Notes on the *Chaîne Opératoire* Concept for Historical Ecology

J. Scott Lyons[1]
University of California
[1] jscottlyons@gmail.com

Abstract: This paper demonstrates the applicability of the *chaîne opératoire* in addressing the concerns of archaeologists working in the framework of historical ecology. Landscapes are products of intentional actions, and their tangible aspects are important in understanding both social and ecological relationships. The *chaîne opératoire* is a fitting tool for examining the mechanisms of physical landscape transformation and the intent, which can easily be overlooked. This contrasts with previous applications in environmental archaeology and historical ecology, which have focused on investigating intangible aspects of the landscape rather than explicating landscape management practices. A brief discussion of ironworking practices on the Osaka Plain, Japan in the Middle and Late Kofun Periods (fifth-sixth centuries AD) shows this approach to be useful even with fragmentary data and when limiting analysis to a single step of the *chaîne opératoire*.

Introduction: Historical Ecology as a Social Environmental Archaeology

Despite increased recognition of its value in the so-called Anthropocene (Braje et al. 2014), environmental archaeology still suffers a reputation for environmental determinism and latent processualism (Arponen et al. 2019). Although archaeologists have long acknowledged that the environment must not be treated as a constant or an independent variable in understanding past societies (e.g. Butzer 1982), emphasis on adaptation and equilibrium, which seem to preclude social explanations for cultural change, remained mainstream into the 1990s.

Since then environmental archaeologists and anthropologists have increasingly recognised the dynamism of human-environmental interactions and sought ways to better account for the complexity of these relationships in their research (Crumley 1994; McGlade 1995). For archaeologists, the relationship between human activities and the non-human aspects of their environments has become something to explain, rather than an explanation for other phenomena. Correlations between paleoenvironmental trends and human activity must be accompanied by mechanisms to be acceptable as an explanation (Arponen et al. 2019 and following commentary; Dincauze 2000).

Efforts to make environmental archaeology a more fully social archaeology have [illegible] logy, discussions [illegible] stream formulations (Dincauze 2000). John G. Evans' endeavour to create an environmental archaeology that recognises social engagement via the environment prior to any biological engagement with it is a particularly noteworthy contribution to the field (2003). Nevertheless, despite mutual influence and the adoption of landscape (as opposed to 'environment' or 'ecosystem') concepts by many environmental archaeologists, environmental archaeology and landscape archaeology by and large remain distinct fields of inquiry.

Amid these shifts, historical ecology emerged as a research program (Balée 2006) or theoretical framework in the mid-1990s from the work of archaeologist Carole Crumley (1994), and has since found utility among archaeologists and other social scientists engaging with issues of human environmental interaction, especially those interested in human impacts on the environment (Crumley 2015). Historical ecology's four core postulates that virtually all environments have been affected by human activity, human activity is neither inherently positive nor negative with regard to environmental parameters, the kinds of effects visited upon landscapes by societies differ according to those societies' socioeconomic, political and cultural organisation, and human environmental interactions in various contexts can be studied as integrative phenomena (Balée 2006) are straightforward.

They combine with an historical as opposed to evolutionary view of environmental change, a conception of time derived from the Annales school—albeit with a focus on the *longue durée*—and a developed concept of landscape (Balée 1998, 2006). Taken together these ideas form a framework that is particularly amenable to integration with social theoretical insights from other areas of archaeology and social science, even though they do not "privilege the importance of social knowledge over ecological information" (Maher 2019: 1014-1016).

LANDSCAPE IN HISTORICAL ECOLOGY

Historical ecology's landscape concept is a particularly apt juncture for integration with a *chaîne opératoire* approach. An accounting of archaeological approaches to landscape is beyond the scope of this article, but it is significant to mention that virtually all approaches agree that in addition to physical features and characteristics, landscapes are constituted socially through place- and meaning-making activities, resulting in intangible features and characteristics (David and Thomas 2008). Which aspects are emphasised or given ontological priority vary, but in historical ecology the landscape as a unit of analysis is a resolutely physical entity with spatial and temporal dimensions (Balée 1998, 2006; Balée and Erickson 2006; Crumley 1994, 2015).

To historical ecologists, the physical aspects do not merely coexist with the intangible social aspects. Rather, the physical features have come to be constituted by the social aspects over time (Balée 1998, 2006; Crumley 1994). The landscape is the physical manifestation of the ongoing dialectical relationship between human acts and acts of nature (Crumley 1994: 9). Landscapes have history and features of the landscape are historiographic indices (Balée 2006: 77). These indices have been:

> inscribed in a subtle, physical sense by learned, patterned behavior and action.... Culture is physically embedded and inscribed in the landscape as nonrandom patterning, often a palimpsest of continuous and discontinuous inhabitation by past and present peoples (Balée and Erickson 2006: 2).

These actions range from highly visible landesque capital investments such as terracing, to small, cumulative management techniques of landscape domestication (Balée 2006: 79). Crumley (1994: 9) notes that the landscape records evidence of the maintenance or modification of practices and decisions that were made, are

"theatres of conflict over resources and values" (2015: 5), and can be understood as "congealed politics" (2010: 10). Although unconscious actions and unintended consequences of actions are certainly recorded in the landscape (Kidder 2013), the landscape is nevertheless a built environment akin to architecture in its intentional creation (Balée and Erickson 2006). In other words, the landscape is a palimpsestic record of the human intentionality and agency in resource management and land use (Balée and Erickson 2006).

Balée and Erickson (2006: 2) contend that researchers can infer human actions and intentions from landscapes by essentially reverse engineering them; using archaeological, palaeoecological and other data to deconstruct their historical formation processes. In practice, identifying intentions has not been as straightforward as identifying actions. Kidder (2013: 178-182) notes the ease with which small-scale societies' intent and purpose in transforming their landscapes can be overlooked. Even when recognising the likelihood of deliberate, albeit subtle, transformations, there are cases in which the intentionality of some transformations is uncertain. Acknowledging that the issue of scale complicates such investigations, Kidder (2013: 178) advocates for a high-resolution microhistorical approach alongside the investigation of the *longue durée*. I suggest that the *chaîne opératoire* is an exceptional tool for such microhistories as well as a tool to link them to larger-scale historical ecological trajectories.

EXPLORING INTENTION WITH A *CHAÎNE OPÉRATOIRE* APPROACH

Defined by Perlès (1987: 23, translated in Sellet 1993: 106) as the "succession of mental operations and technical gestures, in order to satisfy a need (immediate or not) according to a preexisting project", the *chaîne opératoire* is a concept that has found a myriad for uses since its introduction to anglophone archaeology (Schlanger and Sinclair 1990). Although it is most commonly applied in studies of lithic technologies, the range of studies making use of a *chaîne opératoire* concept has expanded to encompass nearly every type of material culture. Products as diverse as ceramics, cultivated plants and textiles are all well represented in recent literature drawing on the *chaîne opératoire*.

For some researchers, it has become a shorthand for 'stages of production' en route to other discussions. For others the full *chaîne opératoire* concept (Chazan 2009; Soressi and Geneste 2011) provides opportunities to explore such diverse ideas as past mental states (Schlanger 1994), social agency and meaning-making (Dobres 2001), phylogenetic approaches to lithic tool assemblages (Riede 2006) and production (as opposed to 'technology') (Kohring 2006).

These provocative investigations are possible because the *chaîne opératoire* is more than just a sequence of physical steps. Lemonnier's (1992) methodology for recording *chaînes opératoires*, based on Cresswell's (1983) approach, involves the setting, elements, technological relations and social relations of each step of the *chaîne*. Separately, Lemonnier notes that techniques are constituted of matter, energy, objects, gestures and specific knowledge (1992: 5-6).

Other scholars have productively collapsed this to three levels of analysis: the material objects involved, the gestures and technical sequences involved and the technical knowledge necessary (Schlanger 1994: 146; Sellet 1993: 107). The technical knowledge can be further described as both the abstract knowledge necessary (*connaissance*) and the actual ability or know-how to perform the sequence (*savoir faire*) (Chazan 2009). To elaborate on the knowledge component, the researcher's *chaîne opératoire* is a description of something that plays out in the mind and actions of a maker that is simultaneously sequential and an integrated whole (Chazan 2009: 471). While the maker must have a concept or template of the process, not just or necessarily the object, in mind to work through, it must be flexible to account for variation in the material being manipulated (Schlanger 1994: 148).

Notably, a researcher should have some knowledge of working the material medium at the center of a *chaîne opératoire*-based investigation in order to understand the physical constraints involved in its use. However, the problem remains that gestures and especially knowledge, are culturally and historically specific, so an archaeologist has no hope of obtaining an emic perspective on an extinct tradition. It follows that reconstructions must sacrifice some precision to maintain accuracy. That is to say, in many cases rather than reconstructing the specific knowledge and gestures involved, a researcher should settle for inferring what kind of knowledge and gestures were involved.

For example, this might entail a knowledgeable researcher noting that an ancient metalworker must have known the how, and some reasoning behind that how, of drawing out wire without commenting on what the reasoning behind that how was. The reason for that reticence would be that both the how and its reasoning are more heavily constrained by the tools and modern tradition the researcher has joined in order to become knowledgeable than by the material itself.

Because the *chaîne opératoire* requires researchers to consider the knowledge necessary for each step, it insists they examine the technological choices available and indeed made by the craftsperson. In his related approach, Lemonnier explicitly frames makers' knowledge as choices (1992: 6): the choice of material, tools, processes and gestures all reflect the specific knowledge mobilised in technological activity. Examining the contingency of past makers' actions, that is to say their socialised choices, through careful analysis of archaeological residues can reveal those makers' aims and intentions with respect to their medium (Schlanger 1994).

Conneller (2006) notes that *chaînes opératoires* are not individual or isolated, but rather multiple and networked over the landscape. Keeping in mind that at least archaeologically, the *chaîne opératoire* is inevitably a reconstructed approximation and thus better treated as an analyst's tool than an actual phenomenon, Coneller's (2006) insight can be reframed: *chaînes* can be combined, or their intersections sought to reveal aspects of social structure as much as physical transformations (cf. Dobres 2010). They can also be expanded or contracted to suit the researcher's needs. While a *chaîne opératoire* usually begins with raw material procurement and terminates with discard at the end of an object's use life, there is no reason the

chaîne might not be expanded on either end or branched out wherever additional objects or people enter the pattern, creating multilinear *chaînes*.

CHAÎNES OPÉRATOIRES OF LANDSCAPE TRANSFORMATION

The consequences for such an expanded approach are that in the same way that we seek cognition and meaning along with economic arrangements arising through making (Dobres 2010; Schlanger 1994), we might seek cognition and meaning even in practices not just *on* the landscape, but *of* the landscape.

Some archaeologists have integrated the *chaîne opératoire* into environmental and landscape archaeologies. Environmental archaeologist John G. Evans (2003) advocates the use of *chaînes opératoires* to examine social expression and accumulations of meaning on the landscape. Conneller (2006) has examined how lithic production links places and in so doing creates the landscape. Recently, Maher (2019) has combined historical ecological concepts with a *chaîne opératoire* approach in concert with theories of situated learning and communities of practice, to explore the social role of technology in understanding landscapes, as well as landscape learning. In other words, the processes by which communities acquire, share and maintain knowledge of their landscape, and make places meaningful (Rockman and Steele 2003). These approaches at least implicitly acknowledge physical engagement with the landscape, but all primarily use the *chaîne opératoire* to investigate the intangible social aspects of landscape that emerge through that physical engagement.

I submit that for historical ecologists, a *chaîne opératoire* approach provides a means to investigate not only the intangible social relations of the landscape but also the ecological relations and landscape transformations. Thus, it encourages a more detailed analysis of the landscape across both spatial and temporal scales. Since the landscape itself is a built environment, it is amenable to a *chaîne opératoire* analysis. Of course, a landscape is created by many people over generations. Although it may have periods of faster or slower transformation, it can never be said to be an end product. From that perspective, the *chaîne opératoire* of landscapes differs from that of other technologies, but the sequences of actions nevertheless involve distinct gestures, objects and knowledge.

A landscape is created both by activities primarily intended to alter it and through activities where alteration of the landscape is secondary to some other purpose; for example gathering lumber for construction. These activities, too, are technological and subject to *chaîne opératoire* analyses. The ability to link and expand *chaînes* as they unfold spatiotemporally allows archaeologists to trace the effects, however subtle, of various practices on the landscape. This makes explicit the mechanisms expected in mainstream environmental archaeology to accompany correlations and conclusions of causal relation (in any direction) (Dincauze 2000).

Of equal importance is the way that *chaîne opératoire* analysis exposes the choices made by actors to a thoughtful analyst. In this way, the reconstruction of *chaînes opératoires* requires the researcher to engage with the knowledge and intentions of past actors. Where Kidder (2013) has found it easy for researchers

to overlook or inadvertently disregard the intentions of small-scale societies, this analysis foregrounds them. In fact, a *chaîne opératoire* approach not only foregrounds the existence of past intentions, it also enables their analysis. Where *chaînes* intersect and different individuals perform technical actions, different sets of required knowledge shift in and out of the *chaîne*, as do intentions. This patterning may reveal the landscape impacts not only of a society generally, but of specific groups or communities within that society. Similarly, knowledge and intent of landscape impact may be discontinuous across the *chaîne*. Such cases invite deeper scrutiny of political economy in landscape transformation and the ways that ecological risks, costs and benefits can be enacted, ignored, absorbed or externalised by different segments of society.

HISTORICAL ECOLOGY AND ARCHAEOMETALLURGY ON THE OSAKA PLAIN

A cursory discussion of ironworking on the Osaka Plain, Japan in the fifth and sixth centuries AD can illustrate these advantages of a *chaîne opératoire* approach in understanding intent in historical ecology. While there are more than thirty archaeological sites with evidence for ironworking in the Kofun Period (mid-third century to early seventh century AD) in modern Osaka Prefecture, only Mori, Katano City and Ōgata, Kashiwara City can be considered large-scale ironworking sites. Ironworking features and residues dating to the Middle and Late Kofun Periods (fifth and sixth centuries AD) have been unearthed from both sites and are thought to be roughly contemporaneous.

The Middle and Late Kofun Periods were a time of considerable political change in the Japanese archipelago and on the Osaka Plain in particular. Construction of the largest monumental tombs shifted location from the neighbouring Nara Basin to the Osaka Plain and then back, and the apparent importance of iron military equipment in the political economy waxed and waned (Mizoguchi 2013).

This was also a period of considerable ongoing landscape change. The Osaka Plain is bordered by mountains and for thousands of years much of it had been underwater. Changes in sea level and sedimentation narrowing the mouth to the bay resulted in the freshwater Kawachi lake, which itself was shrinking, and by the fifth century AD, most of it had become alluvial plain. In terms of vegetation, scholars have known since the late 1970s that there was a transition from broad-leaf forests of *Cyclobalanopsis*, *Celtis* and *Aphananthe* to one dominated by pine and grass species around this time (Yasuda 1978).

Taking this changing landscape not as a backdrop for human cultural activity but rather as the result of both human and non-human activities leads directly to the questions of what types of environmental impact humans made, as well as how that changing landscape affected the practices and historical trajectories of Kofun period peoples. At Mori and Ōgata, questions of how ironworking activities and technologies shaped the landscape and vice versa are of great interest.

Probable ironworking products have been unearthed only at Ōgata (Kitano and Manabe 2016), but smiths at both Mori and Ōgata undoubtedly produced more than a single kind of iron implement. Therefore, reconstructing *chaînes opératoires*

for ironworking at those sites is in a sense impossible. Nevertheless, changes in tuyere size, shape and angle and in forging hearth shape, show some diachronic trends (Okuno and Manabe 2000), indicating transformations in ironworking practices during this period. Further analyses of slag and forging products may elucidate these changes' relationship to fuel and raw material, which are points of interface between the ironworking *chaînes opératoires* and landscapes.

The earliest ironworking activities at both sites predate the advent of iron smelting in the Japanese archipelago. Even after smelting began, it was not conducted at those sites, making the environmental impacts of iron smelting activities external to this landscape. Charcoal fuel on the other hand, presents an opportunity to explore the local aspects of historical ecology, particularly at Ōgata. Amid the ongoing vegetation changes on the plain, the question arises of how and where was this fuel produced. While charcoal analyses from forging residues at both sites are ongoing, preliminary results as well as legacy data provide a clearer picture at Ōgata.

In 1984, a large pyrotechnical feature was unearthed during excavations, which at that time was identified as a very large ironworking hearth (Kitano 1985). Since then, the excavator has concluded that it is not an ironworking feature and may actually be a charcoal kiln (S. Kitano 2018, pers. comm.). While alternative identifications are possible, a kiln designation fits well with the large amount of charcoal unearthed from the feature. Additionally, there are unofficial reports of similar features in the nearby hills, but none have been investigated (S. Kitano 2018, pers. comm.). Given this limited information, the provisional hypothesis is that charcoal was produced locally for use in ironworking, utilising local forest resources.

Taxa of a very limited amount of charcoal collected from various features at the site have been identified and officially reported, and the great majority were broad-leaved trees (Kitano and Manabe 2016; Shimazu 2015). Recently, charcoal unearthed from the possible kiln has begun to be identified. Nearly two-thirds of the identifiable charcoal is not only broad-leaved trees but one particular genus, *Carpinus sect. Eucarpinus*, called *inushide* in Japanese (M. Suzuki 2018, pers. comm.). What is the significance of this selection, when the concurrent local ecological trend is toward the increasing prevalence of pine and grass species?

Despite the limitations of the current data, a *chaîne opératoire* approach is illuminating. Assuming the use of these wood taxa was intentional, it is also reasonable to assume that it was done with the knowledge of its effects through at least part of the *chaîne opératoire*. That is to say, it was a choice that constitutes specific knowledge (Lemonnier 1992). Charcoal making occurs early in an extended *chaîne opératoire* for ironworking. Ironworkers found the use of broad-leaved tree species, *inushide* in particular, to be socially and technically appropriate for their work, despite the probable easy access to conifer wood. Unfortunately, the cultural associations of various woody plant taxa are essentially impossible to surmise for this time period, but the perceived technical characteristics of these woods may also be relevant to their selection.

In historic periods, charcoal of broad-leaved trees was preferred for smelting and refining iron, but conifer charcoal was preferred for fine temperature control for forging operations (Shimazu 2015). Based on excavated features, slag analysis and finds of completed iron implements, evidence for refining work at Ōgata is doubtful, although evidence for the production of finished objects is strong (Kitano and Manabe 2016). If the later historical preference for conifer charcoal for object production holds for this period as well, it follows that the selection of broad-leaved wood taxa for charcoal production was probably related to factors other than forging performance.

Instead, it may relate to the ironworkers' relationship with the landscape itself. Higher resolution paleoenvironmental reconstruction is also pending but perhaps, despite the overall trend toward the replacement of broad-leaved forests with conifers, the local landscape was still heavily populated with broad-leaved taxa, and they were convenient to harvest. However, the high proportion of *inushide* is itself a choice that demands attention. *Inushide* is a particularly difficult wood to work and has not found much use traditionally, particularly not as a construction material (Nishikawa 2016). There is a logic to selecting trees with few other uses for conversion to fuel, especially if broad-leaved forests are already in decline. The choice of this wood reveals the likelihood of related landscape knowledge among ironworkers, as well as knowledge of their effects on the landscape. In other words, this choice points to intentional forest resource management by ironworkers.

Although the data involved is still preliminary and awaits supplementation and confirmation, the above example illustrates how even where the full *chaîne(s)* cannot be reconstructed, thinking in terms of the *chaîne opératoire*, even for a single step of the technical sequence, forces attention on the deliberate choices by members of a past community. These choices directly relate as much to tangible landscape transformation and the intent behind it in its historical ecological trajectory as they do to the intangible social aspects of the landscape.

CONCLUSION

This paper has demonstrated the applicability of the *chaîne opératoire* approach specifically in addressing the concerns of archaeologists working in the framework of historical ecology. Landscapes are products of intentional actions, and their tangible aspects are important in understanding both social and ecological relationships (Balée 2006; Crumley 1994). The *chaîne opératoire* is a fitting tool for examining the mechanisms of physical landscape transformation and the intent, which can easily be overlooked (Kidder 2013).

This is in contrast with previous applications of the *chaîne opératoire* in environmental archaeology and even in historical ecology, which have focused on investigating intangible aspects of the landscape rather than the explication of landscape management practices. A brief discussion of ironworking practices on the Osaka Plain in the Middle and Late Kofun periods in light of this application shows it to be useful even with fragmentary data and limiting analysis to only a single step of the *chaîne opératoire*.

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