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Stratigraphy vs Taphonomy? Towards an Integrative Approach to Stratification[1]

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Introduction

The term "stratigraphy" is generally used in archaeology in a dual sense, referring to either the *method* of stratigraphic analysis or to the documented stratigraphic sequence of a particular multi-layered site, usually derived from a representative section or compilation of section drawings. The former notion of stratigraphy as a method had been adopted from geology in the early decades of the 19th century (Lucas 2012, 77) and applied both to Palaeolithic cave deposits and multi-layered settlement mounds by the pioneers of the discipline during the 2nd and 3rd third of the 19th century. A fundamental methodological discussion of its principles and practice, however, did not take place before the 1970s and 1980s – and it was Edward C. Harris who opened this discussion with his "Principles of Stratigraphy", based on a London PhD thesis and published in 1979 (Harris 1979). This ground-breaking methodological study came amazingly late regarding the fundamental role of stratigraphy as one of the most important ways to establish relative chronologies, and also compared to the much earlier methodological discourses on typology and seriation. Probably it was the seeming simplicity of its basic assumptions which made stratigraphy a less obvious object of theoretical reflection.

Despite its rather all-encompassing title, the focus of Harris' book was clearly on the formal description and logical analysis of stratigraphic sequences of anthropogenic deposits and "interfaces". The latter term was coined by Harris to describe volume-less three-dimensional surfaces witnessing human action such as digging ditches or levelling abandoned architecture, which usually are not directly datable by associated finds. This important difference between layers and interfaces, however, was not further developed by Harris, since in general he didn't deal with the stratigraphic distribution of artefacts or ecofacts at all, as has been pointed out by his critics (cf. Warburton 2003, 12–20; Lucas 2012, 84).

Even more widely known than his introduction of interfaces and his breaking down of stratification into only three basic relations between stratigraphic units became their diagrammatic representation – the Harris matrix.

The Harris matrix – sequence of deposits

Despite the theoretical nomothetic claim of his book, the famous matrix representation of stratigraphic units arose from Harris' practical experience in urban rescue archaeology. Limited space (small trenches) and

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[1] The author enjoyed the fruitful collaboration and many stimulating discussions with Susan Pollock in two Research groups of the Berlin cluster of Excellence Topoi during the last decade. The issue of multiple time scales as well as the stratigraphical resolution of human agency in the past were among the topics we discussed and, thus, it is a great pleasure to contribute to her *Festschrift*.

time constraints on one hand and the "single context" excavation strategy, separating layer contents and backfill of negative features,[2] on the other hand led him originally to apply the "Harris matrix" as a rapid tool for field recording (using blank matrix templates), rather than a method of post-excavational data processing (Harris 1989, 36–38, 144–47). It was its (almost) universal applicability and the benefit of formalised representations of complex stratigraphical sequences that soon made the Harris matrix a standard tool of international field archaeology comparable to Munsell® soil colour charts. Its formal rigidity and the strategy of reducing complexity by removing redundant stratigraphical relations (Harris 1989, 36–39, 105–19) transformed the Harris matrix from a field recording standard into a tool of post-excavational analysis. Meanwhile several software applications have been developed to facilitate the drawing up and analysis of Harris matrices.[3]

Despite its widespread use in field archaeology, the Harris matrix approach has been repeatedly criticised. Gavin Lucas' main critique is that in his formal analysis of stratigraphic relations Harris disregards the formation processes of the units themselves (Lucas 2012, 84).

"*The very advantage of the Harris matrix as a means of presenting stratigraphy are also the cause of its limitations. The matrix strips down the notion of time to a bare sequence and it strips down the notion of a stratigraphic unit to interfaces between units*" (Lucas 2012, 84)

David Warburton even goes one step further accusing Harris of not only completely ignoring the formation processes, but of regarding "*sections [...] as superfluous and [to be] replaced by the Harris matrix*" (Warburton 2008, 2105). Harris' emphasis on recognising stratigraphic units during excavation is understood as "*[...] recognizing the interfaces during excavation and separating the units accounting to the interfaces*" (Warburton 2008, 2108). The first statement reveals an incorrect reading of Harris, who underlines the relations of stratigraphic units, but also defends the use of sections:

"*There are those who would advocate that sections are now obsolete, but sections have a purpose which cannot be met by any other means. … While there is little doubt that archaeological stratigraphy in the past has placed too much emphasis on sections, the reaction to this overbalance should not be to abolish sections*" (Harris 1989, 72–73).

Stratigraphic units and interfaces

Both Warburton and Lucas misinterpret Harris' concept of "interface" to a certain degree by reducing the term to the surface separating two neighbouring stratigraphic units. Harris, however, distinguished two types of interfaces, the layer and feature interface. Both types can be differentiated as either horizontal or upstanding / vertical. *Layer* interfaces can be considered either as the limitations of a deposit or surfaces with their own specific use-life, in which case they should be understood as independent stratigraphic entities and represented as separate units in the Harris matrix (Harris 1989, 55).

At any rate, such a separate recording is considered indispensable for *feature* interfaces which represent the action of digging a pit/ditch or of destroying existing upstanding structures such as walls or ramparts. The

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[2] According to Peter Clark, the term "negative feature" dates back to around 1970, prior to Harris' book (Clark 2000, 103).

[3] Such as BASP Harris (developed by I. Scollar & I. Herzog; http://baspsoftware.org/), Stratify (© Irmela Herzog, Bonn: www.stratify.org) or the Harris Matrix Composer, developed by Ludwig-Boltzmann Institute, Vienna (http://archpro.lbg.ac.at/). The website http://archaeologic.al/wiki/Harris_Matrix provides an overview of existing Harris matrix software solutions.

recording of such feature interfaces as part of the feature itself *"complicates the stratigraphic record, since relationships are often made between layers within a pit, and those surrounding the pit, without due regard for the original interface, which is the pit itself"* as Harris argues (Harris 1989, 60). The definition of interfaces in that sense cannot be overrated and should be regarded as one of the major methodological advances in Harris' ground-breaking study.

He convincingly demonstrates how interfaces should be marked in section drawings (Harris 1989, 76–81) and should be conceived of as separate stratigraphic entities in a Harris matrix, especially those classified as feature or period interfaces (Harris 1989, 63–67). He points out that most conventional stratigraphic sequences are based on depositional periods and ignore interfacial ones, leading to distorted interpretations of their architectural history and cultural dynamics (Harris 1989, 68). He also describes the problem of adequately recording feature interfaces (Harris 1989, 64), a difficulty which nowadays can easily be overcome by 3D recording techniques such as laser scanning or *Structure from Motion*, provided that the feature has been excavated accordingly as "single unit".

There are, however, two fundamental differences between interfaces and deposits which apparently have not yet received the attention they deserve, even by Harris himself. Firstly, almost all feature (and some layer) interfaces represent the material traces of human agency (construction, maintenance, repair, structural alterations, demolition) whereas deposits result from either natural or anthropogenic processes, allowing for temporal and spatial interference of both.

Secondly, interfaces, understood as three dimensional surfaces without any volume, cannot contain associated finds. Thus, they cannot be dated directly but only in their stratigraphical relationship to preceding or succeeding stratigraphic units (deposits). This is a further argument for recording (feature) interfaces as separate stratigraphic units in a Harris matrix in order to differentiate the (potentially) datable, find-containing deposits from non-datable, activity or event-related interfaces. This important distinction, however, is not expressed graphically in the Harris matrix, at least in its original minimalistic layout.

Scalability

Even some of the matrix examples in Harris' book illustrate the quantitative limits of

Kamid el-Lōz		**Uruk-Warka**		**Kastanas**		**Okolište**		**Uivar**	
(Echt 1984)		(Eichmann 1989)		(Hänsel 1989)		(Hofmann 2013)		(Draşovean and Schier 2020)	
Stratigraphy	Building sequence	Stratigraphy	Building sequence	Stratigraphy	Building sequence	Stratigraphy	Building sequence	Stratigraphy	Building sequence
Layer formation	Building period	Layer formation	Building period	–	–	Layer formation	Building period	Layer formation	Building period
Layer association	Building layer	Layer association	Building layer	Layer	Building period	Layer association	Building layer	Layer association	Building layer/stage
Layer group	Building stage	Layer group	Building / construction / destruction stage	–	–	Layer group	Building stage	–	–
Layer	Building phase	Layer	Building phase	Deposits	(Building) phase	Feature/ layer	Building phase	Layer	Building phase

Tab. 1. Synopsis of stratigraphical terminology in selected sites of Southwest Asia and Southeast Europe.

the method (e.g. Harris 1989, 145, Fig. 62). Complex multilinear stratigraphies typical for large-scale excavations in multi-layered sites quite easily exceed the clarity and comprehensibility of the matrix diagram. We can describe this weakness as a *lack of scalability* of the Harris matrix approach.

Stratigraphic analysis and interpretation of large tells and (proto-)urban sites such as Uruk, Kamid el-Lōz or Tell el-Dab'a in Southwest Asia and Egypt has been undertaken as multi-scalar approach, involving a hierarchical array of terms such as *layer*, *layer group*, *layer association* and *layer formation* referring to the depositional sequence or *building phase*, *building stage*, *building layer* and *building period* as levels in the architectural sequence (Echt 1984, 18–22; Eichmann 1989, 3–10; Bietak 1976, 480–84). Similar but not identical hierarchical terminologies have been applied at Southeast European tell sites as Kastanas (Hänsel 1989, 55–58), Karanovo (Hiller and Nikolov 1997), Okolište (Hofmann 2013, 54–56 with Fig. 15) or Uivar (Draşovean and Schier 2020) (**Tab. 1**).

In practice we apply different levels of stratigraphical resolution when we describe a) the replastering of floors or walls, b) the modification of the ground plan of an existing house, c) the rebuilding of a house on top of the levelled remains of its precursor or d) a new architectural layout following layers of large-scale destruction and levelling. We can call these different resolutions *micro-*, *meso-* and *macro-stratigraphy* or just specify the level of reference according to the above-mentioned depositional or architectural hierarchy of terms.

In its original and still today conventional form the Harris matrix does not allow for such a hierarchical nesting of depositional sequences.[4] There is, however, no logical reason why micro- and mesostratigraphic sequences (foundation – walls including repairs and modifications – floors including replastering – collapse / destruction of a house) should not be grouped into larger units ("house A") which in turn can also be depicted in the style of a Harris matrix (house A – house B – house C). As long as stratigraphical ambiguities or even logical contradictions within and between grouped entities can be avoided, a Harris matrix approach could be realised on different levels of sequential resolution, thus reducing the complexity in the graphic representation of Harris matrices (**Fig. 1**).

Sediment description, functional interpretation and time scales

Critics of the Harris approach to stratigraphy repeatedly pointed out that Harris not only widely ignores the formation of find assemblages within and through stratigraphic units (see below), but also the composition and structure of the sediments, which provide insights into both the formation process and the functional meaning of a stratigraphic unit (Stein 2001; Warburton 2008, 2105; Lucas 2012, 84). Actually, this critique is aimed mainly at the Harris matrix itself, which assigns rectangular boxes to units regardless of their formation and/or function, whereas in his textbook frequent reference to functions of deposits and interfaces can be found (e.g. Harris 1989, 50–52). Admittedly, however, neither the formation nor the function of deposits and interfaces are explicit issues in Harris' approach.

Geoarchaeological approaches sought to overcome this deficiency by introducing standardised descriptions of sediments (cf. Gasche and Tunca 1983) and nowadays hardly any excavation recording system will do without

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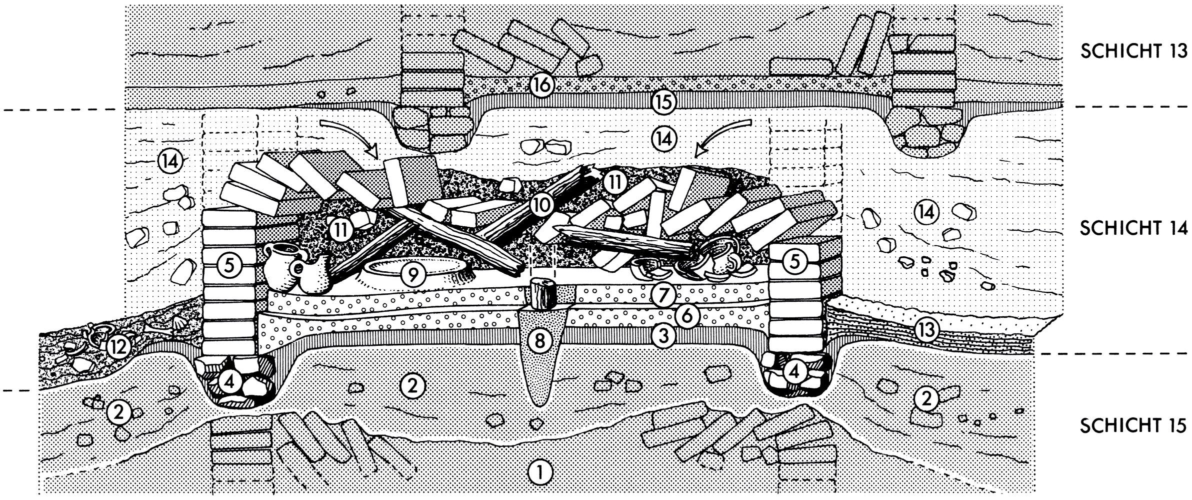
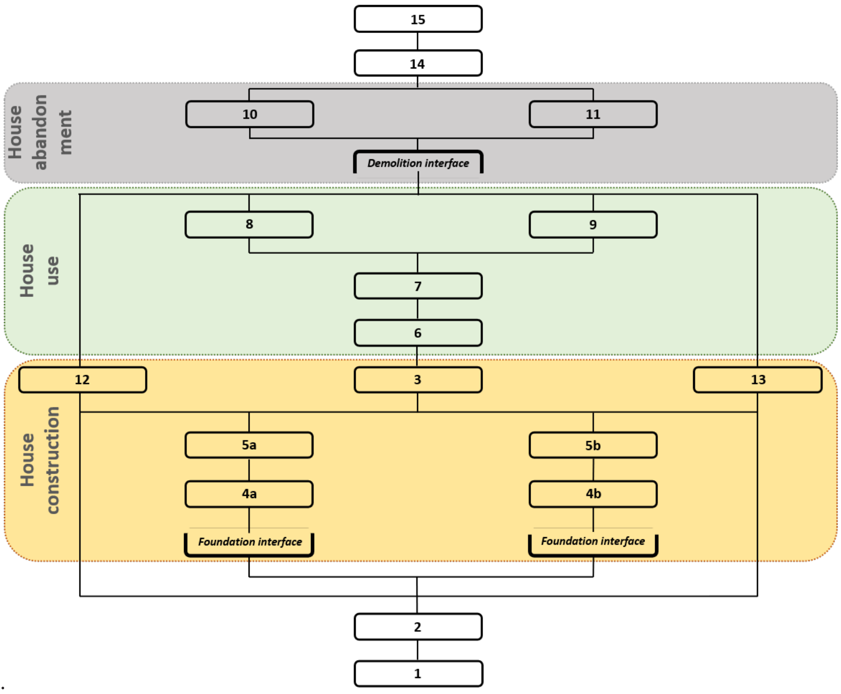
[4] The software Harris Matrix Composer (cf. footnote 2) allows for the grouping of stratigraphic units into larger entities such as phases or stages.

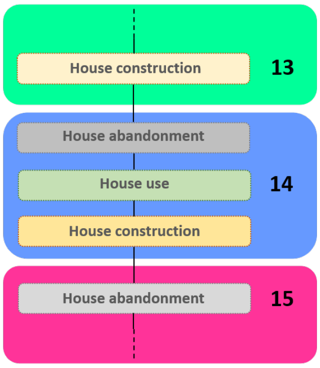


1 Reste eines zerstörten Hauses der Schicht 15
2 Eingeebnete Schuttzone der Schicht 15
3 Bauhorizont der Schicht 14
4 Steinfundament
5 Lehmziegelmauer
6 Älterer Fußboden
7 Jüngerer Fußboden
8 Grube eines dachstützenden Pfeilers
9 Herdstelle
10 Verstürztes Dachgebälk
11 Brandschutt und Asche
12 Abfallzone vor dem Haus
13 Weg zwischen den Häusern
14 Eingeebnete Schuttzone der Schicht 14
15 Bauhorizont der Schicht 13
16 Fußboden

a.



b.



c.

Fig. 1. a.) Kastanas, Greece, stratigraphic elements of a house belonging to layer 14; aus Hänsel 1989, 56, Fig. 8. b.) Representation of a.) as classical Harris matrix; the phases construction, use and abandonment of the house are indicated in different colours. c.) Condensed version of b.), assignment of house phases to layers is indicated by colours; diagrams: W. Schier.

forms or online entry masks describing soil colour, grain size, anthropogenic inclusions and other macroscopically detectable properties of the sediments. As Lucas argues, both the geoarchaeological and the Harris approach fail *"... to understand stratigraphy in terms of cultural formation processes"* (Lucas 2012, 87), a challenge that certainly includes the assessment of probable function and intentionality of deposits and interfaces.

Despite some pleas to strictly separate description and interpretation of stratigraphic entities (Warburton 2003, 57–58; 2008, 2108) we agree to the view that such a separation is epistemologically misleading and almost impossible in practice (Lucas 2012, 88).

A further aspect that is not explicitly considered by Lucas is the role of "tacit knowledge" or rather empirical assumptions derived from our understanding of construction practice, ethnoarchaeological observation or even experimentally reproducing ancient techniques. For instance, we would expect a posthole or foundation ditch to be excavated (feature interface), the post(s) to be installed and the spoil to be used as backfill material (unstratified filling of feature) within a very short interval of time – i.e. one or two days maximum. In a Harris matrix, however, this coherent construction process is divided into three stratigraphic units (boxes), connected by vertical lines of the same length as, for instance, a demolition interface followed by a thick accumulation of sediment into which, centuries later, a ditch was dug. Since the Harris approach is primarily regarded as a method of relative chronology, the vertical distance of its units does not reflect elapsed time. As with other methods of relative chronology, time is assessed on an ordinary rather than a metric scale (Schier 2018, 38–40).

In fact, however, in many stratigraphic situations we dispose of contextual information about probable function and use-life of features or probable time intervals between units that the Harris matrix analysis does not take into account, insofar as methodological analogy can be observed between sequential depositional stratigraphy (without considering context information) and calibration of grouped radiocarbon dates (without Bayesian modelling of available context information). In both situations we fail to include available information which could help to enhance the temporal resolution. In stratigraphic analysis, unlike Bayesian calibration modelling, a coherent and formalised approach to integrate context (and content) information into a depositional and/or interfacial sequence is still lacking.

Taphonomy and assemblage formation

Taphonomy developed in the field of palaeontology and still today is most frequently discussed and applied in Palaeolithic and bioarchaeological research. Whenever archaeological approaches to taphonomy are addressed, they inevitably refer to the work of Michael B. Schiffer (see Sommer 1991, 57–58; Lucas 2012, 94–104). With his *Behavioral Archaeology* (Schiffer 1976) Schiffer can be seen as one of the pioneers in archaeological formation theory, which shares many common aspects with palaeontological taphonomy. Schiffer took a stand against Lewis Binford's "New Archaeology" in rejecting Binford's view of archaeological finds as "fossil record" of extinct societies. He stated

> "*...archaeological remains are not in any sense a fossilized cultural system. ... they have been subjected to a series of cultural and noncultural processes which have transformed them spatially, quantitatively, formally and relationally*" (Schiffer 1976, 11).

He developed the concept of C-Transforms and N-Transforms, relating to cultural and noncultural processes, distinguished between systemic (living society) and archaeological contexts and systematised various transformation processes between both spheres (Schiffer 1976, 27–41). Schiffer himself, however, appears strongly inspired by processual archaeology in his attempt to express his transformation processes in mathematical formulas, supposing that "formation processes behave with law-like regularities" (Gifford-Gonzalez 2011, 301). His *Behavioral Archaeology* and many of his later works – i.e. *Formation processes of the archaeological record* (Schiffer 1987; 1996) – have been enormously influential for formation theory and archaeological taphonomy in the 1980s and 1990s (cf. Lucas 2012, 95–104). Even as late as 2011, a whole issue of *Journal of Archaeological Method and Theory* was dedicated to the impact that Schiffer's work has had on field methodology and theory (Reid and Skibo 2011; Gifford-Gonzalez 2011). Schiffer's main focus in his earlier work has been the view from the living culture (systemic context) towards what *would become* an archaeological context – in a way his approach might be labelled an *emic* perspective on formation processes.

Schiffer's two spheres of systemic and archaeological context have been further subdivided by Warren DeBoer into four categories which he named *behavioural*, *discard*, *archaeological* and *sample* assemblage, the first two of which he assigned to the systemic context, whereas the latter two belong to the archaeological context (DeBoer 1983, 20–22; cf. Lucas 2012, 100–01). What Lucas does not mention is the very close resemblance of this four-part classification to the terminology of taphonomic stages in palaeontology (**Tab. 2**), which had already been developed in the late 19th and first half of the 20th century by German and Austrian palaeontologists (Möbius 1877; Wasmund 1929; Sommer 1991, 74–76).

In one of the first attempts to develop a systematic taphonomic approach in German-speaking archaeology, Ulrike Sommer applied this palaeontological terminology (Sommer 1991, 74–90), which she apparently abandoned in later publications (cf. Sommer 2012). Regardless of the terminology, archaeological taphonomy deals with the classification of processual stages and the analysis of influential factors in the formation of find assemblages. For a more comprehensive understanding of stratification the transformations between these stages are of vital importance (see below), especially for understanding discard and refuse,[5] as well as the post-depositional processes, corresponding to *taphocoenosis* in palaeontology. It could be argued, however, that these four-stage models appear too static and do not account for iterative and reversible transformations and transitions between use, discard, embedding, reuse or redeposition of objects.

A different approach to the processes of assemblage formation has been *time*

Author	**Taphonomic categories in archaeology and palaeontology**			
Schiffer 1976	systemic context		archaeological context	
DeBoer 1983	behavioural assemblage	discard assemblage	archaeological assemblage	sample assemblage
Möbius 1877, Wasmund 1929	*biocoenosis*	*thanatocoenosis*	*taphocoenosis*	*oryktocoenosis*

Tab. 2. Taphonomic categories in archaeology and palaeontology.

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[5] For further differentiation of *de facto*, primary and secondary refuse cf. Schiffer 1996, 58–75; see also Sommer 1991, 76–104.

perspectivism, first formulated by Geoff Bailey in 1981 and developed further in his later works (Bailey 2007; 2008; cf. Lucas 2012, 104–06). The key concept of this theoretical approach is the assumption that "*differing timescales bring into focus different features of behaviour, requiring different sorts of explanatory principles*" (Bailey 1981, 103) and he emphasizes the inverse relation between temporal resolution and visibility of larger (long-lasting) patterns and processes: "*Closeness in time allows observations of higher-definition detail but within a narrower field of view; remoteness in time results in loss of local definition but the potential to observe a bigger pattern*" (Bailey 2008, 15). This observation is also, but not specifically valid for stratigraphic analysis.

A notion which Bailey developed further in the course of *time perspectivism* is the term *palimpsest*, which is of relevance in the context of stratification and assemblage formation. In his 2007 paper he develops a finer classification of palimpsests into five different types (Bailey 2007, 203–08). Its relevance for stratification theory is the core question of how to distinguish between materialisations of single and multiple repetitive activities. His third type, the cumulative palimpsest, in which "*the successive episodes of deposition remain superimposed one upon the other without loss of evidence*" (Bailey 2007, 204) characterise aspects of depositional stratigraphy especially on the micro-scale ("cultural layer", "walking horizon"), which are "*characterized not so much by loss of material but by loss of resolution*" (Bailey 2007, 204).

Fig. 2. Uivar, Romania, Area I, layer 4b. A large burnt house consisting of collapsed walls, upper floor and numerous vessels broken in situ, *disturbed by foundation ditches and pits of the succeeding building layers. © Institute of Prehistoric Archaeology, Free University Berlin.*

Gavin Lucas extensively discusses the meaning and relevance of the palimpsest concept in formation theory. He argues that (true) palimpsests as "total erasure of all previous activity" and (true) stratigraphies as "total preservation of all previous activities" should be seen as opposite ends of a conceptual continuum, whereas "most elements we encounter lie somewhere between these limits" (Lucas 2012, 121, 123). This is certainly true on a general level, but Lucas neglects the enormous effects that superimposed negative features (ditches, pits) have in otherwise accumulative depositional stratigraphies. A bird's eyes view on a trench at the Neolithic tell at Uivar, Romania (**Fig. 2**) illustrates the destructive palimpsest of later pits on the subjacent cultural layer and architectural remains of burned down houses. In this case – and just as frequently in multi-layer settlement mounds – we face the coexistence and interference of both palimpsest and stratified deposition rather than a continuum between both.

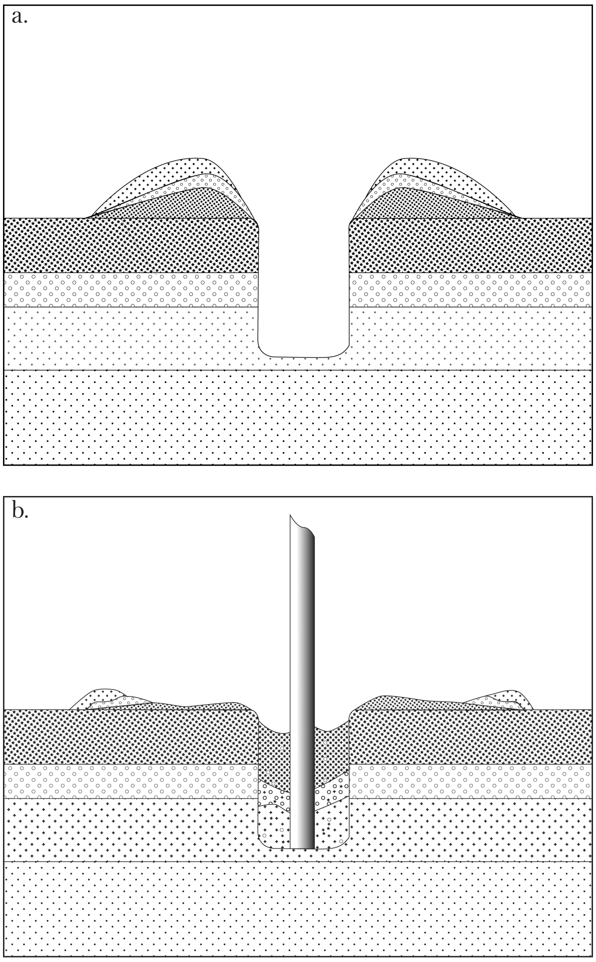

Fig. 3. Excavation (a.) and backfill (b.) of a post pit. The removal and redeposition of earth from different layers containing finds of different age is indicated by grey shades. Drawing: J. Müller-Edzards, Institute of Prehistoric Archaeology, Free University Berlin.

Deposit *vs* assemblage formation – bridging the gap

The difference between depositional sequence and find content of stratigraphic units is illustrated in the following example. Let us assume a building activity in a tell settlement. The inhabitants plan to erect a new building on top of a levelled surface – archaeologically a find-containing "cultural layer." After marking the ground plan, they start to excavate deep pits for the foundation of the main post of the building, along with shallow trenches which will serve as the founding of wall posts, connected by wattle and coated by daub. The spoil excavated from post pits and foundation trenches is heaped up near to the hollows in order to minimise transport. After placing the prepared posts in their corresponding positions where they have to be fixed temporarily with the help of ropes or poles, the spoil will be used to fill the remaining hollows and will be tramped down. Not all of the excavated material can be shovelled back into the foundation pits since the posts occupy part of their volume (**Fig. 3a–b**). Thus, a minor part of the spoil heaps will be spread around the freshly installed posts or will be used as substruction layer for a floor.

Such a scenario is hypothetical but realistic and very likely, based on our understanding of communal construction activities and "reasonable" assumptions. What does it mean for the distribution of finds contained in the excavated material from the foundations?

The deep post pits cut through several older layers and bring finds to the surface that are slightly or considerably older than the contemporary pottery and other artefacts at the time of construction. The spoil taken from the foundation trenches contains only slightly older material, as they are shallower and do not affect layers deeper than a few decimetres below. If we assume that the remaining spoil that does not fit into the deep post holes is distributed inside the future house (below the floor) and the spoil from the foundation trenches along its outer long walls, the construction process will result in a horizontally varying distortion of the stratigraphical sequence of assemblages. Inside the house and below the floor we can expect to find a mixture of slightly to considerably older material whereas along the house only slightly older material will be deposited, possibly together with some contemporary sherds of pots which broke during the construction process and animal bones as refuse of meals. In reflecting the interdependencies between deposit and assemblage formation a central notion is that of contamination.

Contamination – a key concept in assemblage stratification

Despite his main concern for depositional stratigraphy Harris provided a brief view on the relation between stratigraphy and contained finds in the last chapter of his textbook, wherein he distinguished the three categories: 1) *indigenous*, 2) *residual* and 3) *infiltrated* remains (Harris 1989, 121). While the meaning of these categories is rather self-explanatory, Harris rightly emphasizes that "*the major problem in artefact analysis is to determine which of the finds in a deposit are indigenous.*" The term "contamination" is used only to denote unrecognised infiltrated finds: "*The implication is that the trench supervisor has excavated poorly and the artefact collection from a layer has been tainted by allowing later objects to become included in it*" (Harris 1989, 122).

We suggest here a much more general concept of contamination, referring to both infiltrated and residual finds. Analogous to the scientific definition of contamination as "*the process of making something dirty or poisonous, or the state of containing unwanted or dangerous substances*",[6] the proportion of non-contemporary material (i.e. the non-indigenous part) in find assemblages deposited homogeneously will be defined here as *chronological contamination.*

This chronological contamination can be divided into two main components in terms of their formation: *stratigraphic* and *taphonomic* contamination. The former is caused by an incomplete separation of the find assemblages into stratigraphic units or features during excavation, e.g. using artificial spits or incorrectly applying the single context method. We have argued elsewhere (Schier 2000, 188–89; 2001, 374) that, in this type of excavation procedure *first*- and *second*-degree contamination needs to be addressed, depending on whether the contaminating material comes from neighbouring or distant layers or even unknown features. Single context excavation or, as it is also known, "following the layers", is in reality a challenging task and will rarely result in a 100 % separation of finds from different stratigraphic units. If, in the worst case, the stratigraphic units are really indistinct, excavating them in horizontal spits may be the only option. Frequently the actual layer interfaces only become visible in hindsight in the sections. Bernhard Hänsel experienced this issue at Kastanas and described how he attempted to minimise the problem of stratigraphic contamination (Hänsel 1989, 45 ff., Fig. 6). Manfred Korfmann faced the same problem at Demircihöyük which he demonstrated by plotting the excavated units on the drawn section *a posteriori* (Korfmann 1983, 15–19, Figs. 28–29).

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[6] Definition from Cambridge Dictionary (https://dictionary.cambridge.org/dictionary/english/contamination).

Additional sources of contamination can be mistakes in the *post-excavation* proceeding of finds, such as lost or illegible find tags, mixing of sherds due to attempts of cross-contextual refitting and so forth.

Yet even if stratigraphic and post-excavational contamination can be minimised, a certain amount of material of different age (residual or infiltrated) will be found among the finds recovered in a stratigraphic unit. The term *taphonomic contamination* is suggested here to describe the unknown proportion of embedded extraneous material in a feature or a layer. Unlike stratigraphic contamination, it *cannot* be reduced by refining the excavation techniques.

The fourth source of chronological contamination arises from use-life variability or *atypical object biographies* such as curated or reused artefacts.

Forms and effects of contamination

Some quantitative considerations will help to differentiate the kinds and effects of chronological contamination. For the sake of simplicity temporal change in material culture is illustrated here according to the basic seriation model, i.e. an array of shifting unimodal frequency distributions, where each "Gaussian" curve represents a specific type of pottery, lithic tools or other (**Fig. 4**).

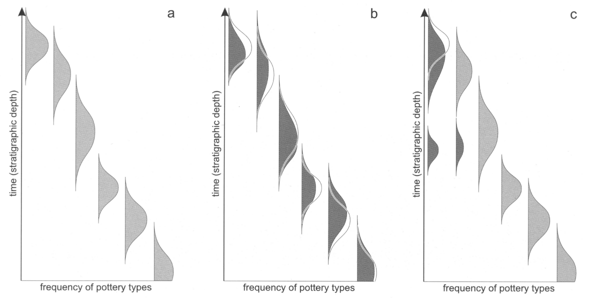

Fig. 4. a.) Vertical distribution of diagnostic pottery types in a stratigraphy. b.) Effect of contamination of first degree on the stratigraphic distribution. c.) Effect of contamination of second degree on the stratigraphic distribution. From Schier 2000, 189, Fig. 2.

The first factor with an obvious influence on the contamination of a given stratigraphic unit is the relative find density of this unit compared to those of the underlying (older) units: if a pit is dug into a layer poor in finds, the probability of older material being taken out with the spoil and being spread on the surface is rather low compared to an underlying find-rich stratum.

Chronological contamination, be it induced by fuzzy separation of stratigraphic units (artificial spits) or by taphonomic processes (residual finds), will lead to a raised occurrence of types whose "zenith" had already passed when the assemblage was forming and which therefore are overrepresented in the assemblage. This type we have suggested to call *contamination of first degree* (Schier 2001, 375) and its effect is to stretch the time distribution of types whose maximum is adjacent to the time of the assemblage formation. The result is a loss of chronological resolution of the types involved, but it does not alter their distributional characteristic, being *unimodal.*

If, however, a deep pit cuts into a much older, find-rich stratum and brings archaic material to the present surface or if a much younger feature remains unrecognised and its finds are erroneously incorporated into a seemingly closed assemblage, this results in a *contamination of second degree.* The types added to the *indigenous* assemblage are either already completely out of use or appear anachronistic. Their unimodal time distribution is not just expanded but is made seemingly *bimodal.*

Both kinds of contamination could, theoretically, occur involving residual (older) finds or infiltrated (younger) finds and could therefore be considered *symmetrical.* In reality, however, asymmetrical contamination can be expected to be more frequent, since most taphonomic processes favour the redeposition of residual material in younger contexts rather than the infiltration of younger finds in older strata.

The stratigraphic contamination caused by inadequate excavation strategy or inattentive documentation probably will cause rather symmetrical error distributions when artificial levels cut layers that are not deposited strictly horizontally. The contamination will, however, be asymmetrical overrepresenting younger types when unrecognised later pits get incorporated into the assemblage. We can therefore expect a majority of asymmetrical shifts of supposed time distributions of types due to contamination.

Without any doubt, contaminations of the second degree have a greater impact on the overall temporal distribution of types and thus on the stratigraphic resolution of find assemblages than contaminations of first degree which just extend the temporal frequency distribution. We suspect, however, that contaminations of the second degree are far more likely to be detected and the associated finds are prone to be classified as "archaic" or "anachronistic." Conversely, contaminations of the first degree have a much greater probability of escaping the attention of the excavators and/or find analysts and, therefore, may in reality be a greater threat to the typo-chronological resolution of stratified assemblages.

Detecting stratigraphic and/or taphonomic contamination

Still today there is no simple answer to Harris' question "which of the finds in a deposit are indigenous" (Harris 1989, 122). Obviously, the problem cannot be solved in a casuistic way addressing single sherds as either indigenous or residual/infiltrated, unless they are clearly diagnostic and as such doubtlessly much older or younger. There is, however, a multivariate statistical approach which can help to identify contaminations in find assemblages – seriation by correspondence analysis. If a depositional sequence is based on stratigraphy and an overall unimodal temporal distribution of the types can be assumed, a seriation should be able to reproduce the stratigraphical sequence to a certain degree. Correspondence analysis (CA) as a widely applied approach to seriate "closed" assemblages is known to reproduce sets of short-living types in a diagram of the first two eigenvectors in a way that resembles a parabola (Müller and Zimmermann 1997).

Assemblages that are chronologically heterogenous and/or consist of types with a long use-life usually get placed in the interior of the parabola, due to the fact that the multivariate method attempts to minimise their distance to both the "older" and "younger" end of the parabolic arrangement of assemblages and types. These properties of CA can be used to detect chronological contamination in a series of stratified assemblages – if the contamination affects only a minority of units and the majority can be reproduced in their stratigraphical sequence.

Such an approach has been applied by the author to the well-known Neolithic tell stratigraphy of Vinča-Belo Brdo (Schier 1996). The tell had been excavated in artificial horizontal levels of 10-20 cm between 1908 and 1934 by Miloje M. Vasić. Until the 1990s most researchers agreed that these levels would not truly represent the real (unknown) stratigraphy and could only be used in a very coarse, synoptic way, grouped in whole meters or even more (Parzinger 1993, 59–64). A detailed typological analysis and seriation of the level assemblages by CA, however, showed that the stratigraphical resolution of these artificial levels was in fact much higher and most levels could be reproduced in their vertical sequence based on their type assemblages (**Fig. 5a**). In some cases, units were misplaced by CA suggesting contamination and as a result, a lack of typological discernibility of neighbouring units. Also, the pits discovered by the excavator only when he arrived at the sterile soil beneath the tell accumulation were shown to have been dug from different layers, based on their type assemblages (**Fig. 5b**).

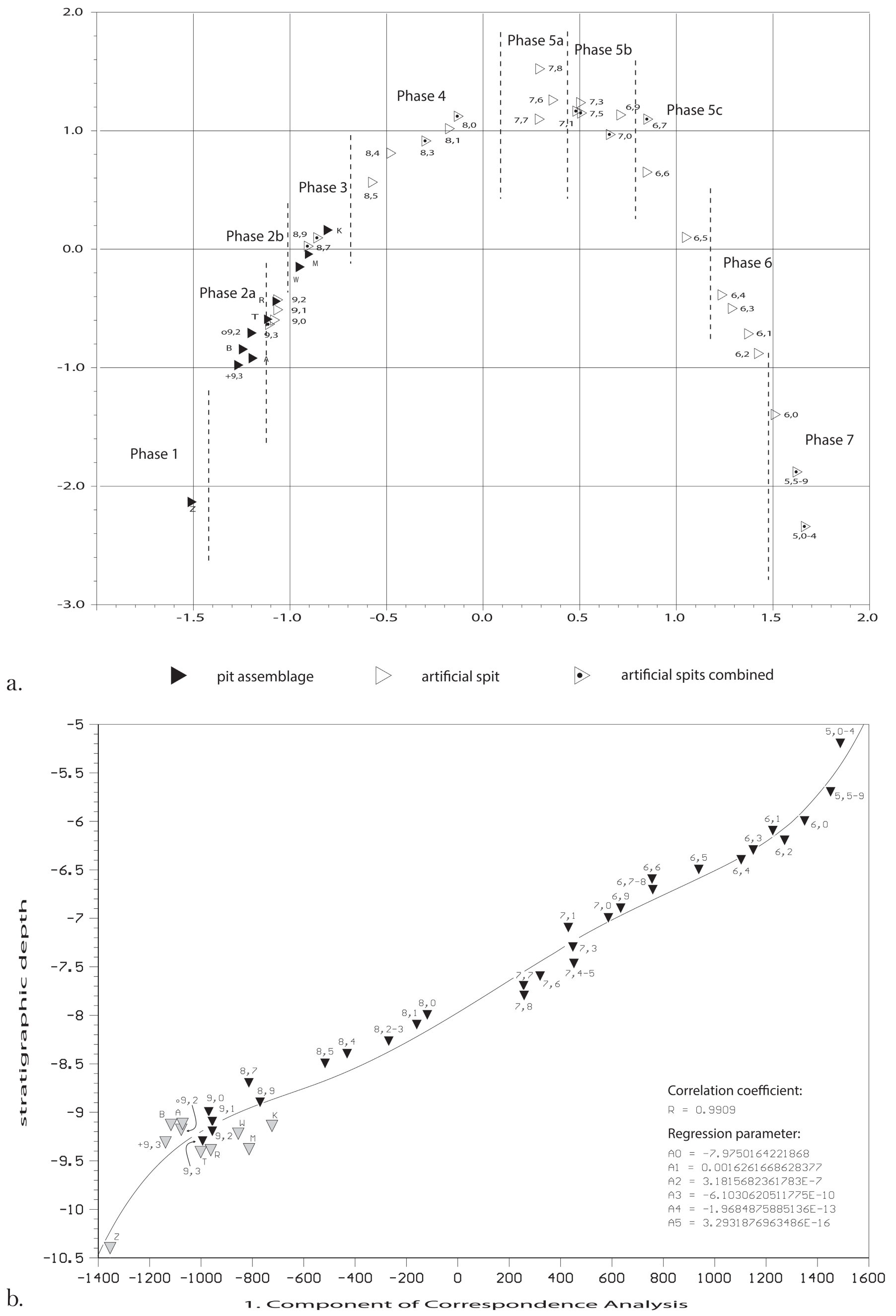

Fig. 5. a.) Correspondence Analysis of artificial strata from the tell Vinča Belo Brdo, Serbia, based exclusively on the typological composition of find assemblages. b.) Seriated sequence of artificial strata from Vinča Belo Brdo plotted against their stratigraphical depth. A very good correlation was achieved, but some strata could not be differentiated according to their finds. Pits that had been discovered only at the bottom of the lowest layer can be shown to be dug from different layers, based on their find content. Fig. 5a: diagram by W. Schier; Fig. 5b: from Schier 2001, Fig. 5.

This "rehabilitation" of the generalised stratigraphical sequence at Vinča-Belo Brdo appears to have encouraged the interest of Alasdair Whittles ERC-funded research project "The Times of Their Lives" in this important Neolithic stratigraphy near Belgrade. Together with Serbian colleagues, they succeeded in achieving an absolute chronology for this key stratigraphy of the South-eastern European Neolithic with almost generational time resolution using a Bayesian modelling of stratified radiocarbon samples from the old and recent excavations at Vinča-Belo Brdo (Tasić et al. 2016; Whittle 2018, 61–67).

In Bayesian calibration, stratigraphic information (among others) is used as a prior assumption to statistically constrain the probability intervals that usually would be considerably extended due to the mathematical properties of the calibration process (Bayliss et al. 2007; Bayliss and Whittle 2015). The samples to be included in a Bayesian calibration model must be selected with great scrutiny to make sure that their dating really refers to the context they are associated with. In working with older excavations, however, the number of samples and quality of context information may be reduced. Therefore, samples that do not match the model specifications based on prior data such as stratigraphic context usually are identified and treated as residual or intrusive (Whittle et al. 2011, 27 *et passim*). Reversing the argument, a Bayesian calibration model of stratified deposits can also reveal the frequency and degree of chronological contamination, provided a sufficiently large proportion of samples can be trusted to be indigenous to their contexts, supported e.g. by articulated bones.

Assessing the probability and extent of contamination

In this section several variables and scenarios will be briefly considered that can be expected to influence taphonomic contamination. These effects can be positive or negative, i.e. they will foster or reduce the risk and degree of contamination and, mostly, they can be assessed in a qualitative or semi-quantitative way at best.

Quantifying deposits and assemblages

A point that has received amazingly little attention in depositional and taphonomic analysis is the relative find density of deposits, expressed as weight or number of fragments / artefacts / ecofacts per litre / m^3 of sediment. Apart from bioarchaeological studies, where macro- or microfossil densities are usually calculated on the basis of sample volumes (as examples: Kreuz 1990, 126–28; Bogaard 2011, 63), density calculations of archaeological finds are far less frequent.[7] This is probably due to the practical difficulties of assessing the volume of depositional units. While this task is straightforward when artificial spits in predefined excavation trenches are chosen (unit volume = excavation area * average thickness of artificial level), the assessment of unit volumes is far more sophisticated when applying the single unit excavation method. Such a volumetric approach requires constant and dense three-dimensional recording of feature and layer interfaces, which recently has been facilitated by 3D-recording methods such as laser scanning and *Structure-from-Motion.*

An example will illustrate the difference between the absolute frequency of finds and their volume-related density. The Neolithic double circular enclosure I of Quedlinburg was partly excavated between 2010 and 2016 (Schier 2012). The ditches were 1.4–1.8 m deep, had a V-shaped cross-section and were (in parts) excavated along their original feature interface. The backfill inside the ditches was removed in artificial spits of 10 cm and the exposed hollow of the original ditch segment was 3D-documented by *Structure-from-Motion* (**Fig. 6a**). This allowed us to calculate the volume of each 10 cm-level rather precisely. (**Fig. 6b**) shows the absolute weight of recovered pottery per level as a bar chart and the relative density (g per m^3) as poly-line. The weight decreases markedly from the top

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[7] In Monjukli Depe (Turkmenistan) locus volumes were recorded by counting the number of standardised buckets (Pollock and Bernbeck 2019, 37). Thus, context-specific find densities could be used both for analysing differences between contemporary households as well as for a diachronic comparison between the Neolithic and Aeneolithic layers (Schönicke 2019, 313–24). In the waterlogged settlement layers at Zurich-Opéra Niels Bleicher and Beatrice Ruckstuhl used z-transformed find frequencies per m^2 as a proxy for volume-based density values (Bleicher and Ruckstuhl 2015, 64–65).

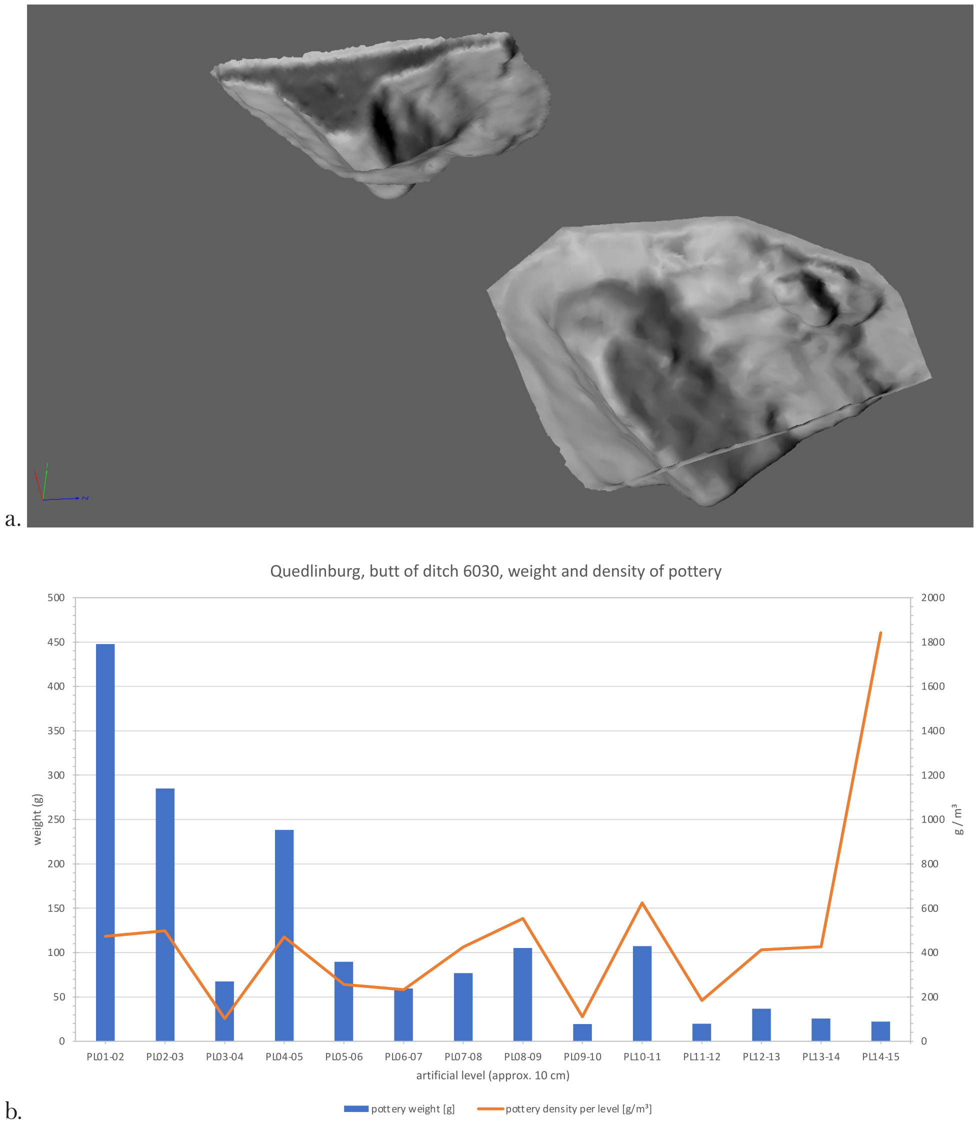


Fig. 6. a.) Quedlinburg I, Neolithic enclosure, causewayed north-western entrance, 3D view of ditches. The ditch in the background is feature no. 6030, the opposite no. 6031; 3D model: Jessica Meyer). b.) Vertical distribution of pottery weight (bars) and density across artificial levels of 10 cm; diagram: W. Schier.

to the bottom level. Since, however, the lower levels of a V-shaped ditch comprise only a fraction of the volume of the upper levels, the find density (line) does not decrease from top to bottom – after oscillating between 300 and 600 g/m³ it instead shows a maximum in the lowermost level which is about 4 times higher than in all other levels.

A first glance at this stratigraphic distribution of finds suggests in this case an increasing deposition of finds during the process of backfill sedimentation (or infilling), whereas the opposite is true when stratified pottery is related to backfill volume; we learn that in relation most sherds were deposited in the beginning of the backfill process, while the increasing amount of earth that made up the upper backfill contained fewer and fewer sherds per volume. In this example, most of the sherds seem to have been deposited just after abandonment of the ditch and there is no unambiguous evidence for residual pottery in the upper levels of backfill.

On a more general level, however, the example illustrates that find densities differing between layers by factor 5 or more would certainly affect the risk of taphonomic contamination considerably. Surely, assessing and comparing find densities in stratified layers will help to estimate the risk of taphonomic contamination especially for later activities that cut into these layers and relocate excavated material.

But we should also make mention of quantitative approaches that attempt to infer from the finds themselves whether or to which extent they might have been moved and redeposited. As early as 1989 Michael B. Schiffer and James M. Skibo systematized the traces of abrasion observable on pottery fragments (Schiffer and Skibo 1989), being a source of information about their use-life and mobility. In a much-cited article Charles A. Bollong used systematic refitting and classified assignment of sherds to vessel units in order to reconstruct formation processes of deposits (Bollong 1994). In their ground-breaking work on fragmentation, John Chapman and Bisserka Gaydarska discuss the approaches and results of various refitting studies (Chapman and Gaydarska 2007, 81–112).

In a recent study, André Spatzier developed a Sherd Size Index (SSI) in order to statistically analyse fragmentation processes and distribution patterns of fragmented pottery (Spatzier 2017). His main objective is to differentiate between accidental and deliberate fragmentation of pottery, but differences in mean sherd size can also be used to track redeposition processes and potential contamination of find assemblages.

Interpreting deposition and backfill processes

It has been pointed out that feature interfaces represent the main innovative element in Harris' concept of stratification. At the same time, they are the most problematic entities for reconciling depositional and assemblage stratigraphy, since in general they are not directly associated with objects. In practice, therefore, the formation of layers or positive features and the backfill processes of negative features preceding and succeeding feature interfaces attract much attention in stratigraphic analysis. Broadly speaking, four conceptual dichotomies structure many of these analyses and discussions:

- Firstly, archaeologists ask whether the sediments that make up a layer or the filling of a negative feature result from natural or anthropogenic processes.
- If they are considered anthropogenic, the second "frequently asked question" (FAQ) is whether the formation is an unintended result of human behaviour or an intentional act of construction, maintenance, repair, deposition or even ritual sealing.
- Thirdly, the relative (and absolute) timescale is relevant: was a negative feature filled back within one day or one generation? Did a "cultural layer" accumulate within one habitation period (of 1–2 generations) or did it take centuries?
- The fourth point refers to the distinction between single or repeated action(s) – an issue that was extensively discussed by Geoff Bailey in developing and differentiating his concept of palimpsests (Bailey 1981; 2007; 2008).

These FAQs have been tackled in various ways, some of which can be classified as methods of microarchaeology (Weiner 2010). Micromorphology based on thin sections of stratified sediments (Matthews et al. 1997; see also Karkanas and Efstratiou 2009; Pümpin et al. 2015; Lisá et al. 2015), the search for micro-debris (e.g. Dunnell and Stein 1989; Cereda and Romano 2018), archaeobotanical (macrofossils, pollen, phytoliths) and archaeozoological (molluscs) evidence or biomarkers in sediments (e.g. Zocatelli et al. 2017) help to understand anthropogenic formation processes and their time scales. Microarchaeological approaches have been applied in order to find answers in all four categories of questions, but the issue of intentionality in the archaeological record is a fundamental one, that has been and still is discussed in contexts within as well as beyond site formation and taphonomy. The discourse in British archaeology about “structured deposition” might serve as a good example in this context (Garrow 2012).

Latent factors of contamination

Several factors can be identified that potentially influence taphonomic contamination. Their effects can operate independently or interfere with the others, raising or reducing the overall risk of contamination.

The *provenance of sediments* which were used as construction material (mudbricks, pisé, wattle-and-daub, clay floors), as backfill material in order to close abandoned negative features or as substruction to prepare a new house site certainly plays a crucial role for taphonomic contamination. Geoarchaeological approaches to assess provenance are very limited if the source of raw construction material is very near or even on the site itself. Careful description of inclusions can be very helpful – if, for example, a substruction layer below a house floor contains small sherds with rounded edges, heavily fragmented animal bones and dispersed tiny pieces of charcoal, it seems likely that this material did not accumulate in situ, but was rather taken from a pre-existing midden or abandoned house somewhere nearby and was redeposited.

As mentioned above, excavators often dispose of context information that is not reflected in a Harris matrix. In many situations, deposits and/or features can be associated with *functionally related activities*, such as digging a posthole – inserting the post – refilling the posthole. Other “stratigraphic chains” might only partly be functionally related – or not at all, as in the following instance (**Fig. 7a**, **b**): 1) digging of a

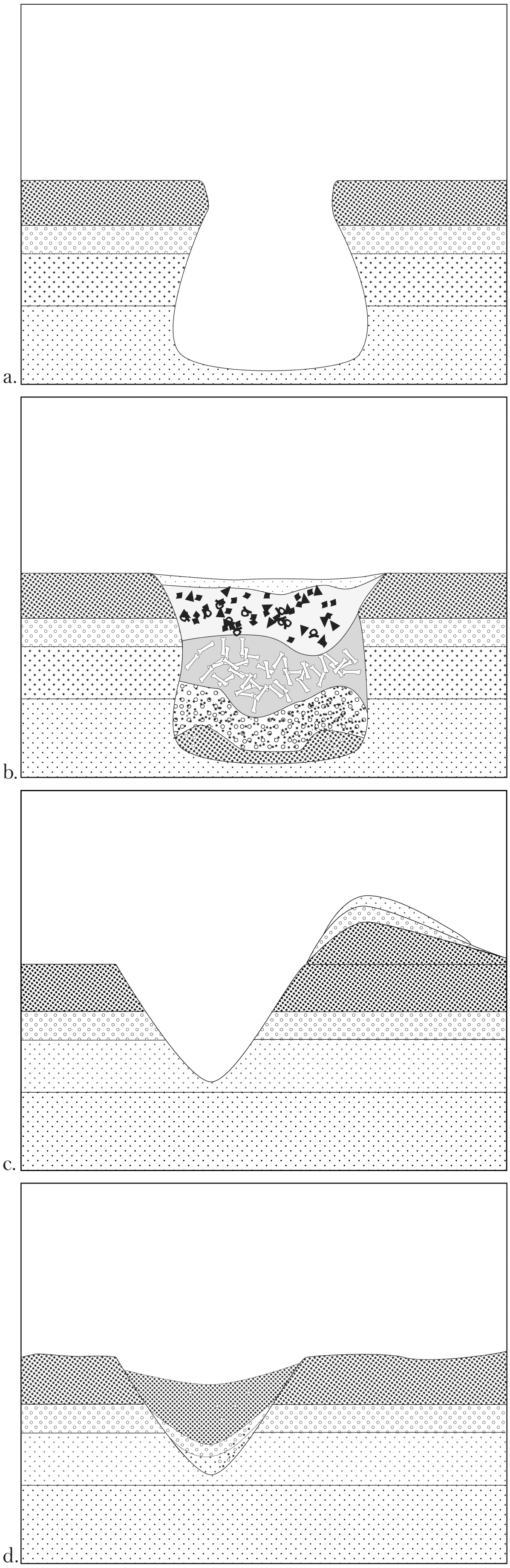


Fig. 7. Excavation (a.), partial collapse and different use (b.) of a storage pit. Of the functional stages described in the text, only 2) = use does not leave any traces in the stratigraphical section. – Excavation (c.) and backfill (d.) of a ditch. The removal and redeposition of earth from different layers containing finds of different age is indicated by grey shades. Drawing: J. Müller-Edzards, Institute of Prehistoric Archaeology, Free University Berlin.

storage pit, removal of the excavated material and redeposition elsewhere, 2) use time of several years, 3) abandonment and partial collapse of the upper walls of the pit, 4) change of function: discard of refuse from slaughtering /defleshing /tanning, and 5) rapid intentional backfill for hygienic reasons.

Such functional relations or their absence partly correlate with the timescale of use-life. Functionally related deposits/features tend to reflect rather short-term activities, whereas, with time, changes in function become more likely.

The temporary or permanent *redeposition of excavated material* from pits or ditches certainly means a crucial factor for taphonomic contamination. As described above, we can expect that foundation pits or ditches will generally be filled with the material that had been excavated shortly before. The surplus spoil, however, can contribute to taphonomic contamination on the surface around the construction activities. Features that have been created for a longer use-life, on the contrary, will usually not contain the spoil from their excavation in their backfill, since this material had to be removed and redeposited elsewhere during their function as a pit or ditch.

As has been shown, the time lag between excavation and backfilling of negative features and the question of what happens to the spoil in the meantime, are important latent factors for taphonomic contamination. In the literature concerning site formation processes, little attention has been given to the *depth* and *shape* of *negative features.* Pits or ditches that have been dug deeply into find-containing older layers obviously have a greater probability of bringing much older material to the surface.

Depending on the temporal dimension of this activity and the whereabouts of the spoil different scenarios emerge. With short-term activities (foundation), we can expect a mixed assemblage in the backfill of the deep pit/ditch that predates the activity itself in any way. If the spoil has been permanently deposited, for example as a rampart in line with an excavated ditch, a reversed sequence of assemblages might result inside the rampart (**Fig. 7c**, **d**). If the spoil is redeposited elsewhere, this will cause a chronologically mixed assemblage, spread out on top (!) of a younger surface.

It is interesting to consider the effect of different shapes of negative features. A deep ditch with V-shaped cross section cut into find-containing older layers will cause less taphonomic contamination than a ditch with the same or even smaller depth, but with a rectangular or trapezoidal cross section. The relative percentage of deeper layers affected by digging the ditch is much smaller in V-shaped than in rectangular or trapezoidal cross-sections. The same holds true for pits: the contamination potential of a bell-shaped storage pit cut into find-containing layers certainly is considerably larger than that of a deep cylindrical posthole.

Another example from the Uivar tell site illustrates the relation between depositional and assemblage stratigraphy when layer, positive and negative feature contents are differentiated.

In Uivar, Area I was the most representative in terms of depositional stratigraphy, 3.8 m of accumulated layers were able to be subdivided into 11 Neolithic settlement phases, followed by an Early Eneolithic phase as well as some Bronze age and mediaeval features. The last two campaigns, 2008–2009, revealed that the tell had started as a settlement of the Middle Neolithic Szakálhát Culture of Southeastern Hungary and only later adopted pottery of the Vinča Culture of the Central Balkan area, to which it had been attributed from the beginning of our research. This transition from (mainly) Szakálhát to dominating Vinča pottery occurred between the settlement stages 5, 4b and 4a.

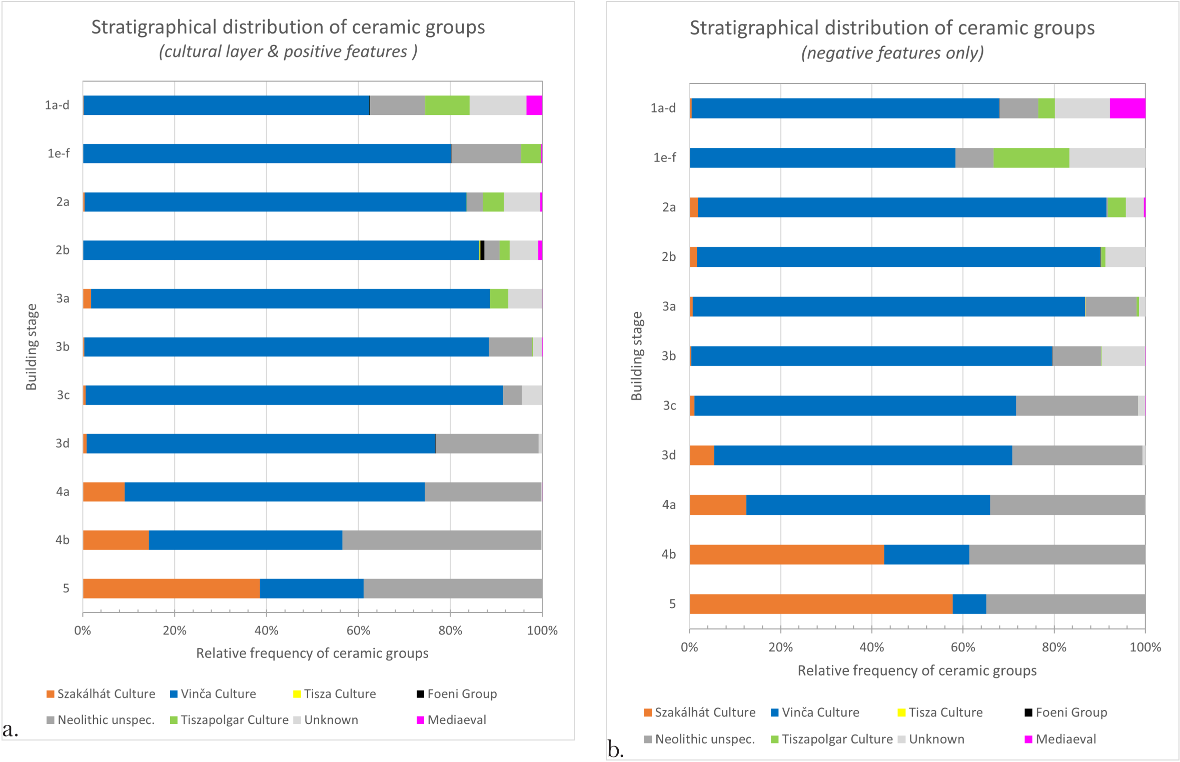


Fig. 8. a.) Uivar, Romania, Area I. Stratigraphical distribution of different ceramic groups from cultural layers and positive features (house inventories). b.) Stratigraphical distribution of different ceramic groups from negative features (foundation pits and trenches). In building stages 5, 4b and 4a their relative portions in the backfill of foundations corresponds rather to the subjacent cultural layer. Diagrams: W. Schier.

The following diagrams show the stratigraphic distribution of the cultural attributions for cultural layers and positive features (floors, house debris) as well as for negative features, comprising mainly foundation pits and ditches (**Fig. 8a–b**).

Szakálhát pottery accounts for almost 40% in the lowest cultural layer 5, but shrinks to 14% in layer 4b and 9% in layer 4a. The foundation features cut into layer 5 were assigned to layer 4b, according to the principles of depositional stratigraphy, and the respective foundation pits and ditches dug into the surface of layer 4b to layer 4a. The relative proportions of attributable pottery, however, strongly supports the assumption, that the backfill of 4b foundations dug into layer 5 contain about the same percentage of Szakálhát pottery (43%) as that layer in general (39%). The foundation backfills of layer 5, cut into sterile subsoil, contain even 58% of Szakálhát pottery and only 7% Vinča pottery.

This stratigraphic analysis (Menzler and Schier 2020), based on some 90,000 sherds, clearly illustrates what has been suggested on theoretical grounds: there is a time lag between the find content of layers and assigned negative features. In a depositional Harris matrix, the foundations of layer 4b (interfaces) would be arranged above the deposition of cultural layer 5 and their backfill would be placed above the feature interface. Comparing the find assemblages, however, the backfill of 4b foundations is almost indistinguishable from the stratigraphically older assemblage of layer 5.

Classification of contamination risk

As has been demonstrated, taphonomic contamination is a common phenomenon in stratified deposits. Obvious and latent factors influence contamination, most of which cannot directly be measured. Some effects, however, can be assessed in their contaminating potential on an ordinal scale (high – medium – low).

Unlike in the classical Harris matrix approach, it is advisable to make use of functional interpretations and use-life estimates when they are based on common-sense experience. Ignoring such contextual knowledge means reducing the chronological resolution of assemblage stratigraphy, since all units would be considered equally threatened by the risk of contamination.

Assessing different grades of contamination risk – or, inversely, different degrees of chronological resolution and reliability – will help to enhance the results of stratigraphic analysis in general. Taphonomic (or stratigraphic) contaminations may be visually detected when diagnostic finds and considerable vertical shifts are concerned. For bioarchaeological finds or radiocarbon samples, however, there is no way to recognise residual or infiltrated specimens.

In the case of the Uivar tell, a classification of depositional contexts according to their contamination risk was developed to facilitate the selection of samples, to aggregate bioarchaeological data and to support the diachronic analysis of pottery (**Tab. 3**).

Conclusion – expanding the Harris matrix concept

E. C. Harris' abstract and formalistic way of documenting and analysing depositional stratigraphies in the form of a matrix has been widely accepted and is still applied by many archaeologists worldwide. Despite this global acceptance, his approach has been criticised for several reasons, as described above. It takes into consideration neither the functionality and circumstances of deposit formation nor their effects on the formation of assemblages. Its lack of scalability makes large, multilinear sets of stratigraphic units hard to handle and comprehend visually.

But are these reasons sufficient to abandon the Harris approach, neglecting its undisputed advantages?

Instead, we advocate a conceptual extension of Harris' approach in order to include aspects of deposit and assemblage formation and to add scaling properties to the famous matrix. (**Fig. 1**) illustrates how sets of stratified units can be grouped graphically into larger depositional or architectural units.

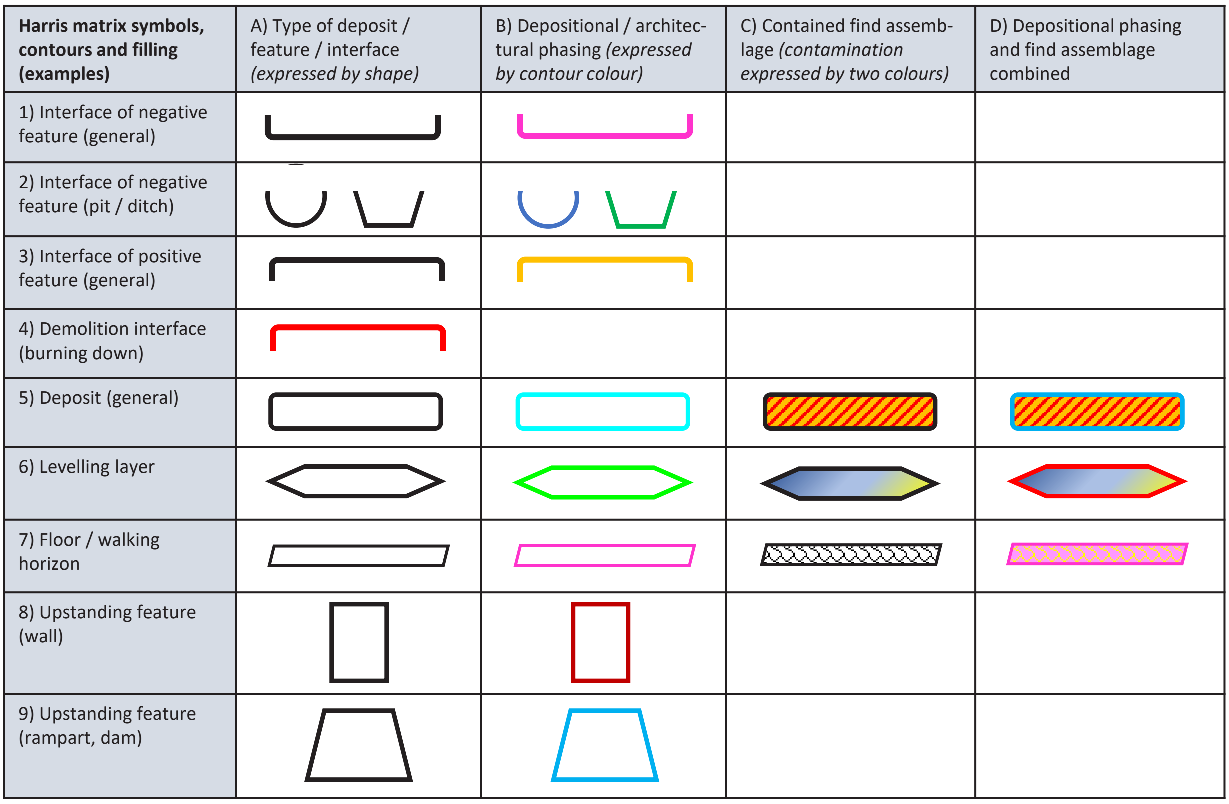
Class	**A**	**B**	**C**	**D**	**E**
Context (examples)	*in situ* finds on a house floor	House collapse, substructure layer, occupation horizon	General layer quadrant, pit fills, ditch fill	Foundation trench fill and deep post-pits	Secondary contexts (Neol. finds from med./ early mod. features
Chronological resolution	Very high	High	Medium	Low	–
Risk of chronological contamination	Very low	Low	Medium	High	Definitively contaminated

Tab. 3. Uivar, Romania. Classification of find contexts according to chronological resolution and potential risk of contamination.

The graphic elements of the original Harris matrix are quite simple – rectangular boxes, vertical and horizontal lines that bifurcate or reunite in order to indicate the relations between stratigraphic units. By widening the graphic spectrum, further levels of information can easily be integrated, as has been suggested and practised by various authors. Patricia Paice applied different geometric symbols to indicate the functional type of deposit and/or feature at Tell el-Mashkhuta in the Eastern Nile Delta (Paice 1991, 20, Fig. 3), Steve Roskams used rectangular and oval boxes in order to distinguish between contexts recorded in plan or in section (Roskams 2000, 86–89). In some publications, the Harris matrix boxes have been coloured differently to indicate specific kinds of formation of the deposit (cf. Becks and Blum 2014, 389).

We suggest a more systematic use of the graphic elements shape, contour colour / line style and colour filling. Generally, closed geometric forms (rectangles, squares, circle segments) could represent deposits, whereas open shapes could signify feature interfaces. Different contour colours of boxes (deposits) and open forms (interfaces) could serve to mark either their formation type (substruction, floor, levelling layer) or their affiliation to a higher stratigraphic unit (layer group, building stage/period) (**Fig. 9**).

Such modifications of the classical Harris matrix have been used to specify either the formation type of the deposit/feature or its affiliation to a higher-level chronological unit. Information about the composition of assemblages contained in stratigraphic units hitherto apparently has not been indicated in Harris matrices. Filling boxes in different colours might indicate in a visually straightforward way the "typological" content of the stratification unit – or, alternatively, its risk



Harris matrix symbols, contours and filling (examples)	A) Type of deposit / feature / interface *(expressed by shape)*	B) Depositional / architectural phasing *(expressed by contour colour)*	C) Contained find assemblage *(contamination expressed by two colours)*	D) Depositional phasing and find assemblage combined
1) Interface of negative feature (general)				
2) Interface of negative feature (pit / ditch)				
3) Interface of positive feature (general)				
4) Demolition interface (burning down)				
5) Deposit (general)				
6) Levelling layer				
7) Floor / walking horizon				
8) Upstanding feature (wall)				
9) Upstanding feature (rampart, dam)				

Fig. 9. Suggestions to expand the graphic spectrum of Harris matrices in order to represent the type of deposits / features (cells A1-A9), their phase assignment (B1-B9) and their find assemblage including taphonomic contaminations (cells C5, C6 and D5, D6). Cell C7 represents a floor containing redeposited sherds, in D7 these sherds belong to a different (older) layer. Diagram: W. Schier.

of containing contaminated find assemblages. Hatching in two different colours (foreground/background) might indicate assessed or suspected contamination and its magnitude (**Fig. 9**). Interfaces, which by definition cannot contain finds, as open geometric forms would remain without filling. Without abandoning the familiar concept of the Harris matrix its information content could be expanded by graphic means in order to specify deposit formation and assemblage composition.

A less straightforward task for future research will be, however, to also develop the methodological approach itself. A first step would be to include classified contamination risks, as described above, for each or for at least the most relevant units into modified Harris matrices. But further refinements appear achievable. Analogous to Bayesian calibration modelling of grouped radiocarbon dates, Bayesian statistics could be applied in estimating taphonomic contamination based on parameters such as find concentration, depth and shape of cutting feature, estimated flow of excavated material and so forth, all of which could be used as priors in a Bayesian model of formation processes.

We conclude with the conviction that forty years after the first publication of Edward C. Harris' analytical approach to stratigraphy and despite justified criticism, its methodological potential is by no means exhausted but could and should be developed further to include other aspects of deposit and assemblage formation.

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