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A RESPONSE TO HART AND LOVIS

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ABSTRACT. Hart and Lovis clearly hold different views than do I about how to view incongruities in age determinations on food residue as compared to those on context dates on other short-lived materials. I explain how I came to the conclusions I drew in my earlier study (Roper 2013a) and suggest that I am evaluating my results, and those of others, by looking for patterns in the incongruities, rather than individually explaining away incongruent dates. I also briefly review some work with a collaborator being undertaken to correct the obvious problem with age-offset dates on residue.

RESPONSE

Hart and Lovis (2014) have written what they describe as a "re-evaluation" of my analysis of the reliability of accelerator mass spectrometry (AMS) age determinations on ceramic residue from late prehistoric sites on the North American Central Plains and come to a different view than my reading of my results (Roper 2013a). Beyond being an isolated comment, it also is one of several papers from these authors and/or collaborators that champion the use of residue for AMS dating in archaeological studies (Schulenberg 2002; Hart and Brumbach 2005; Hart and Lovis 2007a; Hart et al. 2013) and is not the first paper in this series that seeks to refute or downplay conclusions that residue is not reliable (Hart and Lovis 2007b). Their comment on my paper, however, is based on a totally different view than I hold as to what to do about the obvious incongruities of age determinations on residue as compared with ages on annual plant remains.

In responding, I first briefly reiterate the circumstances under which I wrote my paper. A large number of age determinations on materials from late prehistoric sites on the Central Plains have accumulated during the last half-century. I seriously doubt all are equally accurate for their context, largely, although not exclusively, because of the old-wood effect, and I have sought to bring a chronometric hygiene process to the assessment of these dates and to reconsider the regional chronology using the cleansed data set. In the course of this effort, I have sometimes with a collaborator (Roper and Adair 2011, 2012) and sometimes not (Roper 2012), recently obtained a large series of new AMS dates for the region and more are forthcoming. To counteract the likelihood of age offsets of variable and often unknowable duration on wood charcoal and their negative effects on chronologies (Roper and Adair 2011:15–6; see also Roper 2013b), all newly assayed samples are short-lived materials. Maize is the preferred sample material, but the curated collections from excavations conducted as early as the 1920s do not always retain corn or other annual plant remains, and some samples submitted early in the dating program were residue. The chronometric hygiene process proceeded using the entire set of dates, including those accumulated since the early 1960s, as well as the newly obtained age determinations. The course of that analysis revealed significant age offsets of some of the residue dates relative to context dates on other short-lived materials. Cognizant of results in Europe and Asia, cited in my 2013 paper, that document the unreliability of residue and also aware of the scarcity of such studies in North America, my paper extracted the subset of results on residue dating and presented them as a case study. In that paper, I presented a preliminary portrayal of the chronology that results from this analysis. I have since completed a detailed presentation of the full chronometric hygiene study, including grouping sites within localities and replacing the bar graphs with OxCal (Bronk Ramsey 2009) multiplots, in a study now submitted to a regional journal (Roper 2014). The analysis detailed there was essentially complete when I submitted the residue study to *Radiocarbon* in October 2012 and no results have changed. Throughout that study, I maintained no "hypothesis" about the specific temporal placement of the Central Plains Tradition that would emerge from the analysis, and archaeologists familiar with the Central Plains Tradition will know

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that the chronology I presented considerably shortens the chronology and moves it later in time than normally cited (e.g. Roper 2006; Steinacher and Carlson 1998). This, of course, results from, and can be expected from, the fact that the process eliminated a large number of age-offset assays on old wood and relies heavily on high-precision age determinations on short-lived materials. The resulting chronology is sharp, internally consistent, and readily interpretable. A synopsis of that paper has been presented at a conference and is available on www.academia.edu (Roper 2013b).

A substantial number of the residue dates I discussed in my *Radiocarbon* paper are age offset from dates on other short-lived materials from the same context or, in some cases where no context dates could be obtained, from the period indicated for comparable contexts. Many offsets are statistically significant; some are not. Hart and Lovis (2014) apparently do not accept the possibility that these offsets result from old carbon possibly incorporated into the food prepared in the pot but in any event incorporated into the residue at some point during or after the vessel's use as a cooking pot. Instead, they would see offsets as a product of context-specific occupation redundancy or other formation processes. They note my assumption that the contexts of the Native American lodges that form the large majority of the cases in my study (including the full chronometric hygiene study) represent relatively short, decadal-scale occupation, and hence my expectation that all dates from a context will be statistically the same. This is correct—it is a premise of my study, as it is of other Plains archaeologists studying remains from the period during which earthlodges and their late prehistoric wattle-and-daub prototypes were constructed. Ethnographic and documentary data, corroborated by experimental data, attest to the relatively short use-lives of lodges (Roper 2005:118–21). True villages may have witnessed rebuilding episodes on a village-wide scale, although only rarely does one lodge's footprint overlie lie that of an earlier lodge, but the late prehistoric sites I am dealing with were not true villages. Instead, they more likely are accumulations of non-contemporaneous or mostly non-contemporaneous lodges and usually are more loosely arranged than are actual villages. Of course, when any set of dates for a context is considered, and especially when incongruent dates are recognized, it is necessary to consider multiple possibilities and the presence of older materials is among them. In my view, it is circular reasoning to "identify" these older materials solely by ^{14}C dates that stand apart from others from that context without additional, independent, and preferably *a priori*, evidence for multiple occupations. Ahler et al. (2007), for example, *before* analyzing their dates, examined their sites for what they call primary evidence of long-term occupation (PELTO) and factored this into their expectations.

Given all this, I will not here respond on a context-by-context basis to the comments on each individual context I presented in my paper. I suspect that if I had written comments like this, or at least to this extent, in my study of the regional chronology, I could justifiably be accused of seeking to explain away some incongruent results rather than looking for the pattern of the incongruent dates. In other words, Hart and Lovis suggest I am committing a Type II error, a "false negative," whereas I suggest that overlooking the pattern in these results would be a Type I error, failing to reject "false positive" results. My conclusion, after all, is not unique. Age offsets on residue are well documented in northern Europe and parts of Asia. In North America, Ahler et al. (2007) also found residue dates for sites in South Dakota to be age offset from context dates. Hohman-Caine and Syms (2012) working in Minnesota and adjacent areas also did, and a just-released study of Angel Mounds in Indiana lists all ^{14}C dates for the site, including one residue date that is highly offset from a date on cane from the same context and properly appears to have been ignored in building the site chronology (Krus et al. 2013).

What is significant, in both the Ahler et al. study and the Angel Mounds study, as well as several instances in the late prehistoric Central Plains case that I presented, is that there remains a large

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temporal gap between the age-offset dates on food residue and the bulk of dates on other materials. The residue is usually associated with pottery types for which the only temporal "evidence" for accuracy of the earlier date is the circular evidence of the residue date itself, and nothing fills the gap. For example, although Hart and Lovis note that the single residue date on 14OT5-House 2 and the residue date 25FR6 are similar, and thus suggest that they do have equivalents in the region, there remains an approximately 2-century gap with no evidence for the relevant pottery types or associated site characteristics in either locality. From an anthropological standpoint, it is hard to believe that these pottery types made a very brief and geographically sporadic appearance and then disappeared for a couple centuries.

In reviewing the literature, it is noticeable that it always is the residue dates, never or rarely dates on other annual materials, that are age offset. This is apparent elsewhere too—studies by Hart and Brumbach (2003) and Schulenberg (2002) dealing with the appearance of Owasco pottery, and a dating of the earliest pottery in Japan (Nakamura et al. 2001) all argued the earliest dates for the phenomena of interest from residue and not other dated materials. It also may be the case in a series of dates from a single context that all or many residue dates are older than all dates on other materials. Hart and Lovis (2007b) have argued that the dates from Åkonge in the Fischer and Heinemeier (2003:457) study are not statistically different if a single outlier is eliminated, but while this may be true, it overlooks the observation that all but one residue date is older than all dates on other materials (and then the one exception has an overlap of a mere 5 ^{14}C yr), a result that a simple runs test shows has a low probability of occurring by chance. The same is true of Fischer and Heinemeier's (2003:457) results from Mossby and my results from site 25FT56, in each of which all residue dates are older than all dates on other materials. Once again, I am looking at the overall patterning within the larger body of evidence.

In Roper (2013a), I stated that some AMS dates on residue are offset, that the phenomenon is well-documented in Europe and Asia, and that the offsets are usually attributed to a freshwater reservoir effect (FRE). This was in the context of the literature review in my opening paragraph. The statement that offsets are usually attributable to an FRE is correct because cited authors do so attribute age offsets and I am merely reporting their conclusions—whether that attribution is correct or not, or whether it is the whole story or not is another matter. I went on to say, still in my Introduction, that I concluded that residue dates were often not reliable and clearly said that "no conclusions as to why this happens are offered" (p. 152). Later in the paper, I discussed several possible factors, FREs among them, since they are plausible for the period on the Central Plains that I am studying. But in reviewing the circumstances of the contexts with incongruent dates I was observing a few other factors that involve carbon that might be old, so I also indicated that "additional factors that may introduce old carbon should be considered" (p. 159). A couple of examples that I postulated on the basis of my observations may or may not be factors, but my point was that we do not well understand the possible sources of old carbon in residue and that we need to look into not only FREs but also various other possible sources.

Having identified the pattern of age-offset dates on residue in this data set, and to strengthen the argument that this is not a Type I error, as well as to address what we believe is an actual problem, I and collaborators have undertaken to look into what is causing age-offset dates and how the problem can be corrected. In reviewing the literature, it is becoming apparent that residue sample pretreatment and its effect on the outcome of an age assay must also be considered. At least two studies are pertinent. In one, Timofeev et al. (1995), working with Neolithic material from the Baltic region, stated that humics and carbonates from the surrounding sediment need to be eliminated. Accordingly, they separated soluble and insoluble fractions and dated them individually, obtaining different

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results on each fraction (Timofeev et al. 1995:24–5). It is not possible from the data they present to determine which, if either, is accurate relative to context dates, but the essential point is that the two fractions yielded different results. A more powerful demonstration of the apparent effects of pretreatment is that reported by Bayliss et al. (2011) in which replicate pairs of residue samples from a British Neolithic context were dated at different laboratories using different pretreatment protocols, and which resulted in a statistically significant number of pairs producing statistically different dates for the two subsamples (Bayliss et al. 2011). Further, dates on humates extracted from ceramics have been lumped with dates on food crust scraped from pottery and termed "ceramic residue." Clarification of what is being dated as "food residue" or "ceramic residue" is necessary as we go forward.

Focusing on Plains material, I am collaborating with Linda Scott Cummings of PaleoResearch Institute to explore the problem. Noting that Ahler et al. (2007:87) found dates on residue from Plains Village sites in South Dakota to be age offset from context dates, we borrowed those specific food-encrusted sherds for further study. That study has consisted of dating only humates extracted from the residue, resulting, expectably, in a date that is very old relative to its context. It also, however, has involved dating a residue fraction cleaned of fats and lipids for two sherds. These results adjust age determinations for which Ahler et al. (2007:279) reported 110- and 130-yr age offsets to age offsets of 38 and 26 yr, without yet applying the most stringent of cleaning techniques to the fraction. These results have been presented at conferences in Europe (Cummings and Roper 2013a) and North America (Cummings and Roper 2013b). The process is being applied to other samples, including some that are discussed in my *Radiocarbon* paper, but, as of the time of this response, the analysis is still in progress. We have recently received a small seed-money grant to further explore this and will study further samples in the coming months. These will include some samples for which inaccurate AMS dates on food crusts have been obtained, as well as some newly selected food residue samples to be put against context dates in which we have considerable confidence, obtained for regional chronology-refinement purposes, but which also will be suitable for comparison with age determinations on residue pretreated in various ways. This does not yet demonstrate the source of the old carbon, but if the process continues to improve the accuracy of age determinations by reducing or eliminating the age offsets, then it will be pertinent to examine the chemical composition of the discarded fraction and we will begin that effort, too. In the course of this study, we would be happy to consider a few of the sherds from which Hart has obtained age determinations on residue, and might be particularly interested in those used to argue for an older date than previously thought for the beginnings of Owasco culture in New York.

One of the difficulties I have with Hart and Lovis's papers on the subject of AMS dating residue is that I do not understand their resistance to vetting the reliability of residue for dating. They have done some modeling of the effects of FREs (Hart et al. 2013), but verification can come only from actual dates, and, in any event, other possible sources of old carbon also must be considered and possibly compensated for in pretreatment of samples. Some decades ago, archaeologists in the mid-continent began submitting corn and finding the dates seemingly age offset in the direction of being too young. Work by ^{14}C specialists soon determined that correction for fractionation was necessary to produce an accurate age (Hall 1967). Corn now is, to excuse the pun, a gold standard for dating. But it did not happen by denying the issue—it happened by taking the chance of making a Type I error, going to work to identify the problem, and then learning how to resolve it. This is what we are working on for residue. It would be a real boon to researchers using curated collections or investigating sites with few annual plant remains to have an alternative such as residue available. Until we can have more confidence in the accuracy of the age determinations on this material, however, it is difficult to recommend its use.

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