is a geological event, not a formal epoch. *Episodes* 45(4):349–57
- Goff J, McFadgen B, Marriner N. 2021. Landscape archaeology—the value of context to archaeological interpretation: a case study from Waitore, New Zealand. *Geoarchaeology* 36:768–79
- Goldberg P, Macphail RI. 2006. *Practical and Theoretical Geoarchaeology*. Malden, MA: Blackwell
- Grávalos ME, Bria RE, Lau GF. 2022. An examination of Recuay kaolin pottery production and exchange through petrography and LA-ICP-MS (100–700 CE; Ancash, Peru). *Archaeometry* 64:1340–58
- Hakansson NT, Widgren M, eds. 2014. *Landesque Capital: The Historical Ecology of Enduring Landscape Modifications*. London: Routledge
- Haraway DJ. 2016. *Staying with the Trouble: Making Kin in the Chthulucene*. Durham, NC: Duke Univ. Press
- Harman G. 2009. *Prince of Networks: Bruno Latour and Metaphysics*. Prahran, Aust.: Re.press
- Hecht G. 2011. Introduction. In *Entangled Geographies: Empire and Technopolitics in the Global Cold War*, ed. G Hecht, pp. 1–12. Cambridge, MA: MIT Press
- Hecht SB, Morrison KD, Padoch C, eds. 2014. *The Social Lives of Forests: Past, Present, and Future of Woodland Resurgence*. Chicago: Univ. Chicago Press
- Hodder I. 1986. *Reading the Past: Current Approaches to Interpretation in Archaeology*. Cambridge, UK: Cambridge Univ. Press
- Hodder I. 1999. *The Archaeological Process: An Introduction*. Oxford, UK: Blackwell
- Hodder I. 2012. *Entangled: An Archaeology of the Relationships Between Humans and Things*. Malden, MA: Wiley-Blackwell
- Ingold T. 2007. Materials against materiality. *Archaeol. Dialogues* 14:1–16
- Johansen PG, Bauer AM. 2018. On the matter of resources and techno-politics: the case of water and iron in the South Indian Iron Age. *Am. Anthropol.* 120:412–28
- Jones A. 2004. Archaeometry and materiality: materials-based analysis in theory and practice. *Archaeometry* 46:327–38
- Jusseret S. 2010. Socializing geoarchaeology: insights from Bourdieu's theory of practice applied to Neolithic and Bronze Age Crete. *Geoarchaeology* 25:675–708
- Kidder TR, Sherwood SC. 2017. Look to the earth: the search for ritual in the context of mound construction. *Archaeol. Anthropol. Sci.* 9:1077–99
- Kosiba S, Hunter RA. 2017. Fields of conflict: a political ecology approach to land and social transformation in the colonial Andes (Cuzco, Peru). *J. Archaeol. Sci.* 84:40–53
- Kourampas N. 2012. Soils, sediments and landscapes of dwelling: geoarchaeology and the symmetrical project. *eTopoi* 3:209–15
- Latour B. 1993. *We Have Never Been Modern*, transl. C Porter. Cambridge, MA: Harvard Univ. Press
- Latour B. 2004. *Politics of Nature: How to Bring the Sciences into Democracy*, transl. C Porter. Cambridge, MA: Harvard Univ. Press

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- Latour B. 2005. *Reassembling the Social—An Introduction to Actor-Network-Theory*. Oxford, UK: Oxford Univ. Press
- Latour B. 2014. Agency at the time of the Anthropocene. *New Lit. Hist.* 45(1):1–18
- Lee H, French C, Macphail RI. 2014. Microscopic examination of ancient and modern irrigated paddy soils in South Korea, with special reference to the formation of silty clay concentration features. *Geoarchaeology* 29:326–48
- Love S. 2012. The geoarchaeology of mudbricks in architecture: a methodological study from Çatalhöyük, Turkey. *Geoarchaeology* 27:140–56
- Nath A, Law R, Garge T. 2014. Initial geologic provenience studies of stone and metal artefacts from Rakhigarhi. *Heritage* 2:74–100
- Macphail RI. 1989. A reply to Carter and Davidson's "An evaluation of the contribution of soil micromorphology to the study of ancient arable agriculture." *Geoarchaeology* 13:549–64
- Maher L. 2017. Geoarchaeology. In *The International Encyclopedia of Geography: People, the Earth, Environment and Technology*, ed. D Richardson, N Castree, MF Goodchild, A Kobayashi, W Liu, RA Marston, pp. 1–13. Hoboken, NJ: Wiley
- Maher LA. 2019. Persistent place-making in prehistory: the creation, maintenance, and transformation of an Epipalaeolithic landscape. *J. Archaeol. Method Theory* 26:998–1083
- Mallol C, Mentzer SM. 2017. Contacts under the lens: perspectives on the role of microstratigraphy in archaeological research. *Archaeol. Anthropol. Sci.* 9:1645–69
- Malm A, Hornborg A. 2014. The geology of mankind? A critique of the Anthropocene narrative. *Anthropocene Rev.* 1:62–69
- Marshall F, Reid REB, Goldstein S, Storozum M, Wreschnig A, et al. 2018. Ancient herders enriched and restructured African grasslands. *Nature* 561:387–90
- Mentzer SM, Romano DG, Voyatzis ME. 2017. Micromorphological contributions to the study of ritual behavior at the ash altar to Zeus on Mt. Lykaion, Greece. *Archaeol. Anthropol. Sci.* 9:1017–43
- Meskel L. 2011. *The Nature of Heritage: The New South Africa*. Hoboken, NJ: Wiley
- Meulemans G. 2020. Wormy collaborations in practices of soil construction. *Theory Cult. Soc.* 37:93–112
- Mitchell T. 2002. *Rule of Experts: Egypt, Techno-Politics, Modernity*. Berkeley: Univ. Calif. Press
- Moore J. 2016. *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism*. Oakland, CA: PM Press
- Morehart CT. 2016. Let the earth forever remain! Landscape legacies and the materiality of history in the northern Basin of Mexico. *J. R. Anthropol. Inst.* 22:939–61
- Morehart CT, Millhauser JK, Juarez S. 2018. Archaeologies of political ecology—genealogies, problems, and orientations. *Archaeol. Pap. Am. Anthropol. Assoc.* 29:5–29
- Morrison KD. 2009. *Daroji Valley: Landscape History, Place, and the Making of a Dryland Reservoir System*. New Delhi: Manohar
- Morrison KD. 2015. Provincializing the Anthropocene. *Seminar* 673:75–80
- Morrison KD, Hammer E, Boles O, Madella M, Whitehouse N, et al. 2021. Mapping past human land use using archaeological data: a new classification for global land use synthesis and data harmonization. *PLOS ONE* 16(4):e0246662
- Morton T. 2013. *Hyperobjects: Philosophy and Ecology After the End of the World*. Minneapolis: Univ. Minn. Press
- Neumann RP. 2004. Nature-state-territory: toward a critical theorization of conservation enclosures. See Peet & Watts 1996b, pp. 195–217
- Nicoll K, Emmitt J, Kleindienst MR, Evans SL, Phillipps R. 2021. Elinor Wight Gardner: pioneer geoarchaeologist, quaternary scientist and geomorphologist. *Geosciences* 11:267
- Nixon R. 2011. *Slow Violence and the Environmentalism of the Poor*. Cambridge, MA: Harvard Univ. Press
- Olsen BM, Shanks M, Webmoor T, Witmore C. 2012. *Archaeology: The Discipline of Things*. Berkeley: Univ. Calif. Press
- Peet R, Watts M. 1996a. Liberation ecology: development, sustainability, and environment in an age of market triumphalism. See Peet & Watts 1996b, pp. 1–45
- Peet R, Watts M, eds. 1996b. *Liberation Ecologies: Environment, Development, Social Movements*. London: Routledge
- Povinelli EA. 1995. Do rocks listen? The cultural politics of apprehending Australian Aboriginal labor. *Am. Anthropologist* 97:505–18

- Preucel RW. 2020. In defence of representation. *World Archaeol.* 52(3):395–411
- Prijatelj A. 2020. Carlos Cordova. *Geoarchaeology: The Human-Environmental Approach*. *Eur. J. Archaeol.* 23:154–58
- Purdy J. 2015. *After Nature: A Politics for the Anthropocene*. Cambridge, MA: Harvard Univ. Press
- Rapp G Jr., Hill CL. 2006. *Geoarchaeology: The Earth-Science Approach to Archaeological Interpretation*. New Haven, CT: Yale Univ. Press
- Renfrew C. 1976. Archaeology and the earth sciences. In *Geoarchaeology: Earth Science and the Past*, ed. DA Davidson, ML Shackley, pp. 1–5. Boulder, CO: Westview
- Ribot J. 2014. Cause and response: vulnerability and climate in the Anthropocene. *J. Peasant. Stud.* 41:667–705
- Richardson T, Weszkalnys G. 2014. Introduction: resource materialities. *Anthropol. Q.* 87:5–30
- Robbins P, ed. 2012. *Political Ecology: A Critical Introduction*. Malden, MA: Wiley
- Roddick AP. 2015. Geologies in motion: itineraries of stone, clay and pots in the Lake Titicaca Basin. In *Things in Motion: Object Itineraries in Anthropological Practice*, ed. RA Joyce, SD Gillespie, pp. 123–45. Santa Fe, NM: Sch. Adv. Res. Press
- Roddick AP, Cuynet F. 2021. Genealogies and juxtapositions: traces of potting communities and firing facilities in Lake Titicaca Basin. *J. Archaeol. Method Theory* 28:1143–71
- Roos CI, Wells EC. 2017. Geoarchaeology of ritual behavior and sacred places: an introduction. *Archaeol. Anthropol. Sci.* 9:1001–4
- Rosen AM, Lee J, Li M, Wright J, Wright HT, Fang H. 2015. The Anthropocene and the landscapes of Confucius: a historical ecology of the landscape changes in northern and eastern China during the middle to late-Holocene. *Holocene* 25:1640–50
- Sassaman KE. 2012. Futurologists look back. *Archaeologies* 8:250–68
- Sayre NF. 2012. The politics of the anthropogenic. *Annu. Rev. Anthropol.* 41:57–70
- Shackley MS, ed. 2011. *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*. New York: Springer
- Shahack-Gross R, Marshall F, Weiner S. 2003. Geo-ethnoarchaeology of pastoral sites: the identification of livestock enclosures in abandoned Maasai settlements. *J. Archaeol. Sci.* 30:439–59
- Sherwood SC, Blitz JH, Downs LE. 2013. An integrated geoarchaeology of a late woodland sand mound. *Am. Antiq.* 78:344–58
- Sherwood SC, Kidder TR. 2011. The DaVincis of dirt: geoarchaeological perspectives on Native American mound building in the Mississippi River basin. *J. Anthropol. Archaeol.* 30:69–87
- Steffen W, Grinevald J, Crutzen P, McNeill J. 2011. The Anthropocene: conceptual and historical perspectives. *Philos. Trans. R. Soc. A* 369:842–67
- Stephens L, Fuller D, Boivin N, Rick T, Gauthier N, et al. 2019. Archaeological assessment reveals Earth's early transformation through land use. *Science* 365:897–902
- Stewart H. 2022. The ecological life of industrial waste. *Archaeol. Pap. Am. Anthropol. Assoc.* 33:91–105
- Storozum M, Lu P, Wang S, Chen P, Yang R, et al. 2020. Geoarchaeological evidence of the AD 1642 Yellow River flood that destroyed Kaifeng, a former capital of dynastic China. *Sci. Rep.* 10(1):3765
- Storozum MJ, Zhen Q, Xiaolin R, Haiming L, Yifu C, et al. 2018. The collapse of the North Song dynasty and the AD 1048–1128 Yellow River floods: geoarchaeological evidence from northern Henan Province, China. *Holocene* 28:1759–70
- Sundberg J. 2011. Diabolic caminos in the desert and cat fights on the Río: a posthumanist political ecology of boundary enforcement in the United States–Mexico borderlands. *Ann. Assoc. Am. Geogr.* 101:318–36
- Sundberg J. 2014. Decolonizing posthumanist geographies. *Cult. Geogr.* 21:33–47
- Tite MS. 1999. Pottery production, distribution, and consumption—the contribution of the physical sciences. *J. Archaeol. Method Theory* 6:181–233
- Todd Z. 2016. An Indigenous feminist's take on the ontological turn: “Ontology” is just another word for colonialism. *J. Hist. Sociol.* 29:4–22
- Trouillot M-R. 1995. *Silencing the Past: Power and the Production of History*. Boston: Beacon
- Van Dyke RM. 2015. Materiality in practice: an introduction. In *Practicing Materiality*, ed. RM Van Dyke, pp. 3–32. Tucson: Univ. Ariz. Press
- Vayda AP, Walters BB. 1999. Against political ecology. *Hum. Ecol.* 27:167–79
- Walter RC, Merritts DJ. 2008. Natural streams and the legacy of water-powered mills. *Science* 319:299–304

- Waters CN, Zalasiewicz J, Summerhayes C, Barnosky AD, Poirier C, et al. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* 351:aad2622
- Waters MR. 1992. *Principles of Geoarchaeology: A North American Perspective*. Tucson: Univ. Ariz. Press
- Webmoor T, Witmore CL. 2008. Things are us! A commentary on human/things relationships under the banner of a 'social' archaeology. *Norw. Archaeol. Rev.* 41:53–70
- Whatmore S. 2002. *Hybrid Geographies: Natures Cultures Spaces*. London: Sage
- Wilkinson TJ. 2003. *Archaeological Landscapes of the Near East*. Tucson: Univ. Ariz. Press
- Wilkinson TJ, French C, Ur JA, Semple M. 2010. The geoarchaeology of route systems in Northern Syria. *Geoarchaeology* 25:745–71
- Wolf ER. 1972. Ownership and political ecology. *Anthropol. Q.* 45:201–5
- Yusoff K. 2018. *A Billion Black Anthropocenes or None*. Minneapolis: Univ. Minn. Press
- Zalasiewicz J, Waters CN, Williams M, Barnosky AD, Cearreta A, et al. 2015. When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quat. Int.* 383:196–203
- Zhuang Y, Kidder TR. 2014. Archaeology of the Anthropocene in the Yellow River region, China, 8000–2000 cal. BP. *Holocene* 24:1602–23