CHAPTER 4

Analysis
of materials

INTRODUCTION

Alexandre Livingstone Smith[1]

Because it clarifies the reasons for much of the practice of fieldwork, it is good to know what can ultimately be learned through the analysis of artefacts. This chapter explains the work of an archaeologist after the excavations and focuses on the main categories of material culture analysis. The following contributions examine topics pertaining to sampling procedures, the cataloguing of finds and the analysis of lithic, pottery or metal artefacts.

Dominique Bosquet's contribution relates fieldwork practices to laboratory analysis. First, he considers sample types and sampling methods for archaeological artefacts. Here he separates disturbed contexts from *in situ* contexts. Advice is given on the way to pack artefacts in the field and the best way to store the material. As regards ecofacts, he explains what should be sampled and how. Emphasis is put on the need to properly record the excavations before sampling, and to properly locate the origin of the samples (see also Ozainne). Proper labelling is also crucial if one wants to relate the analytical results to their context of origin. Although, as usual, the type and quantity of samples depends on research questions and specialists' opinions, the author reviews general principles and provides simple and efficient procedures on how to sample.

Sylvain Ozainne summarizes a major component of the relationship between fieldwork and laboratory analysis: the cataloguing of finds. He stresses that one needs to design the cataloguing system before going in the field and, although field catalogues may vary according to the type site, he reviews a series of essential elements. The use of the catalogue in the field is considered next, with recommendations on its regular use and back-up, among other things. Catalogue use is also related to the later conservation of the material, and here the author considers museums and laboratories that may have specific requirements. Finally, he gives a series of tips on things to do and things to avoid with the last, clean version of the catalogue. Here he also considers the potential use of the catalogue as an analytical tool, as well as its conversion into a database.

Nicholas Taylor explains how the study of stone artefacts can shed light on the behaviour of past peoples and provides vital clues for identifying site formation processes. After a short note on the broad subdivisions of the Stone Age and Mode I to V classifications, he discusses the initial analytic steps of grouping lithic artefacts according to raw materials. He points to the importance of taking measurements, for both technological analysis and for assessing site integrity. The typological approach implies identifying common attributes of flaked and detached pieces, retouched and shaped tools, polished/ground items, and modified and unmodified pieces. It is based on the concept of *chaine opératoire,* or the sequence of stages from raw material procurement to tool exhaustion/discard. He briefly comments on the conditions and reasons for applying more specialist interpretative analyses (experimental stone tool production, refitting, residue and use-wear analysis).

Using the example of the Shum Laka rock shelter in Cameroon, **Els Cornelissen** describes, step by step, how to proceed with the analysis of a lithic assemblage. Starting with the definition of the unit of analysis which corresponds to the way lithic artefacts were recorded during excavation, a grid of analysis is created using a simple spreadsheet. She lists the characteristics that were taken into account when describing the typological and technological features of the various assemblages, which are organized according to raw materials. As an illustration, she gives two examples that address the issue of raw material choices through time.

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The present author and Cécile de Francquen develop an initial approach to the analysis of pottery. They consider the successive process from the field to the first steps of the analysis. Recommendations for the field are short and emphasise the proper labelling of the material. Laboratory work involves referencing, refitting, description and then analysis. For each step, simple procedures are suggested. These procedures are by no means universal, but they provide a researcher with a straightforward way to deal with an significant amount of pottery. Finally, the authors consider further analysis, hinting at approaches that may lead to the reconstruction of pottery manufacturing processes.

Tom Huffman takes pottery analysis a step further, considering the definition of ceramic styles. Here he separates two main types of interpretation: one aimed at the characterisation of group identity, and one aimed at the development of a culture history sequence. As regards the first, the author starts by outlining the general procedure and proceeds with the notion of stratigraphic distribution. As regards the second, he examines how two build a chrono-cultural sequence and how to approach questions of continuity and discontinuity, as well as questions of boundaries and interaction. Although, there is no room for a detailed contribution, he provides a simple and efficient way to express complex pottery assemblages.

David Killick outlines what can be done with iron artefacts. After a brief reminder of what one can expect to find during the excavations (see also Robion-Brunner & Serneels, this volume, pp. 129-133), he focuses on post-excavation treatment. In this, he first outlines questions pertaining to conservation, summarising the mechanisms of corrosion and the best ways to prevent or delay it. He considers the potential of metallographic and chemical analysis, summarising the techniques to be used and the type of information they can yield on materials used and artefact production methods. The author then explains why the provenance of iron can very rarely be determined. Finally, he notes the possibility of dating iron objects directly.

Laurence Garenne-Marot gives an overview of copper use in sub-Saharan Africa. The characteristics of the material are considered first, and compared to iron. She considers the characterisation of productions techniques for copper artefacts, through compositional and metallographic analysis. The potential of these analyses is outlined and two practical examples are explained. She also appraises the relative weight of cultural and technical choices, and finally considers the limits of technical analysis of copper-based objects.

Nicolas Nikis takes the analysis of archaeological copper-based objects one step further, with a case study on copper ingots from central Africa. He explains how one needs to catalogue, describe and analyse the finds. He reviews the history of copper ingots, using their typology and geographic distribution through use of a free GIS program. He suggests possible avenues of interpretation of geographic patterns of distribution, showing how one can move from the analysis of the artefacts to a more holistic view of this type of object, and to the wider social and economic context.

FROM THE FIELD TO THE LAB

Dominique Bosquet[1]

INTRODUCTION: THE BASIC PRINCIPLES OF INTER-DISCIPLINARY ARCHAEOLOGY

This chapter is devoted to the principles and methods of sampling in the field: artefacts (pottery, lithics, glass, worked bone, etc.) and samples for specialists in archaeology's partner sciences: anthropology, archaeobotany, archaeozoology, geology, pedology, etc.

It is important to organize digs in detail. Choices made in the field will have repercussions on laboratory analysis and thus on subsequent results. Whatever the type of archaeological work – preventive, rescue, or scheduled – we can never investigate, acquire, and store everything. Scientifically, it is much more interesting and productive to focus a dig on the matter under investigation. Digging calls for permanent choices, depending not only on scientific questions (which, incidentally, often change during the search), but also logistical requirements that make up a crucial link in the archaeological chain of operations: human, financial, and material resources frame the field of operation and processing of laboratory data. For example, if you do not have the means to store 100 pollen samples under suitable conditions, you will need to make your search more specific. Samples are taken from one structure because it occupies an interesting position in relation to other structures on the site, because the fill mode suggests that pollen rain was trapped there, because its depth means it is likely unaffected by recent disturbances, etc. This will avoid having unproductive or contaminated samples unnecessarily cluttering up your reserves because they probably would never be studied. Acquisition shouldn't be made on the basis of 'We'll see what comes of it'.

On the other hand, as excavation destroys all or part of a site, the samples taken should be sufficient in quantity and representative of the different structures that make up the site. Indeed, some samples are used by several specialists and some analyses are repeated, requiring additional sampling. This second sampling is not possible in the event that too little material was taken. One should also remember that, since results are often analysed statistically, if the amount of material is greatly reduced by treatment (screening, extraction, etc.), the very validity of the results is open to question.

A fundamental principle follows from the above: to sample correctly, you must be familiar with the disciplines for which your samples are destined because, more often than not, the experts involved will not accompany you to the field. Therefore, before you even start a project, meet them in order to learn what questions they might eventually be able to answer and what their requirements are for sampling. The types of materials studied, sampling and spatial-registration methods, required quantity, storage conditions, sieving patterns, any special precautions, are all parameters that you will need to control to improve the chances of getting quality results and avoid unnecessary sampling.

It may seem an enormous amount of knowledge to acquire, but modern archaeology cannot function without these disciplines. Frequently complementary, they offer extremely rich and varied methods of interpretation that are often decisive when it comes to understanding your site.

I. IN THE FIELD: SAMPLE TYPES AND SAMPLING METHODS

A. Archaeological material

Two scenarios are most often encountered in the field: either archaeological material comes from detrital contexts into which it was cast loose, forming a mixture of all kinds of daily waste, or the equipment is found in place (or *in situ*)* in domestic contexts (habitation deposits, foundations, buried basements, homes ...), or those related to funerals or worship.

1. Detritic contexts

In detritic contexts – pits or ditches – archaeological material will be collected gradually throughout the search and classified into categories (ceramic, stone, iron, bone, etc.) that will be packed separately. These materials will be put without cleaning[2] into plastic bags[3] in quantities

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[2] Objects should never be cleaned in the field, to avoid the risk of destroying organic residues and other micro-elements (phytoliths, grains, etc.) present on many archaeological objects and rich in a variety of information.

[3] If no other material is available, paper bags can be used.

appropriate to their state of preservation: fragile objects must be packed separately, possibly wrapped in paper or plastic to protect them from shocks. Inside each bag (not stapled to the outside of the bag) should be placed a paper label (itself wrapped in plastic) with the following information written in ballpoint pen or pencil (not permanent marker): site name, date, sector number, structure number, letter or square number in which the material was found, stratigraphic unit and/or depth of discovery and any observations. Avoid writing directly on the bag: this fades too easily, resulting in permanent loss of contextual information. The bags should then be placed next to (not on top of) one another in wooden, plastic, or cardboard crates on which will be noted the type of material present and its references, to facilitate the post-excavation treatment. This will avoid having to unpack all the boxes to find the materials needed to establish, for example, a preliminary chronology of the site.

2. Domestic, funerary, and religious contexts preserved **in situ**

In this type of context, be it a tomb, a habitation deposit, or a religious deposit, the material must, at first, be dealt with in place before any sampling. Before dismantling, the relationship of each object to its neighbours should be recorded in detail and in three dimensions in order to recreate the deposit taphonomy,* the *sine qua non* of a precise interpretation of the archaeological fact. Once this is done, we can dismantle all the objects that have been recorded and package them in accordance with the principles set out in the previous chapter and, if necessary, continue the dig using the same method, removing the layers one after another until everything has been removed.

B. Samples intended for use in the natural sciences

Taking samples for natural scientists occurs during excavation of structures that have been completely recorded as maps and sections using drawings and/or photographs. First of all, because the sample destroys part of the remains from which it is taken, and thus a part of the archaeological information (**fig. 6**), and also because it has to be perfectly located in space, both in terms of the map and the stratigraphy. If you do not map your structures and stratigraphy is not carefully assigned, there is no point in taking samples, because no correct link can be made in the laboratory between the bag and the structure and layer from which it comes. A bag or a box that does not contain the name of the site, structure number, excavation square number, and identification of the layer from which the sample was taken (or, failing that, the depth at which it was taken) will be refused by the specialist to whom it is sent! Also, a drawing and/or photo must **always** illustrate this information (see below, 'How to sample'), with a comment in the notes that justifies and explains the sample. Finally, an up-to-date list of all samples is kept in the excavation records. They are numbered **consecutively** over the whole of the dig, from 1 to x. For example, samples 1-8 were taken in pit 12, layers x, y, and z, and samples 9 to 24 in pit 21, layer w. This way, if you forget to write down the pit number on a label or a bag, you have one more chance to find the information in the samples list. If, however, we start at zero in each pit, you will end up with several samples numbered 1, several samples numbered 2, etc., from the same site, which dangerously increases the risk of confusion. This system can be used on a year-to-year planned excavation, so as not to confuse No. 1 from 2014 with No. 1 from 2013 if the year is not mentioned on the bag. These principles also apply to artefacts, and while they may seem trivial, small distractions are inevitable, and there is always a moment when you forget to indicate information on a label or a bag. It is therefore essential to provide the means to find it in another way.

Now we have to answer the following questions:

1. What should be sampled?

Insofar as the analysis of bioremains* contained in your sample is supposed to answer a series of environmental, cultural, and historical questions you have about your site, it is essential that the sampling done on the ground be statistically representative of remains present on the study site. In other words, if you only sample what you can see, average and large remains (2 mm to several cm, called macroremains) will be over-represented, while very small and microscopic remains will be systematically absent from your material. That is why the sediment forming the walls of archaeological excavations will be taken for laboratory analysis: they potentially contain all the site's bioremains. Picking the 'best bits' by eye is not forbidden, but, again, the study of these fragments alone will not reliably deal with issues related to the paleoenvironment and how it was used by man.

Moreover, as it is not possible – or even relevant – to sample everything systematically, we must then ask another question:

2. Where should sampling be done and in what quantities?

Samples are taken preferably from the areas and/or layers in which bioremains are known or believed to be significant and/or about which there are questions that could be at least partially answered through paleoenvironmental study. These are usually detritic layers of dark colour, but not always. In this context, we can never emphasise enough that regular contact with the specialists for whom this material is intended is desirable because they will be the ones to develop a coherent and balanced sampling policy with you throughout the excavation.

The sample amount can vary depending on the context (pit, tomb, ditch, etc.) and the known or supposed wealth of bioremains, itself influenced by the chemical and physical characteristics of the substrate. We can nevertheless give sampling quantities that are valid in most cases, conventionally expressed in litres of sediment, as around 20 litres for macroremains and 0.2 litres for microscopic remains. These quantities may sometimes correspond to significant portions of the sample layer or area. As such, they cannot always be attained when the layer is not plentiful, which should, however, not prevent sampling: interesting results can sometimes be obtained on a small amount of sediment.

3. How should samples be taken?

Depending on the excavation technique, the morphology of the layer or unit to be sampled, and the analysis/es to which the samples will be subjected, samples should be taken loose or as a block, flat or as a cross-section.

a) Loose samples

These samples are made using plastic bags, and mainly concern macroremains. They may be taken flat, while excavating, where concentrations are encountered (**fig. 1a**), or as a cross-section, once one or several squares have been emptied (**fig. 1b**). The samples are then taken from preserved squares (**fig. 1c**). The latter method allows greater control of the stratigraphic location of sampling and is preferable to samples taken flat during excavation, although the two methods can be practiced together in order, for example, to achieve the right amount of samples for a thin layer. In loose samples taken from several layers within a single structure, it is imperative to avoid mixing, within a single sample, the content of different layers: each layer should be a separate sample (**fig. 1b**). To do this, try to take the central part of the layers without touching the interface between layers as much as possible – which is not always easy when the layers are thin.

b) Block samples

These samples are most often cross-sections and are primarily intended for the analysis of microscopic remains. They may be made with the help of a can or metal bracket (such as those used on construction sites) or, if the sediment is sufficiently compact and coherent (clay rather than sand), as blocks which are directly cut in sediment and subsequently packaged in plastic wrap (like cling film used for food). The procedure is as follows:

Step 1: clean the cross section from top to bottom,[4] removing at least 2 to 3 cm to eliminate pollution (pollen in the atmosphere, on tools, hands...);

Step 2: Avoiding bioturbations, desiccation cracks, and other recent sources of pollution, **determine the locations** of your samples and explain in the field book why you will take samples from this layer. Draw the blocks to be sampled and their numbers directly onto the profile using a knife or trowel (you can also number them with plastic letters; **figs. 2a, b and c**).

If you use cans (with lid) or brackets (without), drive them directly into the desired location with a mallet if the sediment is very soft, or, to facilitate penetration, cut the sediment around the box/angle with a thin knife.

Important note: samples from the bottom of a structure must always extended at least 5 cm into the natural substrate* from which this structure was excavated (**fig. 3**);

Step 3: **Orient** the blocks by cutting a small arrow indicating the top of the block into the upper left corner (**fig. 4a**);

Mark the can/angle: With a permanent marker, record the site, the numbers of the placement, cut, and sample, on the top and bottom of the can/ bracket and possibly the boundaries and SU (stratigraphic unit) numbers of the main layers (**fig. 4b**);

Step 4: photograph the entire sampling area (**fig. 5a**), and each block separately (**fig. 5b**) and **draw** your samples on your drawing of the section.

Step 5: **extract** the block by first cutting around the edge of the sediment (**fig. 6a**) and, once the proper depth is reached (at least 6 to 7 cm) cut along the back of the block to remove it. Holding the block in your hand, flatten the back with a knife.

To extract the can/bracket, first loosen the sides (**fig. 6b**) and then cut the settlement at the back of the

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[4] If you clean from bottom to top, sediment will fall back onto the part that has just been cleaned, and this is of course to be avoided.

Fig. 1. Carbonaceous layer before flat sampling (a), loose sampling of a debris layer in a pit (b), carbonaceous layer preserved in the unexcavated squares B and D of a pit (b). (Photos © D. Bosquet.)

Fig. 2. Samples are drawn and numbered on the cross section (a, b) or map during excavations, here on a layer of decomposed wood (b). (Photos © D. Bosquet.)

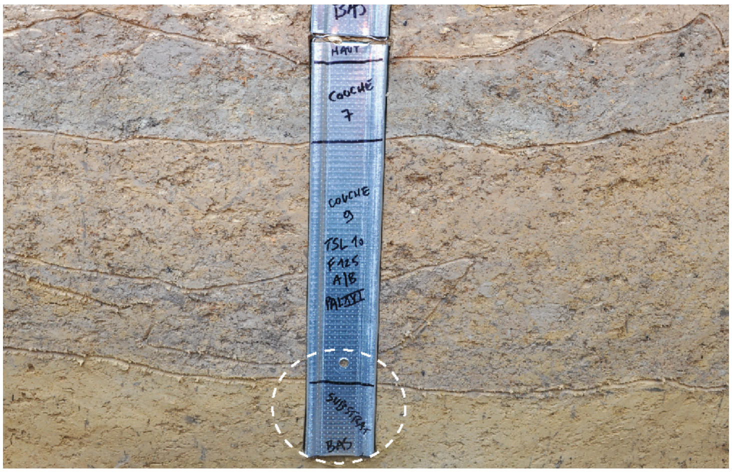


Fig. 3. Sampling from the bottom of a pit; the box should extend into the natural substrate. (Photos © D. Bosquet.)

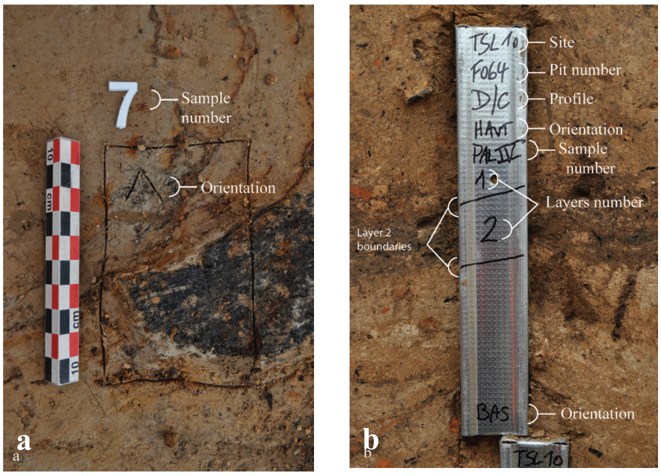


Fig. 4. The block is oriented using an arrow, engraved here in the upper left corner (a), while the background information, sample number, and orientation are all listed on the box (b). (Photos © D. Bosquet.)

can in order to remove the cut, then cut away the excess sediment so the cover can be put in place;

Step 6: **wrap** the block in 4-5 layers of plastic wrap, and then mark the site, the numbers of the placement, cut, and sample directly on the plastic, and then wrap in 4 or 5 additional layers and annotate again with the same information on a different side of the block (**fig. 7a**). After placing the lid of the box, secure the whole with adhesive tape or a layer of plastic wrap (**fig. 7b**). If there is no cover (bracket), wrap tightly in plastic wrap;

Step 7: **store** your samples in a refrigerator or, failing that, somewhere cool and not too dry, if possible.

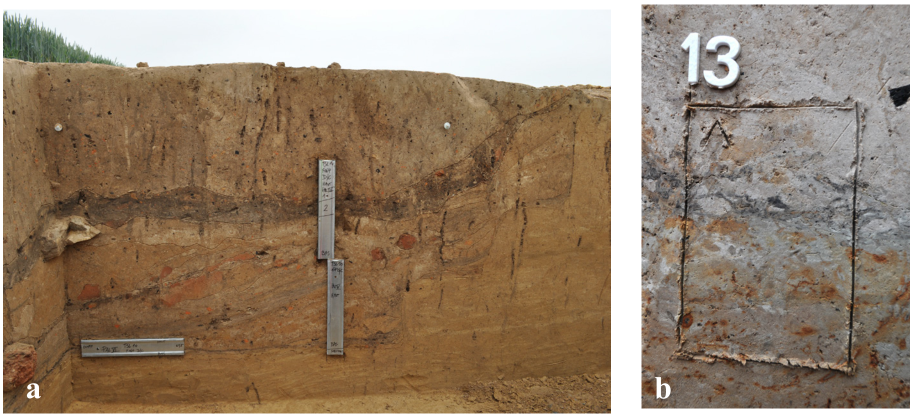


Fig. 5. Photograph of a group of samples (a) and detail of an oriented and numbered block (b). (Photos © D. Bosquet.)

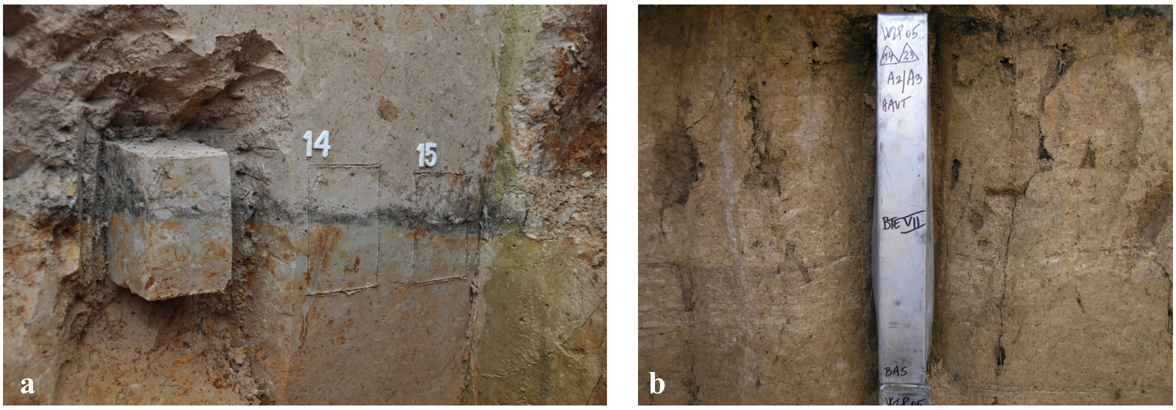
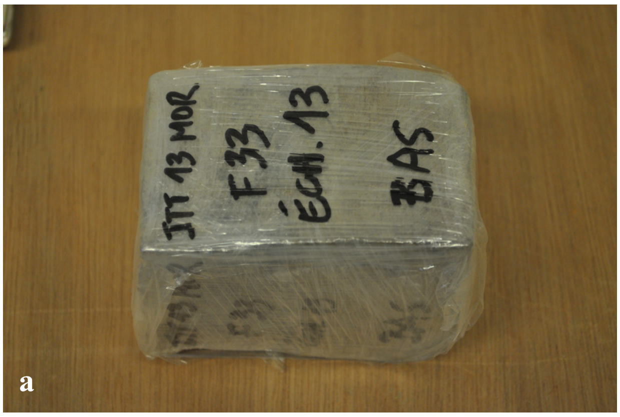


Fig. 6. Clearing a block cross-section (a) and one obtained using a can (b). (Photos © D. Bosquet.)



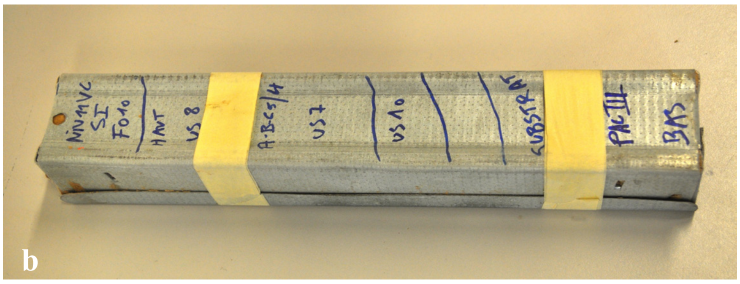


Fig. 7. Samples in blocks (a) and cans (b) ready for storage. (Photos © D. Bosquet.)

GLOSSARY

Taphonomy: history (often complex) of disturbances, alterations, and natural (burrowing animals, roots, erosion, etc.) or human (handling, sorting, looting, etc.) movements that an archaeological site suffered between its establishment several centuries ago, and the time of its discovery by archaeologists.

In place or *in situ*: refers to remains undisturbed since their burial in the ground, of which the location is believed to be close to its original placement.

Bioremains: all remains of biological origin, organic or otherwise, contained in an archaeological site: charcoal, fruits, seeds, pollen, phytoliths, starch grains, bones, etc. These remains may be macroscopic (visible to the naked eye or by using binocular magnifiers) or microscopic (visible under a microscope at high magnification).

Substrate: natural sediment or geological layer which contain archaeological items (or structures) that make up an archaeological site. Substrates may be sandy, clay, calcareous, etc.

CATALOGUING FINDS

Sylvain Ozainne[1]

INTRODUCTION

The catalogue recording objects collected during excavations, surveys, or studies is an important tool. It establishes an interface between several major stages of archaeological research: fieldwork, and analysis and preservation of material. Its main role is to provide a permanent link between the collected items and the context of discovery, without which archaeological objects irretrievably lose their scientific value. The catalogue should be above all simple but effective, and allow the researcher to find contextual information easily for each piece discovered. The number and nature of the different headings may of course vary depending on the nature of the dig. The continued existence of these data is crucial not only for post-excavation analysis but also for the conservation of objects, which in some cases may have to stay in a drawer in a laboratory or museum for many years before being studied by researchers other than those who carried out the excavations.

I. DESIGN AND PREPARATION

The catalogue should ideally be designed before any fieldwork by all the researchers involved, whether in field research or post-excavation studies. It is important to design it in a spirit of collaboration between field researchers and specialists, especially if the latter do not participate in digs.

Specifically, it is also advisable to select a marking system for archaeological pieces when designing the catalogue format. The marking system can thus be employed in cataloguing, whether physically or digitally. If the catalogue is accurate, but the code marking pieces or bags is not explicit, there is a risk that information will be lost.

The list of topics to examine in the field (using a dig log or a site/sector/survey/m^2/etc. sheet) for inclusion in the final catalogue should be discussed by researchers taking part in the search, especially for essential background information: stripping, altitude, spatial coordinates, provisional stratigraphic ascription (stratigraphic unit and/or layer), provisional general cultural attribution, etc. (**figs. 1** and **2**).

The different sections of a field catalogue can of course vary depending on the type of research undertaken, but many essential items should be included systematically, such as: card number or catalogue page, complete date, name of the researcher (the person who completes the sheet), name or site number, GPS coordinates (**figs. 1** and **2**). The form/page number and the site name and number help manage and control the information collected and facilitate the preparation of a database post-excavation (see below). The date and the name of the person completing the form will make it easier to understand and correct any errors found after the excavation or survey. If the archaeologist does not have a GPS device or an accurate map, he must collect enough information (approximate location relative to the village and/or the closest geographical feature; possibly a sketch of the terrain) so that site coordinates can be found following fieldwork. Back in the lab, this will allow him to relocate the site using an official map or an online resource such as Google Earth.

II. FIELD CATALOGUE

In the field, the catalogue should be filled in if possible as the work progresses (**fig. 2**). It is unwise to wait until the end of operations. Indeed, there is a significant risk of loss of information between the time of the fieldwork and laboratory analysis. Although the final version of the catalogue is established after excavation and possible correction, it is important to record information concerning pieces as soon as possible in the field. It is not always possible to prepare a catalogue in the field, for example during surveys or small studies with limited teams in hard-to-reach areas, during which researchers will not necessarily have the time to make a catalogue as the work progresses. In this case, it is crucial that the material collected, even summarily classified in the field, be associated with specific contextual information (survey or site sheet; **fig. 1**) that will allow the catalogue to be generated as soon as possible.

A field catalogue should be easy to use. Ideally, this should be done initially on paper (a binder with good quality paper: wind and/or humidity can easily degrade pages) or a notebook of the best possible quality. It is also crucial to keep this first paper version safe; it will

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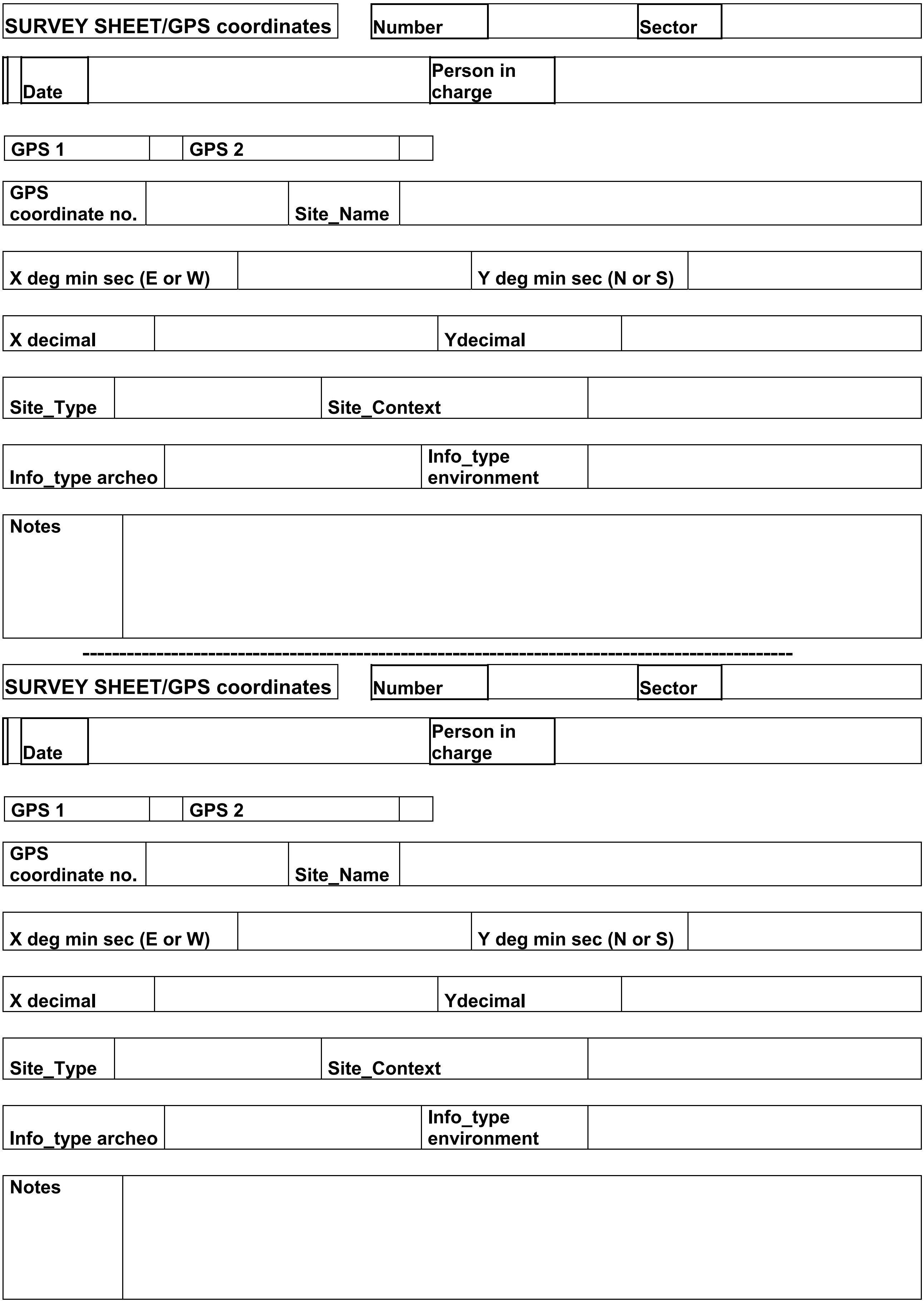
[1] Laboratoire Archéologie et Peuplement de l'Afrique (APA), département de Génétique et évolution de l'Université de Genève (GENEV), unité d'Anthropologie, Switzerland.



SURVEY SHEET/GPS coordinates	**Number**		**Sector**	
Date		**Person in charge**		
GPS 1		**GPS 2**		
GPS coordinate no.		**Site_Name**		
X deg min sec (E or W)		**Y deg min sec (N or S)**		
X decimal		**Ydecimal**		
Site_Type		**Site_Context**		
Info_type archeo		**Info_type environment**		
Notes				

SURVEY SHEET/GPS coordinates	**Number**		**Sector**	
Date		**Person in charge**		
GPS 1		**GPS 2**		
GPS coordinate no.		**Site_Name**		
X deg min sec (E or W)		**Y deg min sec (N or S)**		
X decimal		**Ydecimal**		
Site_Type		**Site_Context**		
Info_type archeo		**Info_type environment**		
Notes				

Fig. 1. Example of a survey record, documenting the contextual information that will be associated with archaeological finds in the final catalogue. This type of document is easily prepared using a word-processing program, although it is recommended that they be created directly in a spread sheet (MS Excel is a widely used application) that will also be used for digital data entry.

Site name/year: Kéli Sogou 2006						**Sheet N° 15**		
Date:02.05.2006			Researchers: Bemba, David					
Sector	**Stripping**	**N°**	**M2**	**Material**	**X**	**Y**	**Z**	**Notes**
7	**2**	**1**	AO121	Sherd			3,09	
7	**4**	**1**	AO120	Sherd			2,86	
7	**4**	**2**	AO120	Sherd			2,86	
7	**4**	**3**	AO120	Sherd			2,85	
7	**4**	**4**	AO120	Sherd			2,85	
7	**4**	**5**	AO120	Sherd			2,86	
7	**4**	**6**	AO120	Sherd			2,85	
7	**4**	**7**	AO120	Sherd			2,83	
7	**4**	**8**	AO120	Sherd			2,84	
7	**4**	**9**	AO120	Sherd			2,84	
7	**4**	**10**	AO120	Sherd			2,84	
7	**4**	**11**	AO120	Sherd			2,85	
7	**4**	**12**	AO120	Sherd			2,87	
7	**4**	**13**	AO120	Sherd			2,86	
7	**4**	**14**	AO120	Sherd			2,86	
7	**4**	**15**	AO120	Sherd			2,87	
7	**4**	**16**	AO120	Sherd			2,86	
7	**4**	**17**	AO121	Sherd	175	160	2,83	Noted on map n° 3
7	**5**	**1**	AO120	Sherd	138	43	2,82	Noted on map n° 4
7	**5**	**2**	AO120	Sherd	106	34	2,82	Noted on map n° 4
7	**6**	**1**	AN120	Sherd			2,59	
7	**6**	**2**	AN120	Sherd			2,57	
7	**6**	**3**	AN120	Sherd			2,58	
7	**6**	**4**	AO120	Sherd			2,59	
7	**6**	**5**	AO120	Sherd			2,60	
7	**6**	**6**	AO120	Sherd			2,60	
7	**6**	**7**	AN121	Sherd			2,61	
7	**6**	**8**	AN121	Sherd			2,69	
7	**6**	**9**	AN121	Sherd			2,60	
7	**6**	**10**	AN121	Sherd			2,61	
7	**6**	**11**	AO121	Sherd			2,61	
7	**6**	**12**	AO121	Sherd			2,62	
7	**6**	**13**	AO121	Sherd			2,63	
7	**6**	**14**	AO121	Sherd			2,65	
7	**6**	**15**	AO121	Sherd			2,63	
7	**7**	**3**	AO120	Sherd			2,52	
7	**7**	**4**	AO120	Sherd			2,54	
7	**7**	**5**	AN121	Sherd			2,49	
7	**7**	**6**	AN121	Sherd			2,56	
7	**7**	**7**	AN121	Sherd			2,54	
7	**7**	**8**	AN121	Sherd			2,57	
7	**7**	**9**	AN121	Sherd			2,55	
7	**7**	**11**	AN121	Sherd			2,58	

Fig. 2. Example of a field catalogue, used during a survey of the Kéli Sogou site (Mali). This is a clean version of an identical sheet filled in by hand in the field.

help to understand and correct errors that might occur, for example, during conversion to digital. It is also simply the primary version of input, and a necessary physical supplementary archive to the digital format.

The use of paper is often essential during surveys or ex-extensive fieldwork programmes, as it is suitable for very mobile researchers with little logistical support. In this context, logistics are often reduced to the bare minimum, and researchers obviously will not have access to digital resources. Even during excavations, it is not always possible to have a computer in the field, for logistical and/or financial reasons (cost and fragility, access to electricity). On long digs, it is recommended that a digital version of the catalogue be made in the field, or as near to it as possible.

Ideally, the paper catalogue comes from a digital document (a printout of an MS Word or Excel file, for example). The advantage is that it will use exact the structure and fields defined by the research team before excavation and thereby facilitate future data entry (**fig. 2**). If the catalogue is to be made by hand directly in a notebook, it is suggested that this be prepared before starting the work.

The key is to have a systematic catalogue completed according to the techniques and topics chosen prior to the search, whether on paper or directly in electronic format. It is possible to correct or delete some items if the catalogue is complex and it becomes clear during excavation that some fields are unnecessary. In this case, all the researchers in the field must be involved in the decision, and the information must be transmitted to all stakeholders. Ideally, especially if some experts who participated in developing the catalogue are not present in the field, it is best to avoid significant changes to the catalogue during excavations.

III. THE CATALOGUE AND CONSERVATION OF MATERIALS

If the institution through which the research was conducted (laboratory, museum) has its own cataloguing system for the conservation of materials, archaeologists can of course develop their catalogue based on this system. Again, good collaboration between the different actors involved in fieldwork and the analysis and storage of materials is essential.

If the catalogue is developed entirely by archaeologists, a final version may be reprinted back in the lab, possibly corrected or improved for readability if flaws are found during the dig. It is important to maintain identical field-entry orders and topic names when making updates, whether this is done regularly in the field or afterwards in the laboratory.

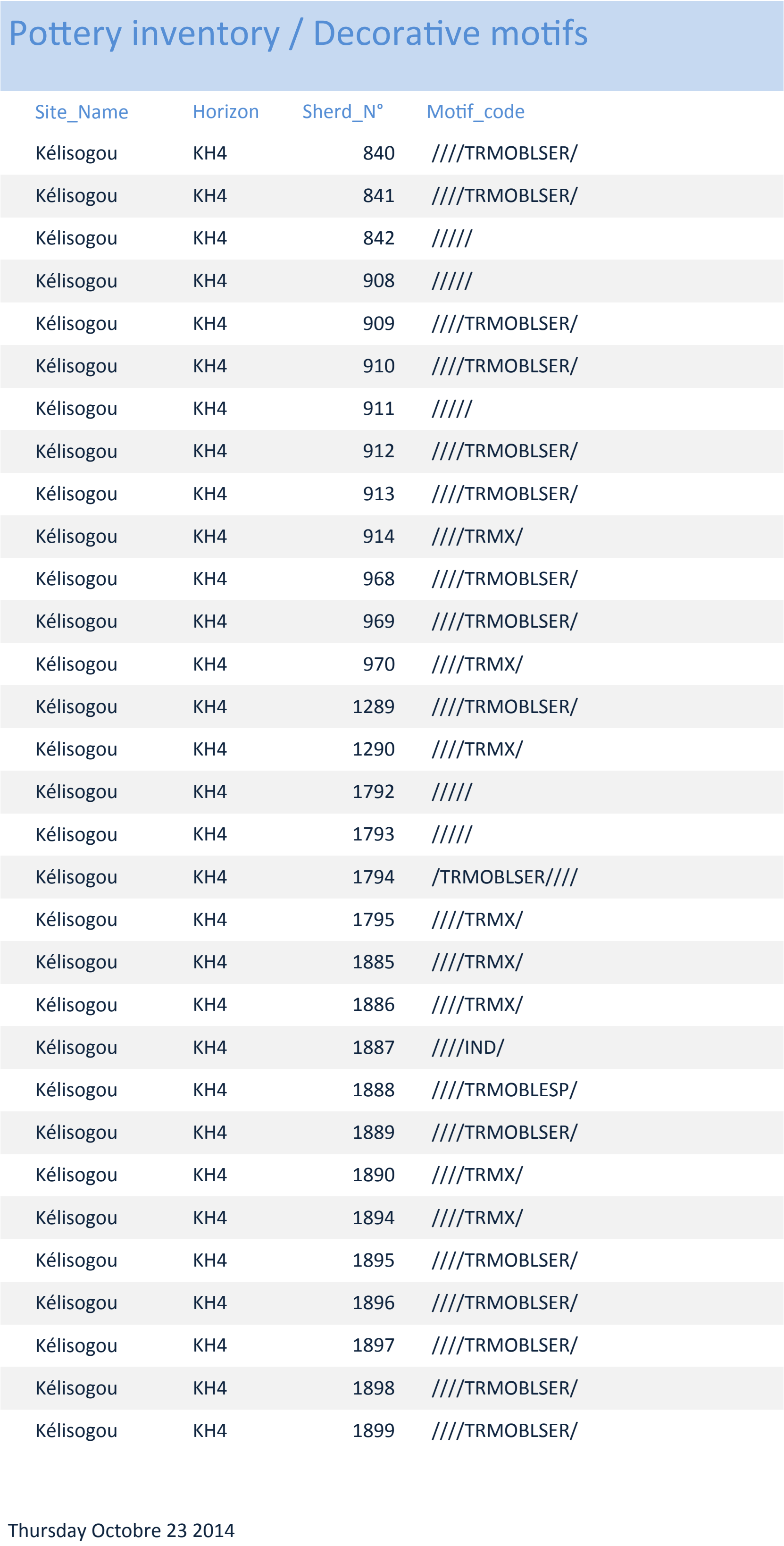
The definitive version of the basic catalogue for conservation must be kept in physical format (printed) and in the form of several computer backups, one ideally on a server in the lab. The sustainability of physical and digital versions should be ensured (for computers, make backups and manage format changes, saving in a new application format if required, etc.).

It is very important that a copy of the catalogue be printed and kept physically associated with the material. This version, in workbook form or as sheets in a folder carefully arranged in a cardboard or plastic container or a sturdy envelope, will accompany the box or carton containing material when deposited in a laboratory or museum. This crucial baseline information should always remain with the material. This is a security measure and important safeguard in case the museum or institute that houses the equipment relocates. This also offers security in the event of disaster, theft, or any other event which may result in the loss of computer files or folders from a laboratory or a museum.

In any case, it is necessary to communicate well with everyone involved and inform everyone who will be responsible for the conservation of the material, be it the staff of a laboratory or a museum, of your approach. Keep in mind that in some cases the material brought back from excavations may be studied only several years later, and by people who did not participate in the excavations. These researchers will need access to contextual information about the objects, otherwise any scientific study will be impossible.

IV. THE FINAL CATALOGUE AND ANALYSIS OF THE MATERIAL

When the material is first analysed, certain pieces may need to be removed from the catalogue, for example if it turns out that an object registered during the excavation as a potsherd is actually a lithic fragment without any archaeological value. In this case, it is important to cross out the entire entry in the notebook and/or delete the record (database) and/or the line in a computer file. All related information is suppressed. The object number is deleted and no longer used, otherwise there can be serious problems later. It is better to have a list with non-consecutive numbers rather than trying at all costs to have a clean list with consecutive numbers and risk creating serious errors during the renumbering.



Pottery inventory / Decorative motifs

Site_Name	Horizon	Sherd_N°	Motif_code
Kélisogou	KH4	840	////TRMOBLSER/
Kélisogou	KH4	841	////TRMOBLSER/
Kélisogou	KH4	842	/////
Kélisogou	KH4	908	/////
Kélisogou	KH4	909	////TRMOBLSER/
Kélisogou	KH4	910	////TRMOBLSER/
Kélisogou	KH4	911	/////
Kélisogou	KH4	912	////TRMOBLSER/
Kélisogou	KH4	913	////TRMOBLSER/
Kélisogou	KH4	914	////TRMX/
Kélisogou	KH4	968	////TRMOBLSER/
Kélisogou	KH4	969	////TRMOBLSER/
Kélisogou	KH4	970	////TRMX/
Kélisogou	KH4	1289	////TRMOBLSER/
Kélisogou	KH4	1290	////TRMX/
Kélisogou	KH4	1792	/////
Kélisogou	KH4	1793	/////
Kélisogou	KH4	1794	/TRMOBLSER////
Kélisogou	KH4	1795	////TRMX/
Kélisogou	KH4	1885	////TRMX/
Kélisogou	KH4	1886	////TRMX/
Kélisogou	KH4	1887	////IND/
Kélisogou	KH4	1888	////TRMOBLESP/
Kélisogou	KH4	1889	////TRMOBLSER/
Kélisogou	KH4	1890	////TRMX/
Kélisogou	KH4	1894	////TRMX/
Kélisogou	KH4	1895	////TRMOBLSER/
Kélisogou	KH4	1896	////TRMOBLSER/
Kélisogou	KH4	1897	////TRMOBLSER/
Kélisogou	KH4	1898	////TRMOBLSER/
Kélisogou	KH4	1899	////TRMOBLSER/

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Fig. 3. Example of a catalogue of ceramic sherds, generated from a database. The sherds were sorted by site, horizon, and sherd number. The catalogue also already includes some analysis, as the last column contains a descriptive code for decorative patterns observed on each sherd. In a single field, this code describes observable decorative patterns sorted by placement on the vessel (edge, lip, neck, body, etc.), each part being separated by a slash (/). This example only records fragments from body sections, most showing a tightly printed basket-weave decor (TRMOBLSER). Sherd 911 on the other hand displays no decoration. When using this type of cataloguing, the coding information must of course be available to anyone likely to work with the document in future.

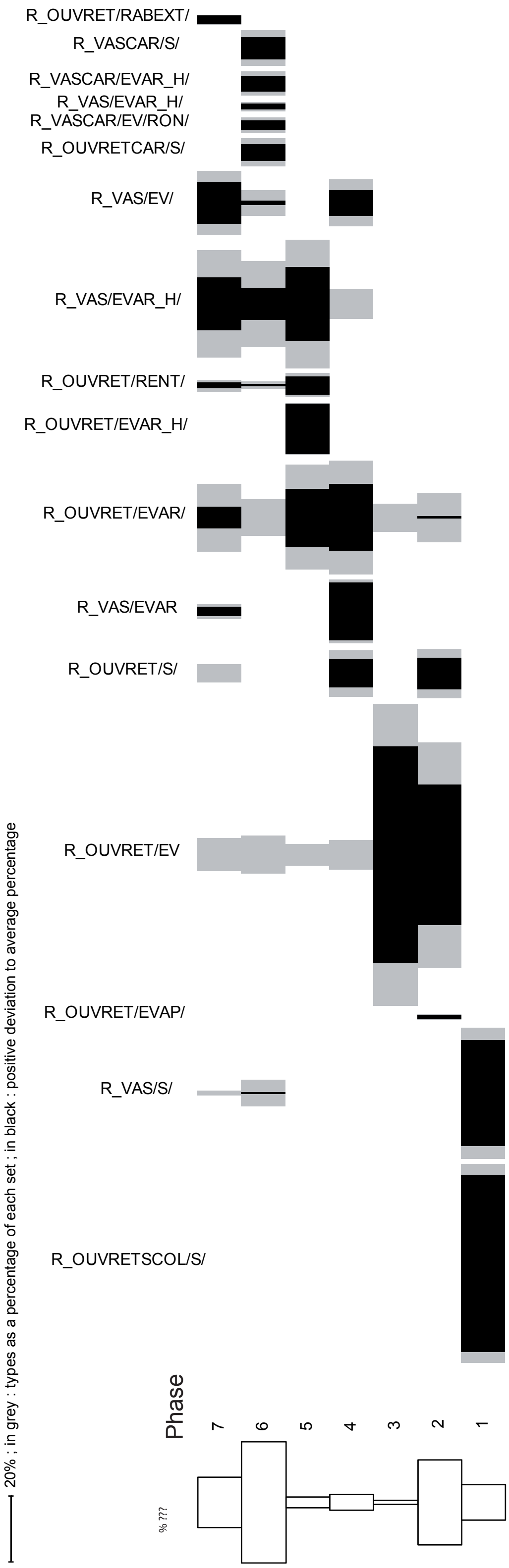

Fig. 4. Example of serial ordering of Neolithic ceramic types from the Dogon district (Mali) created using a database synthesising information from multiple catalogues. The coding of the types analysed (horizontal) was generated by the database from several sections of the original ceramics catalogue. Serial ordering was performed using the seriograph tool designed by B. Desachy (2004). (Based on Ozainne 2013, fig. 62, modified.)

Once data entry and layout are completed, either during or after the dig, the catalogue may be used immediately to develop a more complex database for analysis. It creates a link between the field data and the analytical process that will allow the archaeologist to offer interpretations.

A complex catalogue can also be designed as a database or an intermediate step towards the creation of a database. This comprehensive approach should be considered systematically if the researcher knows that they will oversee the entire research process, from excavation to publication, particularly in the context of a doctoral thesis. In this case, the researcher will gather more data in the field. This approach should also be considered when the researcher knows that they will not study the material extensively on site for logistical and/or financial reasons. If this approach is adopted, the cataloguing may be more complex, and include information related to a broader range of topics. This creates an analytical catalogue, one which collects and codifies basic information and raw descriptive information that can be used directly by the researcher who conducted the excavation or other researchers who study the material at some later date (**figs. 3** and **4**).

This type of analytical catalogue naturally requires that the documentary language employed (codes, abbreviations, etc.) be recorded, transmitted, and preserved. This more complex approach will not prevent the creation, afterwards, of a simpler catalogue for the conservation of materials. It also aids in the swift preparation of specific catalogues to accompany publication.

REFERENCES

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Ozainne, S. 2013. ‘Un Néolithique ouest-africain : cadre chrono-culturel, économique et environnemental de l’Holocène récent en pays Dogon (Mali)’. *Journal of African Archaeology monograph series* 8 (*Peuplement humain et paléoenvironnement en Afrique de l’Ouest* 3). Frankfurt am Main: Africa Magna Verlag.

MAKING SENSE OF LITHICS

Nicholas Taylor[1]

INTRODUCTION: FRAMES OF REFERENCE

Lithic artefacts are the most enduring and ubiquitous feature of the African archaeological record. Found across all of the continent's major geographic regions, in some areas they provide a record of early human (hominin) and modern human (*Homo sapiens*) activity from 3.3 million years ago until recent historical times. Scientific understanding of the technical processes or 'reduction strategies' involved in the production of lithic tools means that when recorded at an excavation and recovered and treated carefully, their study can shed light on the behaviour of past people in a particular location – including subsistence strategies, economic activities, social organization, and cognitive abilities – and provide vital clues about the integrity of archaeological levels and sequences.

Knapped ('chipped') stone tools are always made from brittle rocks (e.g. chert, obsidian, quartz, quartzite, rhyolite, various lavas, etc.) that break in a predictable way when struck with a percussor made of stone or organic material (e.g. wood), while groundstone lithic tools are made by abrading tough, coarse materials (e.g. basalt, rhyolite, granite, hematite and sandstone), sometimes after an initial phase of knapping. The processes involved in stone tool manufacture are reductive and irreversible: once fractured or ground, the separated pieces of rock can never be permanently put back together to form the original whole – over time individual artefacts can only become smaller, while concurrently the overall number of lithics produced increases. While leaving a proportion of lithic material in the ground for future archaeologists to examine in context, it is strongly advisable to collect all lithic pieces from the excavated part of a site, since it is the study of whole assemblages – including very small and non-diagnostic pieces less than 1 cm in maximum dimension – that provide the detail needed to understand the past.

The African stone tool record is distinct from that of Eurasia and the rest of the world, but some parts of the continent – notably Central and West Africa – are still poorly documented and it is therefore best to study any lithic material based first on its own characteristics, rather than by imposing concepts or naming conventions developed for distant archaeological cultures. The three-age system, in which the African record is divided into sequential Early Stone Age (ESA), Middle Stone Age (MSA) and Later Stone Age (LSA) periods corresponds roughly with Lower, Middle and Upper Palaeolithic European subdivisions, and offers a very broad framework into which an archaeological lithic assemblage can be placed to give a *general impression* of its relative age and content. Assigning a lithic assemblage to one or other of these periods is based on the identification of diagnostic tool types (*fossiles directeurs*) and dominant technologies. A system of categories that distinguishes between flake and core (Mode 1); bifacial (Mode 2); prepared core (Mode 3); blade (Mode 4), microlithic (Mode 5), and polished (Mode 6) lithic technologies offers a useful scheme for this purpose. It is important to remain mindful of the many examples of lithic archaeological industries and assemblages that contradict any notion of clear, sequential 'advances' in stone tool making techniques over time. However, assemblage characterisation provides a useful starting point on which to base the following stages of a lithic study.

I. INITIAL ANALYTICAL STEPS

A good idea is to lay out all material on a table (retaining excavation and stratigraphic context information with each piece, so its provenance can be tracked in all future work) and, for each stratigraphic or excavation unit, to group together all pieces by raw material type. Even without specialist geological knowledge, distinctive attributes such as raw material grain size (fine or coarse), translucency, and/or colour (including if relevant any subtle internal features such as rock banding) can be used. Since lithics of one rock type cannot result from the working of a different raw material, this grouping ensures some separation of technical sequences and allows for the comparison of similarities and differences within and between rock types and excavation units. Differences in the original form and physical characteristics of raw materials can dictate the strategy a stoneworker employed to make tools, and affect the size and form of the lithics produced. Occurring naturally as small pebbles or angular chunks, quartz for example is far less suited to the manufacture of long blades than larger blocks of chert or quartzite, while granite and hematite are rarely good for knapping but can make effective ground stone tools.

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Trends in raw material frequencies and sourcing can also be examined, revealing networks or efforts put into obtaining rocks – if a material is present in local geology it may have been sourced nearby, but other non-local ('exotic') rocks might have been collected and transported from many kilometers away.

Measuring the lithics in an assemblage provides essential information about individual pieces so that other researchers can understand their scale as well as artefact diversity across the wider assemblage. Within each raw material grouping per excavation unit, count the lithics by size class (for instance >20 cm, 10-20 cm, 5-10 cm, 1-5 cm, <1 cm) before measuring their maximum length, width and thickness (and weight too, if possible). Very small pieces usually reflect waste shatter or dust generated incidentally during tool knapping or grinding, and can instead be counted or weighed in bulk. Make a note of these details, to which further information about the typology and technology of each piece can then be added.

II. TYPOLOGICAL AND TECHNOLOGICAL APPROACHES TO ANALYSIS

A. Typological approach

Typological categorisation is based on the identification of recurrent shapes and forms in lithic end products according to a set of attributes and a shared vocabulary. This process can include very specific categories and sub-categories of types, but the application of any scheme should always reflect the lithic materials being examined and condense assemblage variability for easier description and comparison with other horizons and sites. Although many typological terms (e.g. scraper, handaxe) imply the function of each group, the actual use of lithic artefacts cannot be accurately determined based on their morphology or technological features; to understand function requires specialist microscopic analysis (see below). Certain morphological types might act as diagnostic *fossiles directeurs* of a particular industry or culture (e.g. Acheulean handaxes, MSA points), while others occur widely in time and space (e.g. flake scrapers, notches, burins).

With the lithics laid out as before, look both within and between raw material groups for artefacts with common attributes. An initial categorisation applicable to most lithic assemblages might discriminate between flaked and detached pieces, small retouched tools and shaped tools, polished/ground items, and modified and unmodified pieces. **Flaked pieces** such as cores show multiple negative scars indicating they were repeatedly struck to produce flakes. ***Simple cores*** can have just a few removals initiated from one surface near the edge (a single platform), while more ***complex cores*** have flake removals initiated from several platforms in multiple directions. ***Specialised cores*** including Levallois, discoidal, blade, and microblade types show careful preparation to form particular shapes designed to enable systematic detachments of flakes or blades the size and shape of which are controlled by the knapper. **Detached pieces** include all lithics knapped from a larger piece but lacking secondary modifications (retouch), including ***whole flakes*** retaining distinctive production features (a striking platform, point of percussion, bulb of percussion, and termination), ***broken flakes*** that split into pieces during knapping, elongated ***blades or microblades*** with parallel lateral edges and dorsal ridges, and ***angular fragments*** and ***waste*** of irregular morphologies produced as knapping by-products. **Shaped tools** can be divided into ***large cutting tools*** such as cleavers (**fig. 1**) and handaxes (**fig. 2**) showing bifacial working around the perimeter, ***heavy-duty tools*** like core-axes, picks, choppers and core-scrapers typically knapped from large cobbles or blocks of material, and ***light duty tools***, including points (retouched (**fig. 3**) and unretouched), microliths (**fig. 4**), scrapers, denticulates, burins, becs, and borers. **Polished/ground** lithic artefacts, with some degree of deliberate edge and surface abrasion or beveling, include ***ground and polished axes*** (**fig. 5**), ***grindstones*** with one or more smoothed, polished faces, pebble or cobble ***rubbers*** showing worn, smoothed faces from abrasive wear, and ***bored stones***. **Modified** pieces show some degree of surface alteration and or flaking caused by human activities, including items such as: ***hammerstones*** used as hand-held percussive tools for knapping which exhibit pitted and battered surfaces; ***anvils*** with percussive impact damage on one or more surfaces; and also ***pigment with rubbed surfaces***, soft stone pieces that can be worked into colourful powders through rubbing. **Unmodified** includes any lithic item brought to the site by people but which lacks any evidence of subsequent alteration. Care must be taken to ensure neither ***manuports*** nor ***unmodified pigment*** could have occurred naturally at the site, or been transported there by physical processes such as water action. The frequency of artefacts in each of these categories should be noted, and can be tabulated per excavation horizon and raw material to help identify trends in toolmaking.

B. Technological approach

Technological analysis focuses on understanding the processes involved in producing lithic artefacts and is based on a careful reading of the order and pattern of detach-

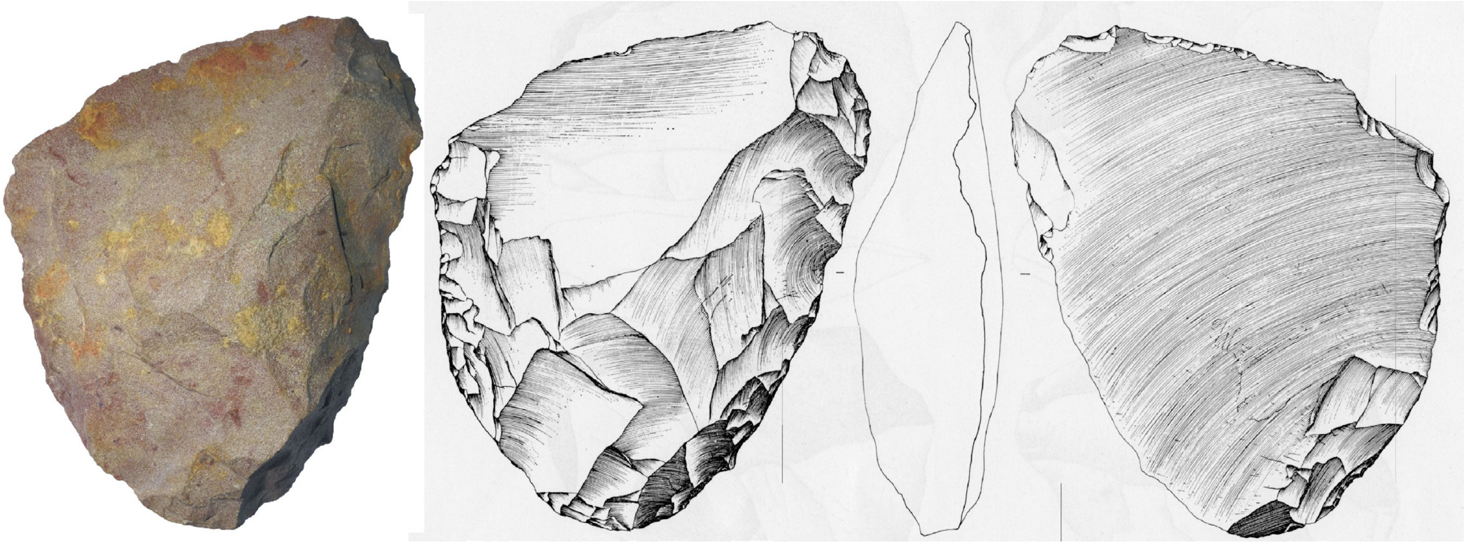

Fig. 1. Late Acheulean cleaver (20.6 x 17.0 x 5.4 cm) from Kamoa (Democratic Republic of Congo) in polymorphic sandstone. (Drawing from CAHEN, D. 1975. *Le Site archéologique de la Kamoa (région du Shaba, rép. du Zaïre). De l'Âge de la Pierre ancien à l'Âge du Fer* (series 'Annales in 8°, Sciences humaines', no. 84). Tervuren : RMCA, plate 1. Photo © RMCA.)

Fig. 2. Late Acheulean handaxe (16.6 x 8.8 x 3.7 cm) from Kamoa (Democratic Republic of Congo) in polymorphic sandstone. (Photo © RMCA.)

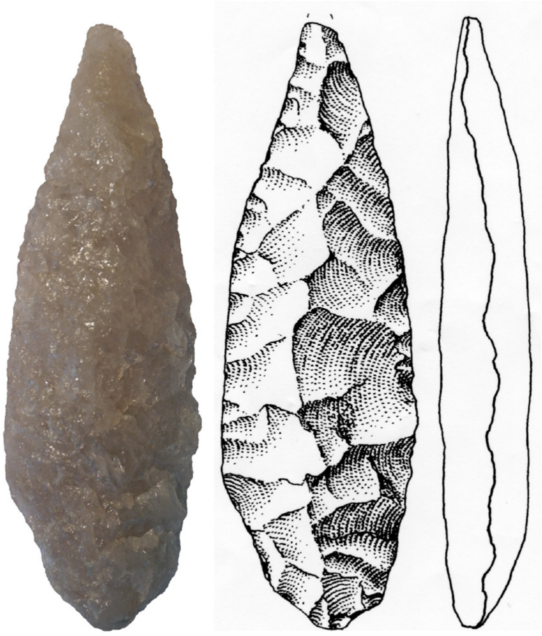

Fig. 3. Foliate point (12.8 x 4.2 x 1.8 cm) in vein quartz found during mining operations in a gravel layer at the Kasongo-mine (Democratic Republic of the Congo) and donated to the Royal Museum for Central Africa in 1939. (Photo © RMCA.)

ments or abrasive processes (grinding/polishing) that led to the final form of lithics. Scar patterns on core, flakes and shaped tools can be used to infer the repeated use of particular knapping patterns (e.g. bifacial, Levallois, blade, microblade, bipolar) reflecting the decisions taken by a knapper or group of stoneworkers at a site. These may reflect some collective cultural and social habit of a past community, with some techniques also requiring greater knapping preparation and forethought to complete, suggesting a greater investment of effort, increased skill, or more complex cognition. The typological examination already undertaken should provide strong clues about technological trends in the lithic assemblage; for example if there are many bifacially shaped tools, or numerous razor-like blades, microblades or blade/microblade cores, or groundstone items, this might indicate the repeated use of particular reduction strategies. Look for differences in the frequency or use of these techniques between rock types and excavation horizons. Considered with caution (see above) some technologies such as microlithic and polished/groundstone appear later than others in the African record, and may indicate a relatively more recent age for an assemblage. Microlithic technology should not however be identified based on the presence of 'small flakes' (which can result from any lithic reduction strategy) but rather the recognition of deliberately made geometric pieces, often from microblade or small bipolar cores. Similarly, artefacts with ground and smoothed surfaces occur alongside Acheulean, MSA, and LSA flaked technologies at some sites, making it important to distinguish between items showing grinding as a by-product of other activities (e.g. processing wild plant material or colourants) from carefully and deliberately made groundstone tools such as shaped and polished axes.

Detailed technological analysis can result in very high-resolution information about past behaviour. Excavated lithics are the outcome of dynamic, sequential stages that make up a *chaîne opératoire*, including: raw material procurement and testing; initial knapping (cortex removal); shaping/trimming or core preparation and flake manufacture; artefact use (including possible re-sharpening); secondary and subsequent transformations (reshaping into other tool types), and tool exhaustion/discard. All of these stages may be recorded in an assemblage, but some parts of a knapping sequence may be missing, especially if completed at another location. In their natural state, almost all rocks have a weathered outer coating – cortex – that is gradually removed as a rock is fractured or ground into tools. Per raw material and excavation horizon, record the percentage of the surface of each piece covered by cortex. The retention of cortex on any portion of a lithic piece by definition records the outer surface of the original piece of rock; if cortical artefacts of a particular raw material are absent or very infrequent in an excavation unit this may suggest the initial reduction phase was undertaken elsewhere (perhaps at the raw material source) and that flaking of this material was already at a relatively advanced stage when it was brought to the site. Similarly, if the assemblage includes mostly completely cortical artefacts, this indicates initial flaking took place at the site and, if no clear end-product tools of that material are present, that these were subsequently transported away for use at another location. The size-class information for each rock type previously recorded can be combined with this cortex data to further assess these possibilities, since the smallest and lightest fraction of material (<1 cm) typically represents knapping shatter resulting from on-site tool manufacture. Care should be taken here, however, since these light pieces are also the most prone to being washed or blown away by post-depositional processes – their complete absence from an excavated horizon may not mean knapping did not take place at the site. But, if absent for one rock type but present for another, it can be suggested that raw materials were knapped at different locations in the landscape.

GOING FURTHER: SPECIALIST INTERPRETATIVE ANALYSES

Other kinds of more detailed lithic analysis also help to understand the behaviours and technological decisions of past people. The **experimental knapping** of the same or very similar raw materials as those identified at a site can provide comparative information about the suitability and difficulty of making tools from particular rocks, as well as insights into the morphology, technology and size-range of artefacts that typically result, which can then be used to interpret more accurately the archaeological assemblage. For example, if very few pieces of small shatter are produced when knapping a rock, it might not be appropriate to explain the identification of only a few such archaeological pieces as relating to technical decisions (off-site knapping) or post-depositional disturbance of the materials.

Even higher resolution technological analysis can be undertaken by attempting to piece back together lithics of the same material into **refitting** groups. If two or more conjoinable pieces are present, this technical procedure likely took place at the site and, moreover, the integrity of the archaeological horizon has not been badly com-

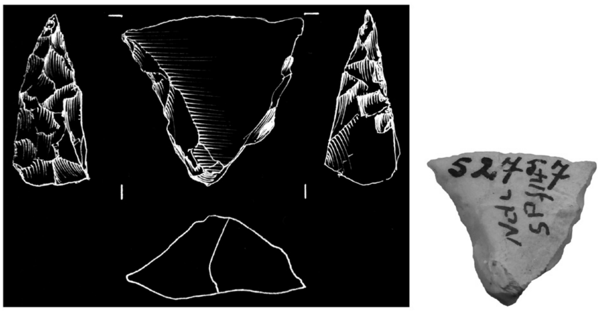

Fig. 4. Later Stone Age transverse arrowhead/*petit tranchet* (2.0 x 2.2 x 0.9 cm) in white patinated polymorphic sandstone, Ndinga Saint-Pierre (Democratic Republic of the Congo), 1952 excavations M. Bequaert. Note the inventory number of the Royal Museum for Central Africa (52757), reference to the site and pit (Ndi SP f 14). On the ventral side the depth (-1.20-1.25 m) at which the artifact was found and the date (23.v.52) are written. (© RMCA.)

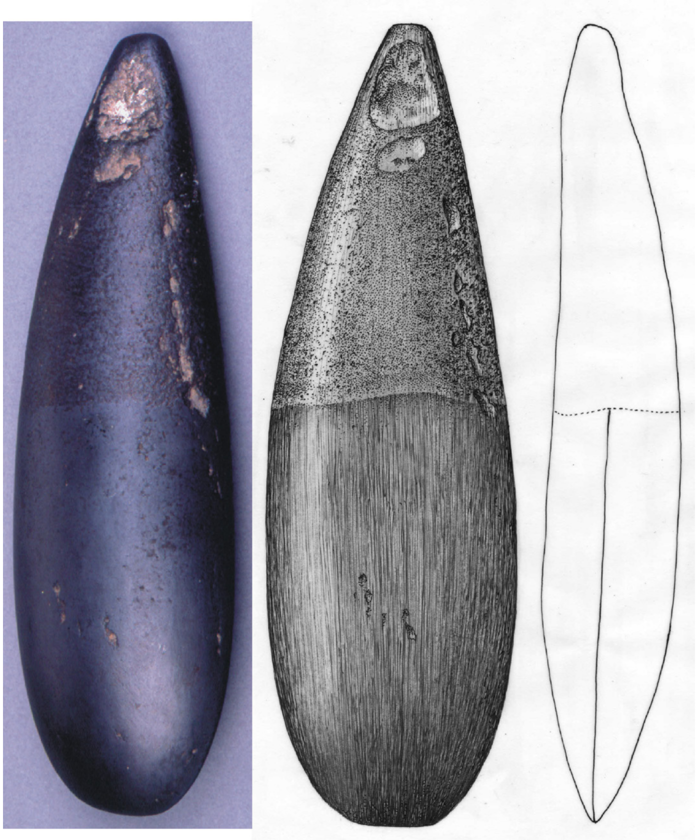

Fig. 5. Polished axe (20.4 x 6.1 x 2.7 cm) in hematite from Uele (Democratic Republic of the Congo), chance find and gift to the Royal Museum for Central Africa in 1898. (Photo J.-M. Vandyck © RMCA.)

promised since artefact deposition. Furthermore, if multiple pieces can be refit, it can be possible to identify very specific knapping decisions, including the number and sequence of core rotations and any accidents avoided or resolved, while the absence of certain lithics from the *chaîne opératoire* may indicate their preferential selection for transport and use at another location.

Functional analyses attempt to determine the actual use of archaeological lithic artefacts (whether flaked, shaped, retouched/unretouched, or ground) through the microscopic examination and interpretation of adhering organic particles (**residue analysis**) and/or the presence of patterned damage on their edges and surfaces (**use-wear analysis**). These are true scientific specialisms that take years to learn but, if considering their application, it is recommended as a first step not to wash after excavation any artefacts intended for residue analysis, and to retrieve some sediment samples from the excavation horizon so that residue types and frequencies on tool surfaces and the burial environment can be compared. To avoid contamination of any ancient residues, restrict artefact handling to a minimum; if possible only handling with powderless laboratory gloves or, if not available, with clean hands. After excavation, artefacts should be isolated inside two sealed (preferably Minigrip®) plastic bags before a lithic residue analyst is contacted for further advice. For use-wear analysis, restrict artefact handling and if it is necessary to remove sediment from surfaces, wash pieces lightly with a soft toothbrush (avoiding heavy scrubbing). Again, keep artefacts selected for further specialist analysis inside two sealed plastic bags and avoid as much as possible any percussive or abrasive contact as they are transported from the site to a laboratory environment.

SUGGESTED FURTHER READING

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Also at : http://www.mae.u-paris10.fr/prehistoire/IMG/pdf/Technology_and_Terminology_of_Knapped_Stone.pdf

Inizan, M.-L., Reduron-Ballinger, M., Roche, H. & Tixier, J. 1995. *Technologie de la pierre taillée* suivi par un vocabulaire multilingue (allemand, anglais, arabe, espagnol, français, grec, italien, portugais). Meudon: CREP, 199 p.

Also at: http://www.mae.u-paris10.fr/prehistoire/IMG/pdf/Technologie_de_la_pierre_taillee.pdf

A CASE STUDY: ANALYZING LITHICS FROM SHUM LAKA, NW PROVINCE, CAMEROON

Els Cornelissen[1]

I. THE GENERAL SETTING OF THE ROCK SHELTER

The rock shelter of Shum Laka was excavated as part of the Wide Bantu Homeland Project under the general direction of Pierre de Maret in two field seasons in 1991 and 1993. The incentive was to document the archaeological record in the area considered by linguists to be the cradle of the Bantu languages. The sequence of occupations turned out to date back to beyond 30,000 years (**fig. 1**) and yielded a substantial amount of lithic artefacts. As at any rock shelter, the re-occupation of the same area most certainly provoked disturbances of previous occupations that obliterated borders of separate horizons, but at the same time the gradually accumulated sediments and artefacts offer a chronological referential frame work.

The abundant lithic material at Shum Laka revealed a microlithic industry mainly on quartz starting in the Late Pleistocene, and a Holocene large flake and blade industry made on basalt. In order to assess the extent of continuity and variation through time between these two different assemblages, we compared a number of typological and technological features. Here I will focus on the patterning in the choice of raw materials over the 30,000 years that the rock shelter has been frequented. Below you will first find an overview of the units and general grid of analysis of typological and technological elements that we used, which are then applied to the specific question of the use of raw materials through time.

The general typological and technological approach and some of the specific analyses from Shum Laka will be useful to your own analysis; however, the first step is to lay out your own material and to look at it for any patterning that will guide your choice for applying a specific typology (see also Taylor, this volume, pp. 163-164).

II. UNITS OF ANALYSIS

All artefacts including lithics measuring ≥ 2 cm were recorded three-dimensionally out in the field. All sediment was collected in artificial spits of 5 cm over a square meter. This was dry- and then wet-sieved on 5 mm mesh. A unit of 1m²x 5 cm is thus the common smallest unit of analysis between sieved and 3-dimensionally recorded artefacts and according to which bones, lithics, pottery and charcoal retrieved from the sieves were bagged and labelled.

The choice at Shum Laka for excavation in artificial spits was made in the absence of clear stratigraphic or cultural units whilst excavating (see also Vogelsang, p. XX). Extensive geomorphologic studies lead to the identification of 6 large stratigraphic units (**fig. 1**) which are from top to bottom: a lens-shaped A-layer or loose ashes subdivided into grey (Ag) and ochre ashes (Ao) with correlating T-deposits that are fluvial sediments brought in by the fall at the entrance. These Holocene A- and T-deposits were further subdivided using radiocarbon dates from charcoal and from human bones. The underlying S-Si deposits and P-deposits belong to the Pleistocene. Except for the grey and ochre ashes, the stratigraphic units were hard to distinguish out in the field, hence artificial spits were grouped into one of the stratigraphic units after excavation. Depending on the slope of these stratigraphic units and lateral variation, some of the artificial excavation spits will be transitional, meaning that they belong partly to two of the large stratigraphic units.

III. GRID OF ANALYSIS

A simple Excel spread sheet was used to analyse various parameters in order to answer the questions listed above. Other software can of course be used but Excel spreadsheets and especially its Open Office equivalent are widely used and accessible. Its major convenience – that contents of cells can be changed at any time by simply overwriting – is also its major inconvenience. Columns will contain variables. Rows correspond to one single artefact, or to an assemblage of similar artefacts, e.g. 20 fragments non-cortical quartz fragments all measuring between 1 and 2 cm (or size-class 1). Questions such as ‘what is the number of quartz artefacts smaller than 2 cm in the level -120-130 cm in square B12’ can be answered by using the data filters in the various columns or by using specific Excel functions.

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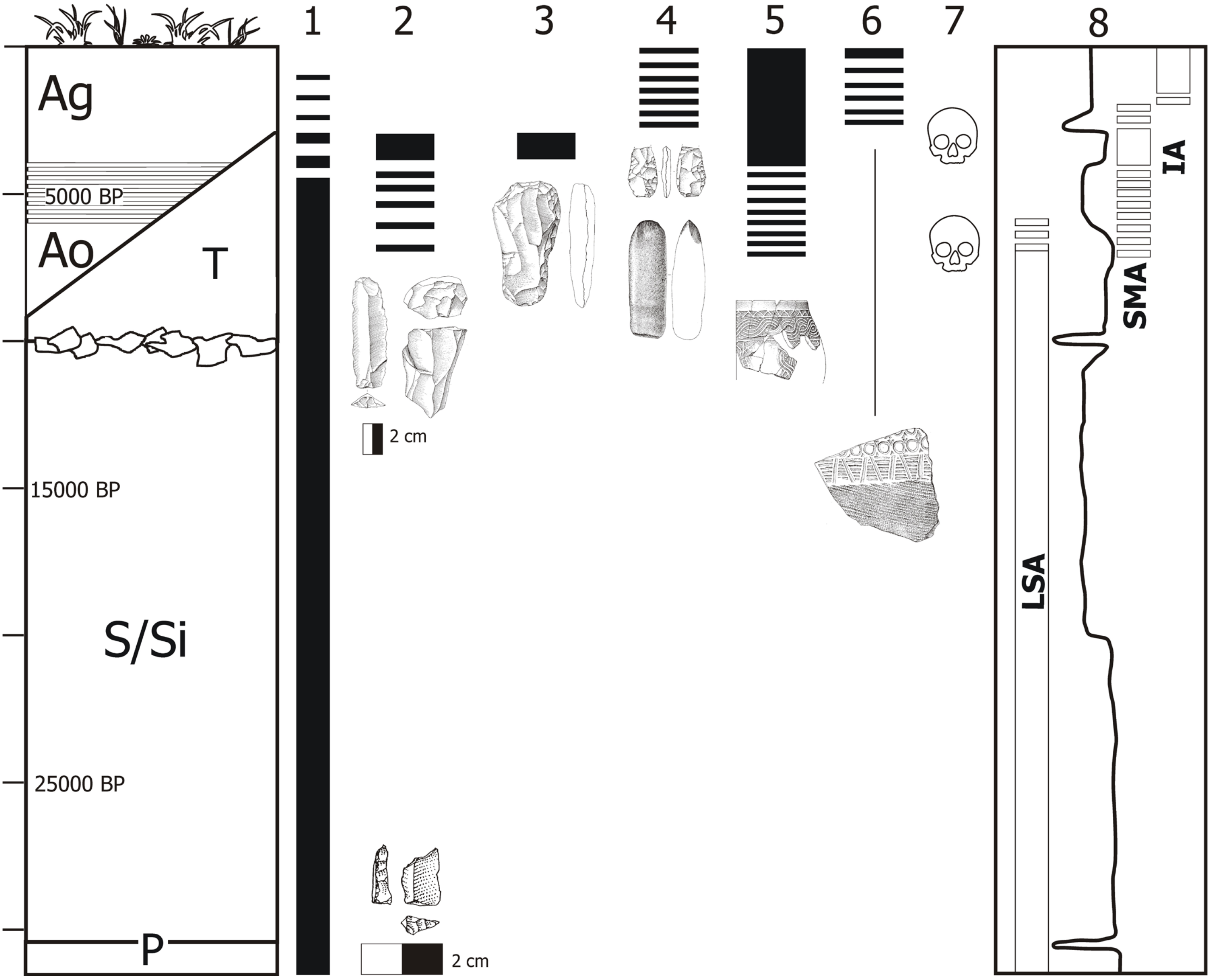

Fig. 1. Overview of results from Shum Laka. The left column represents general stratigraphy and red dots indicate position of radiocarbon dates. 1 to 6 are the technological traditions with appearance and disappearance: (1) the microlithic quartz industry, (2) macrolithic flake and blade industry on basalt, (3) bifaces of the axe-hoe type, (4) pecked grounded adze and arrow heads, (5) pottery and (6) iron objects. (7) indicates the two burial phases and (8) the oscillation between arid (on the left) and humid (on the right) climate conditions. LSA = Late Stone Age, SMA = Stone to Metal Age, IA = Iron Age.

In the list of parameters (in columns) for the analysis of lithics of Shum Laka we included:

1. Date of excavation
2. Site: official abbreviation LAK91 or LAK93; 91 referring to the field season 1991-1992 and 93 to that of 1993-1994.
3. Square: grid system of letters and figures
4. Levels or excavation spits expressed in cm below datum/surface: depth was calculated from an artificial datum set at 10 m and was afterwards recalculated as depth below surface.
5. Inventory number: only for artefacts with x, y and z recordings
6. N coordinates within square
7. E coordinates within square
8. Depth for individually recorded artefacts below datum/surface, see 4.
9. Number: 1 for a three-dimensionally recorded artefact or specific unique artefact, more for any given number of artefacts that share all characteristics recorded (e.g. 20 non-cortical quartz fragments of size-class 1)
10. Cortex: in order to assess the extent to which raw material had been processed prior to its introduction in the rock shelter, the presence (C)/absence (N) of cortex for all non-flakes was recorded. In the case of complete flakes the classification system of N. Toth (fig. 9, 1985)

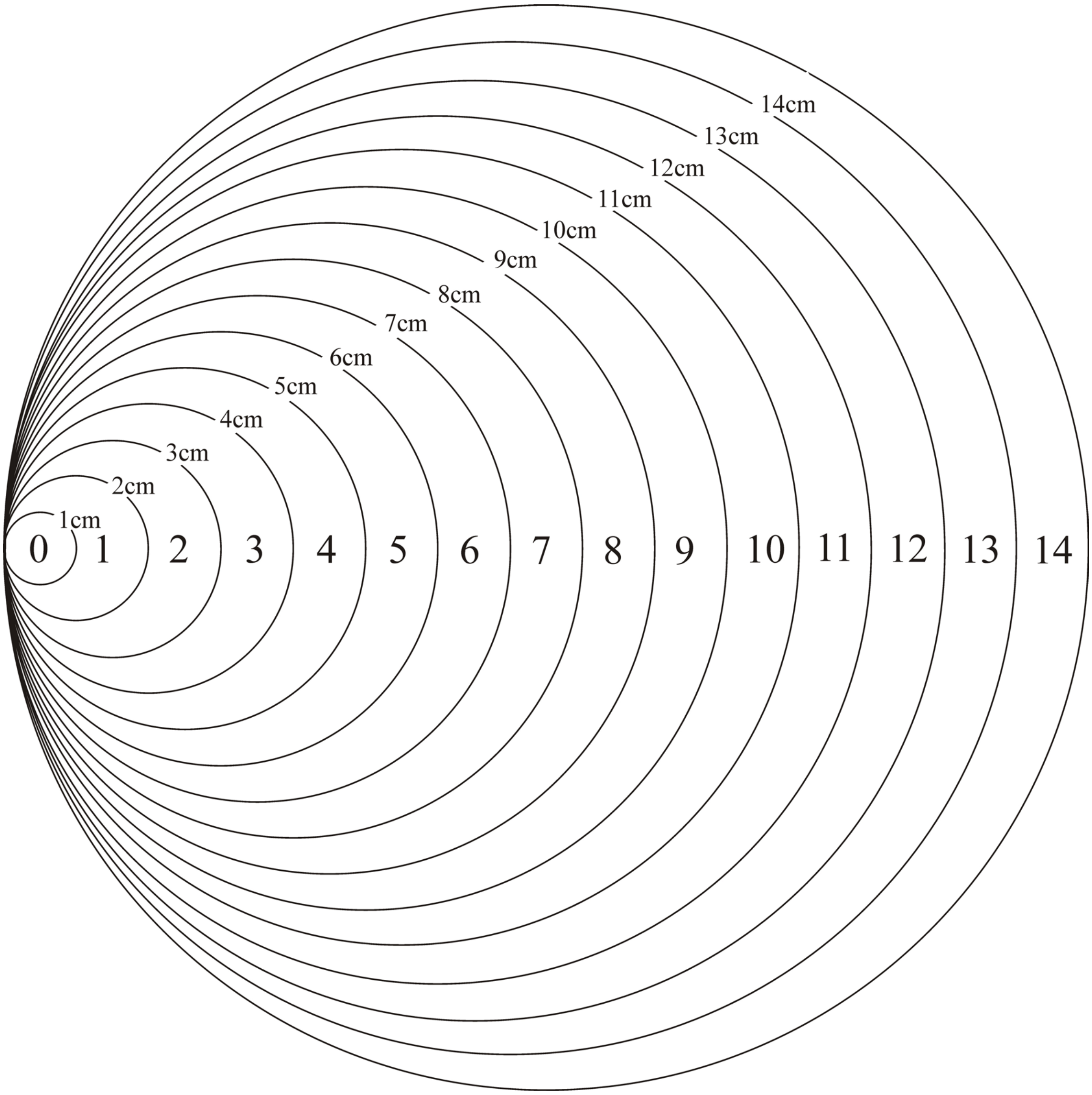

Fig. 2. Concentric circles are the easiest way of measuring the maximum dimension of any given artefact/stone. Class 0 corresponds to all items of which the maximum dimension is < 1 cm, class 1 to those ≥1 cm and < 2 cm, etc.

was followed. Six flake-types represent a combination of cortical/non-cortical flaking platforms and dorsal surface (50% or more, less than 50%, and no cortex). If raw material was processed on the site, flakes with cortical flaking platforms (types I-III) and cortex on the dorsal face (types I-II and IV-V) will prevail. Raw materials that have little or no cortex to begin with, like the vein quartz used at Shum Laka, yield mostly type VI flakes if any.

11. Raw material: codes refer to various raw materials. However, in the analyses we classified them into three large categories according to their flaking properties: (1) welded tuffs and basalts, locally available in the rock shelter that was carved into this type of rock; (2) all types of quartz – mainly vein quartz – which must come from granite layers in the surroundings of the rock shelter; and (3) all fine-grained rocks such as siliceous sandstone, obsidian, silicified mudstone, cherts which were carried into the rock shelter. All raw materials were available on site or nearby at a maximum of 5 km during the entire occupation of the rock shelter. Hence any variation in the exploitation of rocks and minerals can be interpreted as a deliberate choice to use one specific raw material over another.
12. Physical condition: fresh, weathered, rolled

For flakes (retouched, modified pieces, and complete flakes), the following measurements were recorded:

13. Maximum length, ML
14. Maximum width, MW
15. Maximum thickness, MT

The ratio of ML/MW of flakes is used for assessing tendencies in the general flake production. A distinction is made between lateral or side-struck flakes (ML/LW <1) such as for instance obtained during bifacial trimming, and end-struck flakes (ML/MW ≥ 1 and < 2) and blades (ML/MW ≥2).

16. For all artefacts the maximum dimension was recorded positioning them on concentric circles (**fig. 2**). This parameter allows visualisation of the size fractions present/absent for assessing site integrity (see also Vogelsang, this volume, pp. 104-108).
17. Type:
 At the time of analysis Shum Laka was relatively unique at a regional scale. Therefore we developed our own typological and technological framework essentially inspired by that proposed by M. Kleindienst and J.D. Clark in 1974 for the site of Kalambo Falls (Zambia). We did not consider Shum Laka similar to Kalambo Falls but their approach and terminology, developed for a site spanning Stone Age into Iron Age, allowed for an adoption and adaptation of material previously unstudied. In fact, they distinguish between four large categories through increasing modification or retouch and we followed those.
    (1) waste (detached pieces (FLAK for flakes, FRAG for fragments and CHUNks) and flaked pieces (cores) – CF or CB for Core for Flake- or Blade-production. This can be followed by a number referring to a specific type of core, e.g. 01 for one single flaking platform.
    (2) utilized (grinding stones or hammerstones),
    (3) modified pieces (retouched, notch)
    (4) shaped tools (arrowheads, bifaces): TC is a Core Tool and TF a Flake Tool; TCSC a core scraper and TFSC a flake scraper. Letters and digits can be endlessly added for more detail.
18. Flake shape using the position of maximum width at the proximal edge, intermediate, and distal edge for respectively convergent, intermediate and divergent shapes; triangular and rectangular –the latter two may point to the search of predetermined shape on cores
19. Flaking pattern and number of scars
20. Butt shape or flaking platform
21. Terminal release
22. Remarks: this is a useful column for noting down anything observed during analysis that does not fit into any of the previous categories, that might turn out to be absolutely irrelevant or a recurrent significant feature.

Columns can be added for listing numbers of drawings or pictures, for links to other databases, or for units defined after recording and in the course of analysis or as dating evidence becomes available.

More fine tuning of this general typology can be done in agreement with a specialist who may orient you in the enormous offer of specific technological studies.

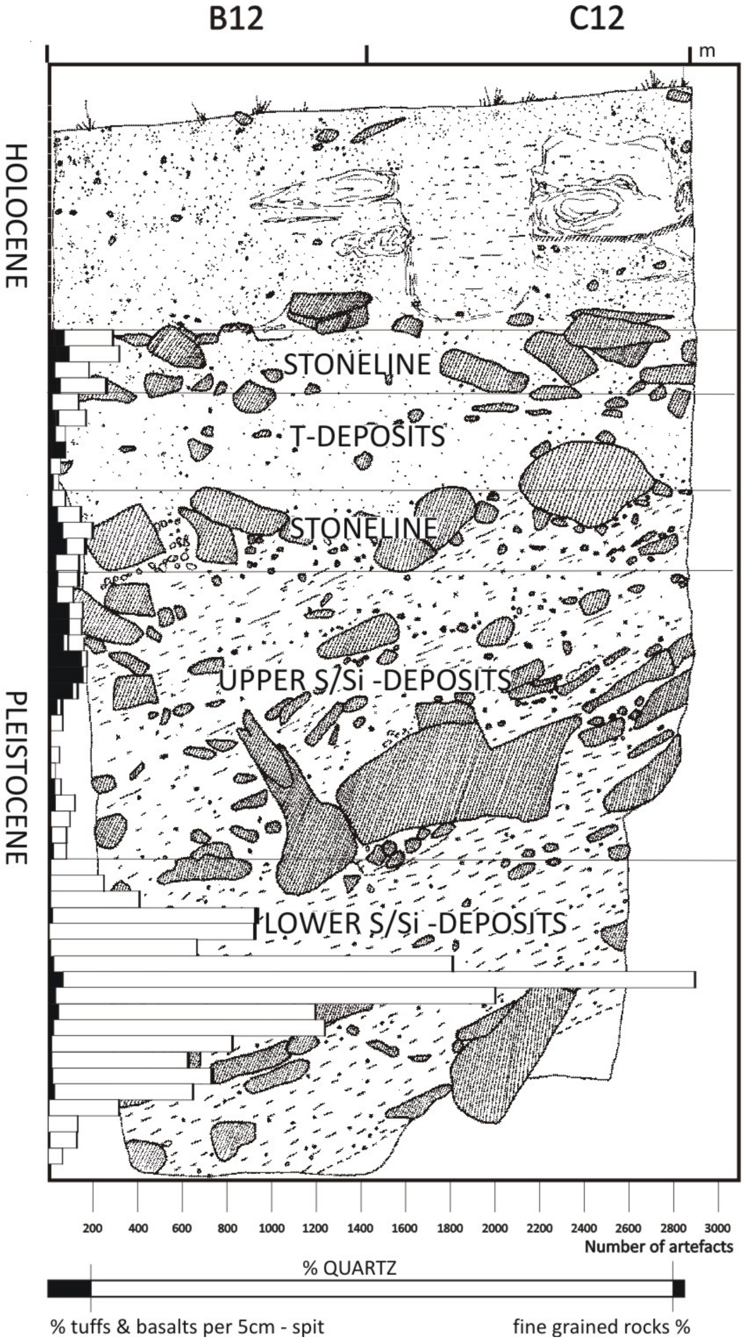

Fig. 3. Distribution of raw materials and density of artefacts throughout the Pleistocene lower layers based on the analysis per artificial spit in square B12. Projection of the artificial excavation spits onto the stratigraphic drawings allowed assignment of the spits to larger and chronostratigraphic units.

IV. EXAMPLE: EXPLOITATION OF RAW MATERIALS THROUGH TIME AT SHUM LAKA

A. From spits to chronostratigraphic units

A first step was to group the 5 cm spits in the various squares that were chosen for analysis into relevant chronostratigraphic units. This was based on the combination of geomorphological interpretation and C14 dates. **Figure 3** illustrates this for the lower levels. The resolution for the upper, Holocene ash-layers is

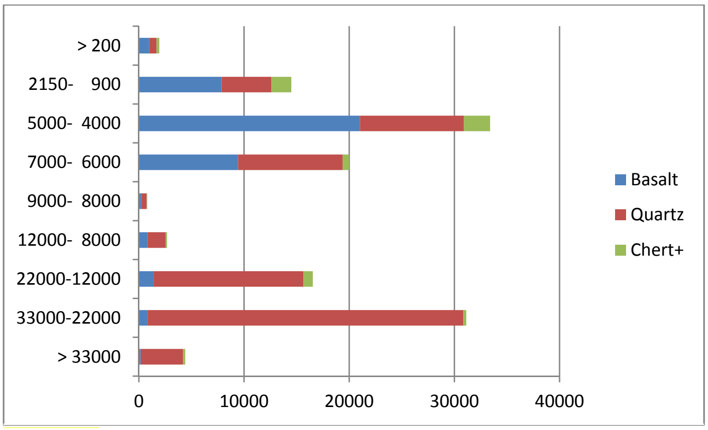

Fig. 4A. Number of raw materials per chronostratigraphic unit.

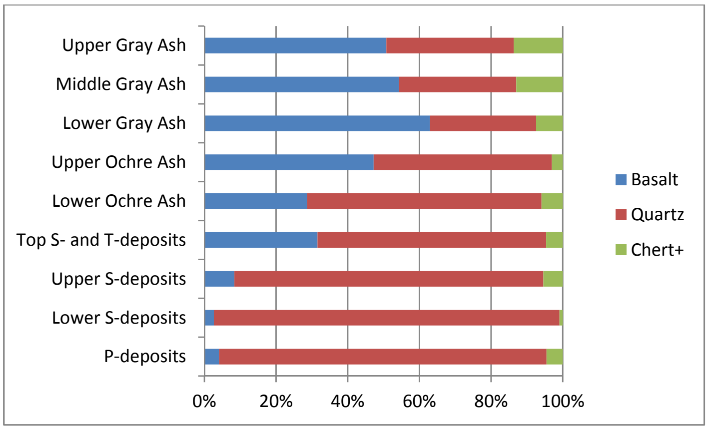

Fig. 4B. Percentage of raw materials per chronostratigraphic unit.

Fig. 4. Representation of three categories of raw material (see text) per chronostratigraphic unit. The chart in 4A shows the density or total number. Note that although the unit between 4000 and 5000 BP has yielded a comparable amount of artefacts as that dated between 33,000 and 22,000, a comparison is totally irrelevant because of the difference in time slice (1,000 versus 11,000 years). In chart 4B the proportion of each raw material is given making abstraction of the total number of artefacts. This shows a general tendency from bottom (P-deposits) to top (Upper Gray Ash) for basalt to increase at the transition from Pleistocene to Holocene and to a lesser extent for the category of cherts as well and a concomitant decrease of quartz artefacts. Based on Table II, Cornelissen 2003; Tables II, V, VII-IX Lavachery 2001.

higher than that of the lower Pleistocene layers both in terms of deposit description and formation and of dating (**fig. 4**). Because of that difference, the Holocene part can be compared to the Pleistocene record for general tendencies and similarities or differences in composition of artefact assemblages, but not for the density or number of artefacts.

B. From tables to graphs and interpretations (fig. 4)

For figure 4 the parameter (or column) 'Time BP' was selected in the Excel file together with the numbers of basalts, quartz and fine grained raw materials – mainly cherts – in figure 4A. For Figure 4B the column 'chronostratigraphic unit' was selected and the percentages of the three groups of raw materials calculated on the total per unit. These allow for different assessments of patterning through time (see explanation in captions). Quartz is clearly the prevalent raw material in the lower levels and since all raw materials were accessible and available throughout the occupation, this reflects a deliberate choice on behalf of the Pleistocene occupants.

This example serves to illustrate how simple means allow lithic analysis that answer questions on tendencies in the procurement and selection of raw materials. The same approach can be used for any other parameter like size distribution of each class of raw materials within the various Holocene ash layers, or comparing size distribution of a specific category of artefacts (e.g. quartz cores) throughout the entire sequence.

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Lavachery, P. 2001. 'The Holocene archaeological sequence of Shum Laka rock shelter (Grassfields, Cameroon)'. *African Archaeological Review* 18: 213-247.

Toth, N. 1985. 'The Oldowan Reassessed: A Close Look at Early Stone Artifacts'. *Journal of Archaeological Science* 12: 101-120.

Clark, I.D. 1974. *Kalambo Falls Prehistoric Site. II: The Later Prehistoric Cultures*, Cambridge: Cambridge University Press.

For further information on terminology, typology and technology, see

- Taylor, this volume, pp. 163-167
- http://www.mae.u-paris10.fr/prehistoire/IMG/pdf/Technology_and_Terminology_of_Knapped_Stone.pdf

POTTERY ANALYSIS

Alexandre Livingstone Smith[1] & Cécile de Francquen[2]

INTRODUCTION

Because it is at the same time enduring and abundant on most ancient sites, but also because it is very informative on past and present populations, pottery is an important part of many archaeological projects. Indeed, pottery, like all things made by humans, changes over time and, very often these changes can be related to changes in the ways of living. It is thus very useful, when trying to understand what happened in the past, to be able to recognize a specific kind of vessel and know when it was made and used. To be able to do so, one needs to process the potsherds found in the field and build a catalogue reporting the characteristics of the different vessels found in each context of an excavation. Once this is done it is possible to proceed with detailed interpretations. It is possible to identify different pottery styles (by looking at shapes and decorations) and outline their chronological and spatial evolution in the studied area (**fig. 1**).[3] One can then compare the characteristics of the various styles[4] and how they change over time, opening avenues of interpretations on the people who made and used the vessels. How does one get there, starting with a pile of dirty potsherds? There are many ways to proceed with archaeological pottery analysis and what follows must be considered as a very general introduction in this endeavour (see also Huffman, this volume, pp. 180-186).

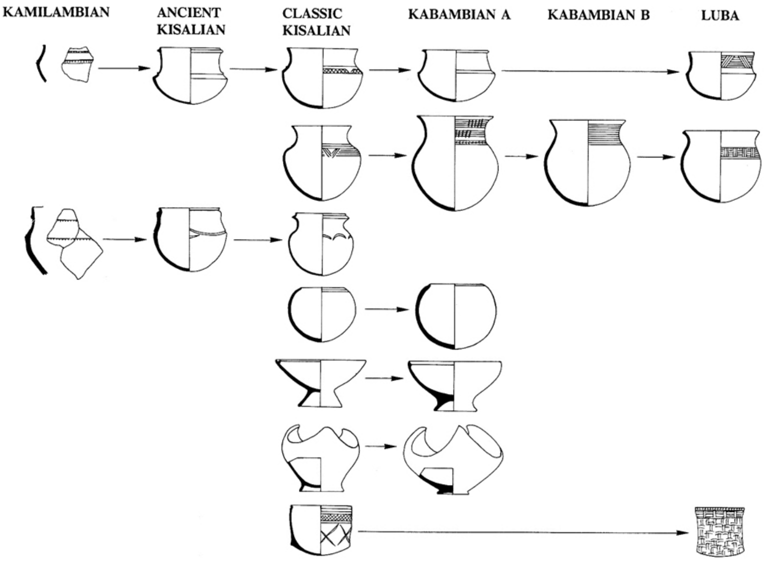

Fig. 1. At the end of the study, a pottery analyst can outline the evolution of pottery styles through time, in a given area. For instance, the typochronology established by Pierre de Maret in the Upemba depression of DRC summarizes the evolution of pottery styles in this area. It also shows in a simple manner that archaeological pottery in the area displays both elements of stylistic ruptures (related to distinct archaeological cultures) and elements of continuity. (Modified after de Maret, P. 1999.)

Fig. 2. Marking the potsherds. To make sure one always knows where each potsherd is coming from it is best to mark them clearly. The code should be short but allow for clear identification of the provenance of the potsherd (site, context, depth and potsherd number). (Photo A. Livingstone Smith, © RMCA.)

I. IN THE FIELD

Potsherds are generally cleaned in the field as there is no need to transport dirt around the world, but that is not a requirement. Cleaning should be done with water and

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[3] For classic examples, see Pierre de Maret's work on pottery from the Upemba depression in Katanga (de Maret 1985) or Hans-Peter Wotzka's work on pottery from the inner Congo Bassin (Wotzka 1995)

[4] Generally a style may be composed of a wide functional range of vessels (for cooking, service, storage, transport, etc.), but one may also observe that a style is associated to only one shape. It is thus important to establish the morphological range of each style. For instance near Tenkodogo in Burkina Faso, one may identify a style A (composed of cooking, storing and serving vessels), and a style B, displaying exclusively water bottles. All the potters live in the same area, belong to the same ethno-linguistic group, but consider themselves as distinct classes of specialist: Style A is produced by female specialists, while style B is made by male specialists.

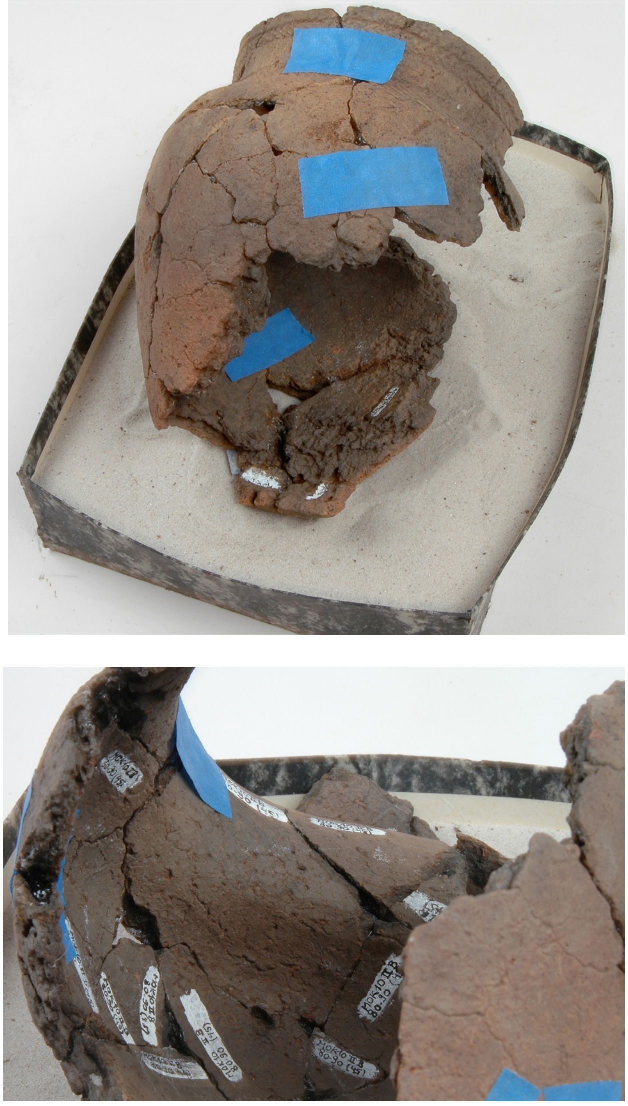

Fig. 3. If possible use reversible glue made with paraloid B72 (25%) and acetone (75%). When two sherds are refitted and glued together put them in a box filled with sand or rice grains to keep them in the right position while the glue sets. It is important to make sure the breaks are clean for a tight fit and that the curve is right. The accumulations of small errors change the curve of the vessel and can be very problematic towards the end. (Photo A. Livingstone Smith, © RMCA.)

soft brushes. Once dried, the potsherds are then put away in clearly labelled plastic bags. Whatever the reference system, make sure the bags refer to the *site*, *test-pit*, *context* and *depth* at which the pottery was found. Little holes should be made in the bags if the material is not completely dry when packed. If the material is in poor condition it is strongly advised to take pictures of the most diagnostic examples just after cleaning, as they may crumble during transport.

II. FIRST STEPS AT THE LAB

At the laboratory, the following steps are a minimum: (1) reference, (2) refit, (3) sort in different categories, (4) draw and/or photograph and (5) build a catalogue presenting the material. The material is then ready to be (6) analysed.

A. Reference

The first thing that needs to do be done is (1) to mark and number the potsherds. This will enable the researcher to take the potsherds out of their bags without losing track of their origin[5]. The marking has to summarize the information written on the bag (for example: a sherd excavated on the site of Birni Lafia 2014 in test pit 9, context 5 at a depth of 40-50 cm and numbered 514, may be referred to as follows: LAF/14/9/5/40-50/514). The mark should be small, but clearly written to avoid confusion (**fig. 2**)! One way to do it is to first lay a thin layer of varnish, before writing the code in Indian ink (black or white), depending on the colour of the sherd), then to apply another protective layer of varnish. It is important to make sure that all the marks are accurate and clearly legible.

B. Refitting

The next stage (2) involves refitting the potsherds, first within each context, then between contexts. This can be done by laying out the potsherds on a table, with their external surface showing up, and grouping them by appearance and fabric – a sort of family game. Then, one should look at each group of potsherds, turning them over in order to see their internal surface. It will then be possible to split the groups apart a little more depending on the characteristics of their internal surface. The analyst generally ends up with a few groups of potsherds that look very much alike and some isolated ones – the number of potsherds per group varies greatly depending on the archaeological context of origin. It is then possible to start looking for fragments that fit together within each of these small groups. When this is done, it is easier to look for further refits with other potsherds in other contexts. It is important to record the reference of the potsherds that fit together to facilitate further refitting and further analysis – one may add a pencil mark on the internal

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[5] If you are working on an enormous amount of material (i.e. tens of thousands), you may need to proceed first with steps 3a. and b. to reduce the quantity of material to be marked and numbered).

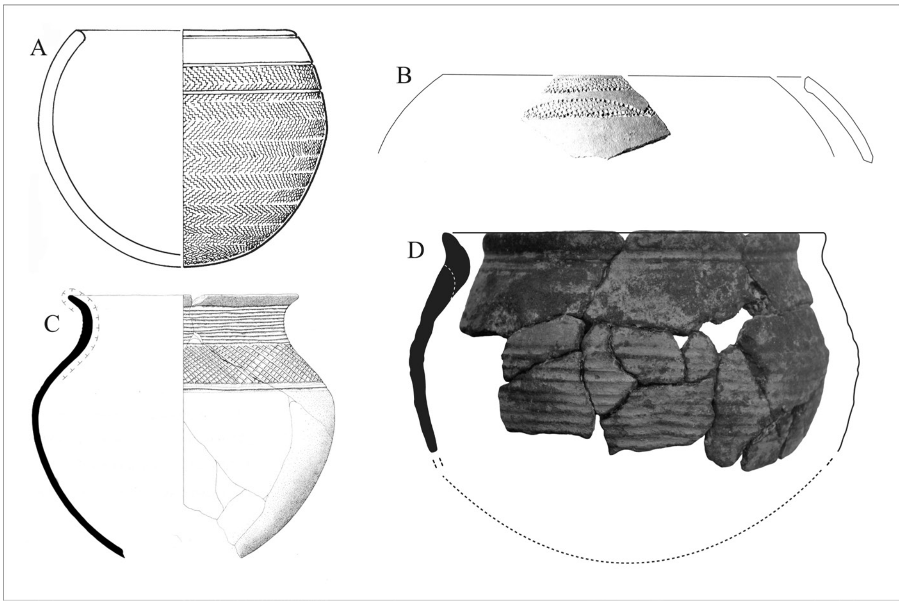

Fig. 4. Pottery finds may be illustrated in various manners depending on regional and academic traditions. This may be done by drawing the section and surface of the vessels as in A (after Mayor 2011) or C (after de Maret 1985) or by combining drawings and photographs with the help of computer programmes as in B (after Wendt 2007) or D. (after Delvoye 2012). Whatever the system it is important that surface treatments (including decorations) be clearly illustrated and photographed. Whatever the system, the final plates should include a reference to the exact origin of the potsherd (i.e. site and context of discovery).

surface and to keep them close when you store them. They can also be temporarily refitted with a piece of paper tape. When all the refitting potsherds have been identified, they can be glued back together to form vessels (or at least their profiles). To do so it is best to start with the bases, working upwards towards the neck (**fig. 3**).

Refitting is very time consuming. If there are tens of thousands of potsherds to study, one may arbitrarily decide the time spent on it. One may also save time and energy by studying first a representative sample of the site.

C. Sorting, counting and describing

To simplify the analytical procedure, the material needs to be sorted in different categories depending on their usefulness – this is particularly true on very large sites yielding over a hundred thousand potsherds. Indeed, a little fragment with an eroded surface does not yield as much information as a well-preserved decorated fragment or a set of potsherds refitted to form an almost complete vessel. Sorting them in different groups, a. eroded, b. small, c. body sherds, d. shapes (i.e. bottom to neck sherds) also reduces the quantity of material to be studied in detail.

(a) All eroded body fragments have to be counted and stored. Indeed, they give us very little information even though their composition can be informative at a later stage.

(b) Very small potsherds (less than 2 cm in diameter) whose shape and decoration are difficult to interpret should be counted and stored. Very small potsherds, like eroded ones, are very difficult to interpret and can be a waste of time on large assemblages.

The results of steps a. and b. can be summarized in a table or expressed as a function of the number of eroded or small potsherds per stratigraphic unit in a graph.

(c) Body sherds are then described, counted and stored. Fragments with complex designs may be kept apart for future reference and illustration.

(d) Bottom and neck potsherds (including refitted fragments whose shape allow for a reconstruction of a partial or complete profile) must be catalogued for further analysis. This group enables the calculation of the minimum number of individual vessels in each context and to establish a general typology.

In order to establish the catalogue, all the finds in the last group (d) must be photographed and inserted in plates organised by context and depth in the pottery assemblage (one may add some of the body sherds bearing complex designs as they are not represented elsewhere). This catalogue, which may constitute a teamwork document or an annex to a Masters or PhD thesis, is above all the complete report on what was found at a site.[6] A last sorting will be needed in order to select potsherds sufficiently well preserved, or particularly characteristic, to be drawn for the published version of the catalogue (which, depending on the budget, should at least display a figure for every type of vessel identified). As regards drawing, an internet search using keywords such as “archaeology, drawing, pottery” provides many drawing tutorials, but there are many different ‘traditions’ as regards how to represent the vessels and one should make sure to fit within regional conventions (see for instance Huffman, this volume, pp. 180-186) (**fig. 4**).

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[6] This is crucial as we know that collections may later be lost or deteriorate due to poor preservation conditions.

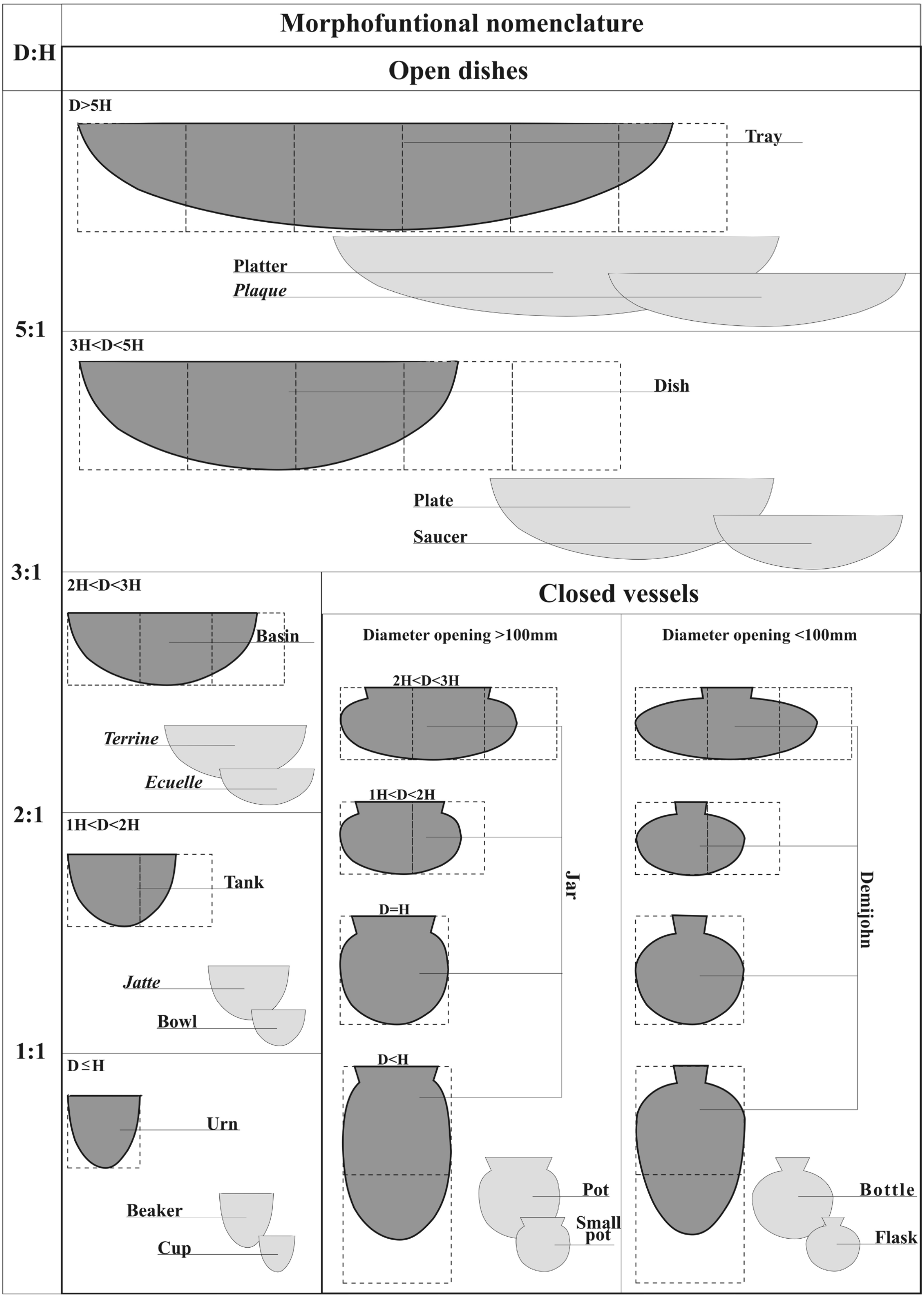

Fig. 5. P. de Maret (1985: 282), inspired by other researchers, suggested using a simple system to name the different types of vessels. This nomenclature should not be used as a strict classification system, as cases of continuum between some categories of vessels might occur, but it provides a simple way to sort out general forms, loosely related to broad functions. For example, once all the vessels that fall in the category of *bottles* have been identified in an assemblage, it is easy to go further and examine the various types of *bottles*. This scheme summarizes the various morphological categories and their nomenclature, it is based on a simple divide between *Open* and *Closed* vessels, sorted in three size classes, large (30cm<Diameter), medium (30cm<D<15cm) and small (D<15cm), depending on their maximum Diameter (D) - in each case the large size is in dark grey, with medium and small size in light grey. Open vessels are divided in four sub-categories depending on their diameter (D) to height (H) ratio. Closed vessels are divided in two sub-categories depending on the diameter at the opening (d): cooking & storing (d>10cm), liquid containers (d<10cm). Closed vessels with different D to H ratio are labelled under the same name because their function is essentially the same.

D. Analysis

Building a pottery typology can be done, theoretically, by confronting various existing pottery classifications or, intuitively, while building up the catalogue of finds. Here, we will focus on the second method. Indeed, it is rather easy, when building the catalogue of finds, layer by layer, to group vessels displaying similar shapes (**fig. 5**), and then with similar decorations (see Gallin 2011 for a robust decoration nomenclature).[7] Once the various categories of vessels in an assemblage are outlined (i.e. dishes, pots, bottles, jars, etc.), it is possible to distinguish different types within these categories (i.e. different kinds of bottles may be distinguished when considering the length of their neck or the shape of their belly, etc.). Unless the analyst is already very experienced, doing it gradually while laying out the pictures and drawings in correlation with the stratigraphy is easier than building a theoretical model in advance. The conclusion of this empirical and intuitive classification can be incorporated in a spreadsheet whose criteria include general information about the archaeological context of the vessel (latitude and longitude of the site, reference of the test-pit) and the detailed description of shapes, decoration, etc. (but see also Ozainne or Huffman this volume). This will permit the analyses of the spatial and chronological distribution of the various characteristics of pottery finds, at the site level (stratigraphic or plan analysis) or at a regional or continental level, using computer programs designed for this purpose (see for example http://www.qgis.org/en/site/, a free GIS software that can be used to make distribution maps).

Finally, it should be possible to establish typical pottery sets for a given area during a given period. A pottery set includes examples of all the types in each morpho-functional category, usually presented in one plate. It is useful, because it expresses in a simple way the range of vessels one may expect to find and highlights variations at the same time. For example, a certain type of 'cooking' pot may always be found in association with a series of other typical vessels (**fig. 6**). But it may also happen that in a given set, the type 'cooking' pot displays an important variability (**fig. 7**). Thus such sets make it more easy to identify stylistic variations that can be interpreted in terms of stratigraphic or cultural dynamics.

In many cases, it will only be possible to reconstruct partial shapes and some typologies are even built only on rim sherds. Whatever the case, the analyst should bear in mind that several shapes can share the same kind of opening or the same kind of base and frame their interpretation accordingly (**fig. 8**).

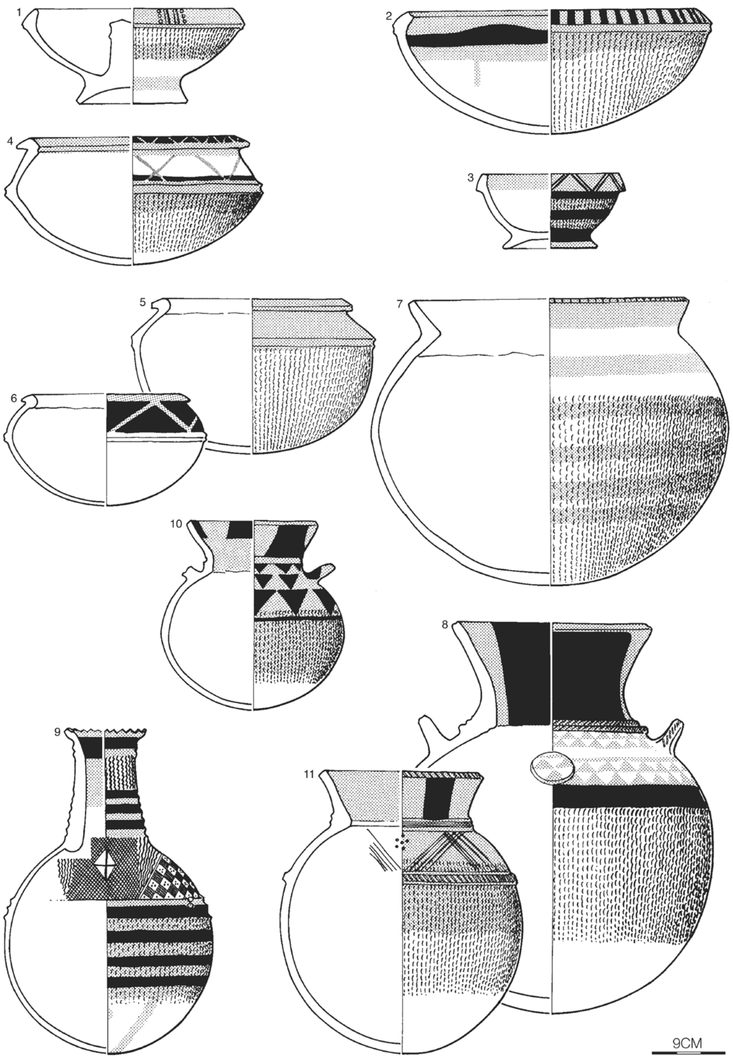

Fig. 6. Typical set of the Songhay pottery tradition of Mali, late 20th century AD (after Mayor 2011). As this material was produced by living potters their function is known: 1. ablutions; 2-3 washing; 4-6 cooking; 7-8 water storage; 10-11 water transport.

III. FURTHER ANALYSIS

When the typological and chronological framework of the pottery assemblages is firmly established, it is possible to answer some of the questions on stylistic variations by reconstructing pottery *chaînes opératoires* and studying their geographic distribution through time. Although there are important methodological gaps in the reconstruction of pottery manufacturing processes, a se-

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[7] Bearing in mind that the same shape may be represented several times with different decorations, but distinct shape may also be decorated in the same way. It is thus best to focus first on the shape and then on the decoration.

ries of analytical protocols are available (see van Doosselaere 2014 for a review) to identify raw materials and their preparation (combining mineralogical and chemical analysis), building methods (macroscopic examination of surfaces and fresh sections, x-radiography), ornamental methods (macroscopic examination and image analysis), firing techniques (archaeological data on firing structures and fuels combined with physical characteristics of the paste), post-firing treatments (no standardised analytical protocol), and use (macroscopic and binocular examination, analysis of food remains).

With minimal training, the observations and analysis can be done simply by looking at the potsherds (surface and sections) or examining them with a binocular microscope.

CONCLUSIONS

At the end, this process will allow the analyst to characterize typical sets of various types of vessels. For example, the typical set of an household assemblage will include vessels for service, cooking, storage and maybe some specific purpose items such as children's toys or sacred / ritual vessels. While the function of vessels is difficult to ascertain on archaeological pottery, it is possible to define broad morphological categories. It might then be possible to observe variations within a morphological category. For instance, one may observe that two distinct types of cooking pots were found on a given site or in an area. Differences generally mean that they were made by different people, but the question is 'how' different. The first possibility is that people were different because they did not live in the same time – in other words, one may observe diachronic variations (potsherds were found in the same levels, but they were made at different times and, later, mixed up in the archaeological layers). A second possibility is that vessels look different because people living more or less at the same time, but not in the same place, made them. Vessels can be carried far away from the place they were manufactured. But if different

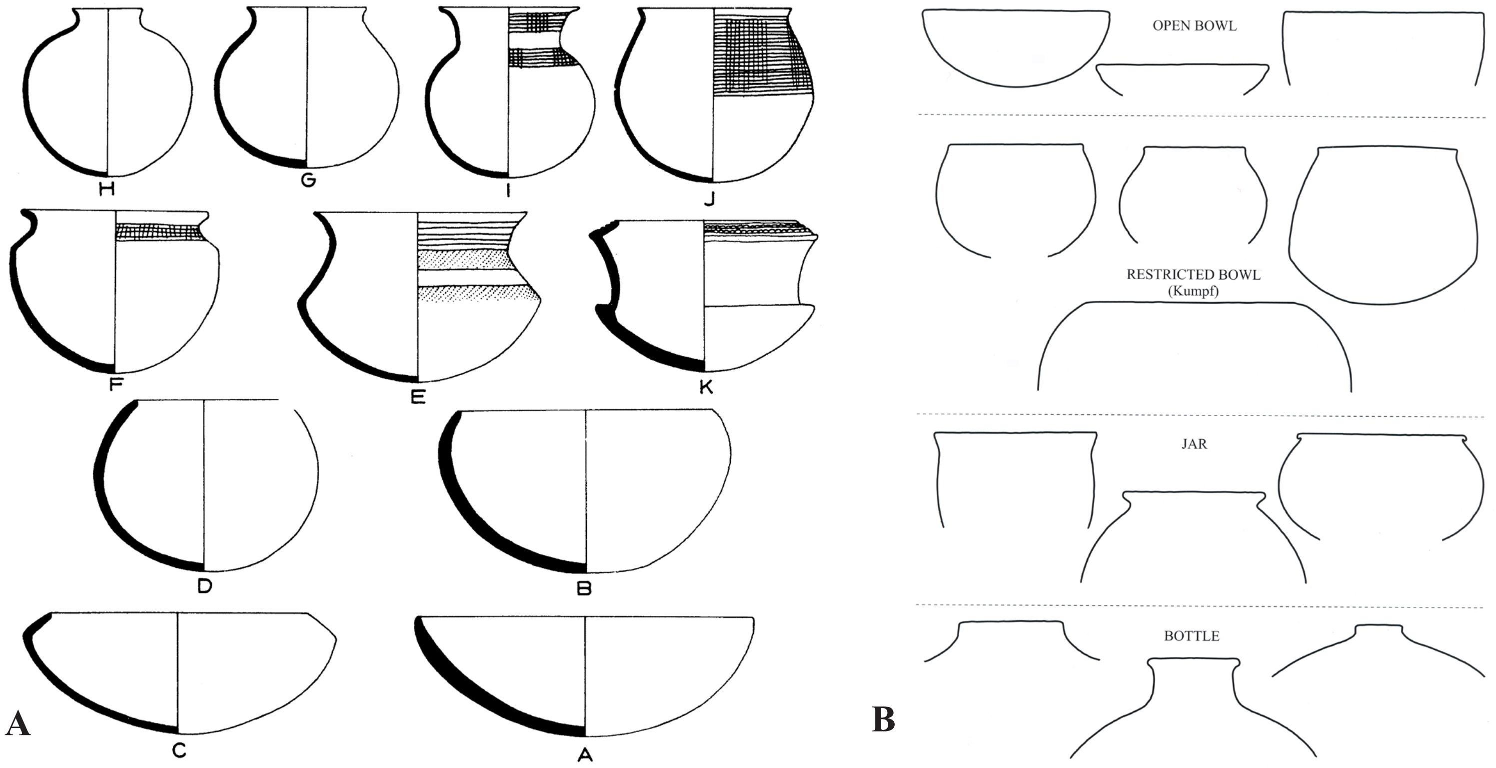

Fig. 7. Examples of archaeological pottery sets. **A**. Typical set of vessels that can be found in graves attributed to the Kabambian culture of the Upemba depression of DRC, 13th to 18th century AD (after de Maret 1985: 290) In this case, is it striking that the Kabambian funerary pottery set displays several types for the same category of *pots* (which can certainly be related to the chronological extension of this culture). **B**. Typical set of vessels found at the site of Gajiganna, Nigeria. They are attributed to the *Final Stone Age* and dated between 2500 and 3500 BP. The pottery material excavated from a settlement site did not yield as many complete vessel shapes as the aforementioned graveyards, but it is still possible to characterise typical pottery sets and outline variations within morphological categories. Exploring the chronological and spatial variation of such variations is the first step of interpretation.

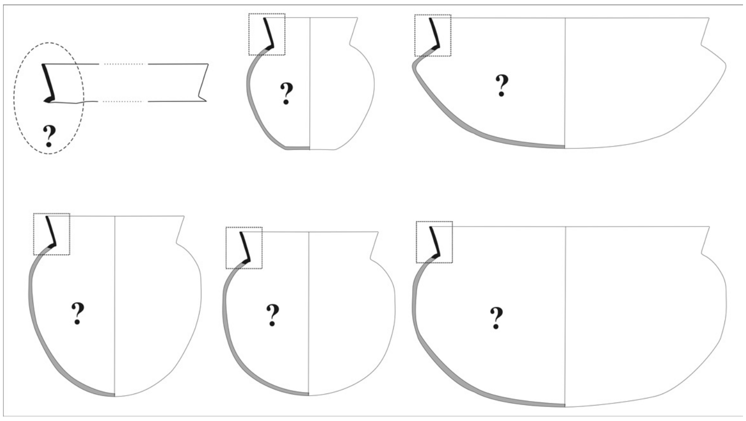

Fig. 8. One should be careful when using typologies based on pottery fragments only, as distinct categories of vessels may share, in part, similar profiles. In this example hypothetical case, based on archaeological observations, one can see that partial profiles offer a limited view of the assemblage. Refitting is crucial.

vessels from one morphological category were made at the same time and in the same place, they must have been made by people belonging to different social groups or sub-groups – for example, people belonging to different nations or distinct linguistics groups or even different sexes. In short, synchronic and local stylistic differences always mean that there is a certain degree of social distance between the producers.

The interpretation of pottery analytical results is a complex business. This contribution covers the first steps of the process and should be seen essentially as guideline. Ultimately, this protocol will need to be adapted to the archaeological material to which it is applied.

In the same way, interpretations drawn from this protocol will always be dependent on the questions the archaeological team will want to answer, but, ultimately, one should always bear in mind that archaeological pottery should inform us on the lifeway of past people. Before undertaking any analysis, always make sure it is going to achieve results that can be interpreted in terms of human behaviour.

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DEFINING POTTERY STYLES

Tom Huffman[1]

INTRODUCTION

All classifications are arbitrary in that many variables could be selected: the choice depends on the purpose of the classification. One purpose is to identify real groups of people in the archaeological record. By 'real groups' we mean people who shared a common history, language and cultural norms in contrast to other such groups. Many groups at this broad scale have used material- culture signatures to demarcate, negotiate and recreate their identity. Indeed, people sometimes use their material-culture differences to distinguish themselves from other groups with whom they interact daily (Hodder 1982). The material-culture signature at the group level often includes a common repertoire of designs on different items, ranging from small wooden boxes, headrests and meat platters to drums, smelting furnaces, houses and granaries, as well as the human body.

Fortunately for archaeologists, decorated pottery is part of this larger 'design field'. In the recent past, some 47% to 75% of designs found on other media also occurred on pottery. We know from archaeological evidence that design fields existed in the past, for designs on stone-walls also occurred on the pottery in 13th to 15th century Zimbabwe culture palaces, while designs on the famous Lydenburg ceramic masks also occurred on the associated 8th century pottery (Inskeep & Maggs 1975). This is the empirical justification for using ceramic style as a proxy for people. As long as the makers and users were the same (and the style is complex), ceramic style can be used to recognize groups of people, their movements and interactions with other groups.

I. GROUP IDENTITY THROUGH STYLISTIC ANALYSES

It is possible to characterize a ceramic style by a multi-dimensional analysis that selects three variables: profile, layout and decoration.

Vessel **profile** provides different areas to be decorated, while **layouts** are the combinations of different **decoration** positions used on any one vessel, for example rim (position 1), neck (position 2) and shoulder (position 3). Note that these positions must be determined from the assemblage under study. The variable of decoration encompasses all motifs that occupy a single decoration position. Combinations of the three variables create a **stylistic type** and the complete list of types defines the **ceramic unit** (called a '**facies**' in my scheme). **Figure 1** illustrates a set of interrelated jar types belonging to the Ziwa facies in Zimbabwe. Because the types are the result of repeated choices, this approach captures the underlying structure of a ceramic facies (Huffman 1980).

Note that the Ziwa types are based on complete profiles. Analyses based on shards alone are deceptively attractive but inadequate. They appear scientific in that they often have numerical codes and are easy to count. However, shard analyses can not characterize a style because they ignore purposeful combinations. More detail about determining stylistic types will be useful.

A. Procedure

Preparations begin in the field. Many archaeologists sort

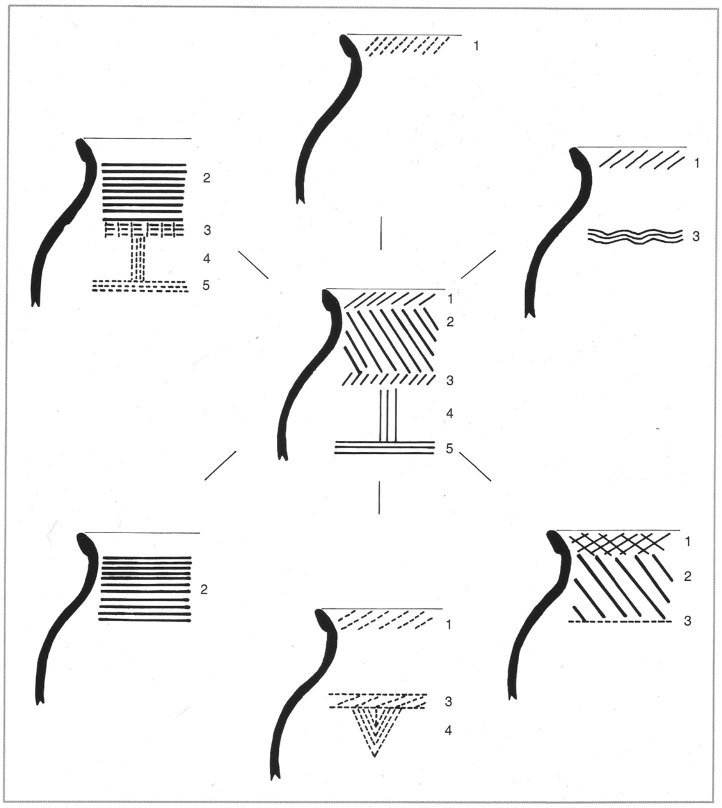

Fig. 1. Interrelated stylistic types of *Ziwa*. In terms of design layout, the outer types are simpler versions of the most complex type in centre. (From Huffman 2007: 112.)

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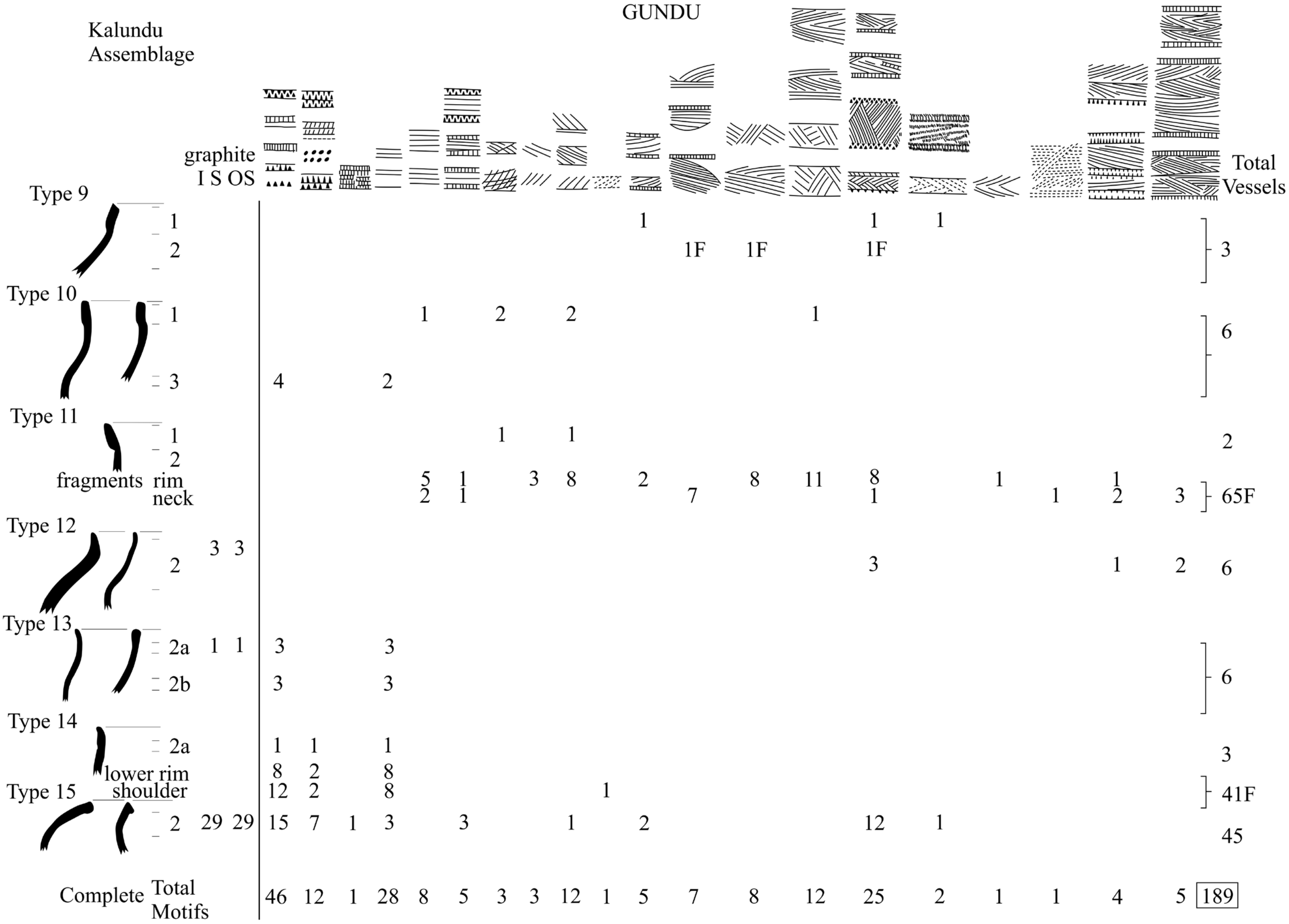

Fig. 2. Stylistic types of a *Kalundu* assemblage from the Gundu site in Zambia. (From Huffman 1989.)

on site, discarding small fragments and undecorated body shards (after counting them). One should keep a representative sample of different vessel parts for material analyses and fragments with a residue for functional analyses. If possible, the ceramic collection should be washed and labeled in the field. Ideally, the labels should be the excavation code (e.g. trench, square and level, or feature). At the least, there should be a number for each shard, from 1 to n. The analyst will want to return to the same vessel on different occasions and a unique number will prove invaluable. If this is the only number, excavation codes should be kept in a notebook.

Some simple steps help to save time and to organize the analysis. First, separate the shards into profile categories, for example recurved jars, straight-sided beakers and curved bowls. Refit fragments from the same vessel, and draw examples of each profile. Secondly, divide the profiles into vessels with the same layout; that is to say, decoration in the same positions. Refit fragments from the same vessel and draw examples of each layout. Vessels with the most decoration will help to determine the different decoration positions, as shown in **Figure 1**. Thirdly, divide the layouts by type of decoration, i.e. complete single bands, multiple bands, spaced motifs, animals, etc. Categories of decoration are more important than individual motifs. Once again, refit fragments from the same vessel and draw examples of each complete motif. You should now be able to determine stylistic types by the combination of profile, layout and motif. Draw examples of each type. The journals *Azania* and *Southern African Humanities* provide good examples. Good illustrations must be clear, easy to understand and representative.

A table is a useful format for describing types and it provides a check on the internal consistency of the analysis. A type that has decorations in positions 1 and 3, for example, should not have an example with decoration in

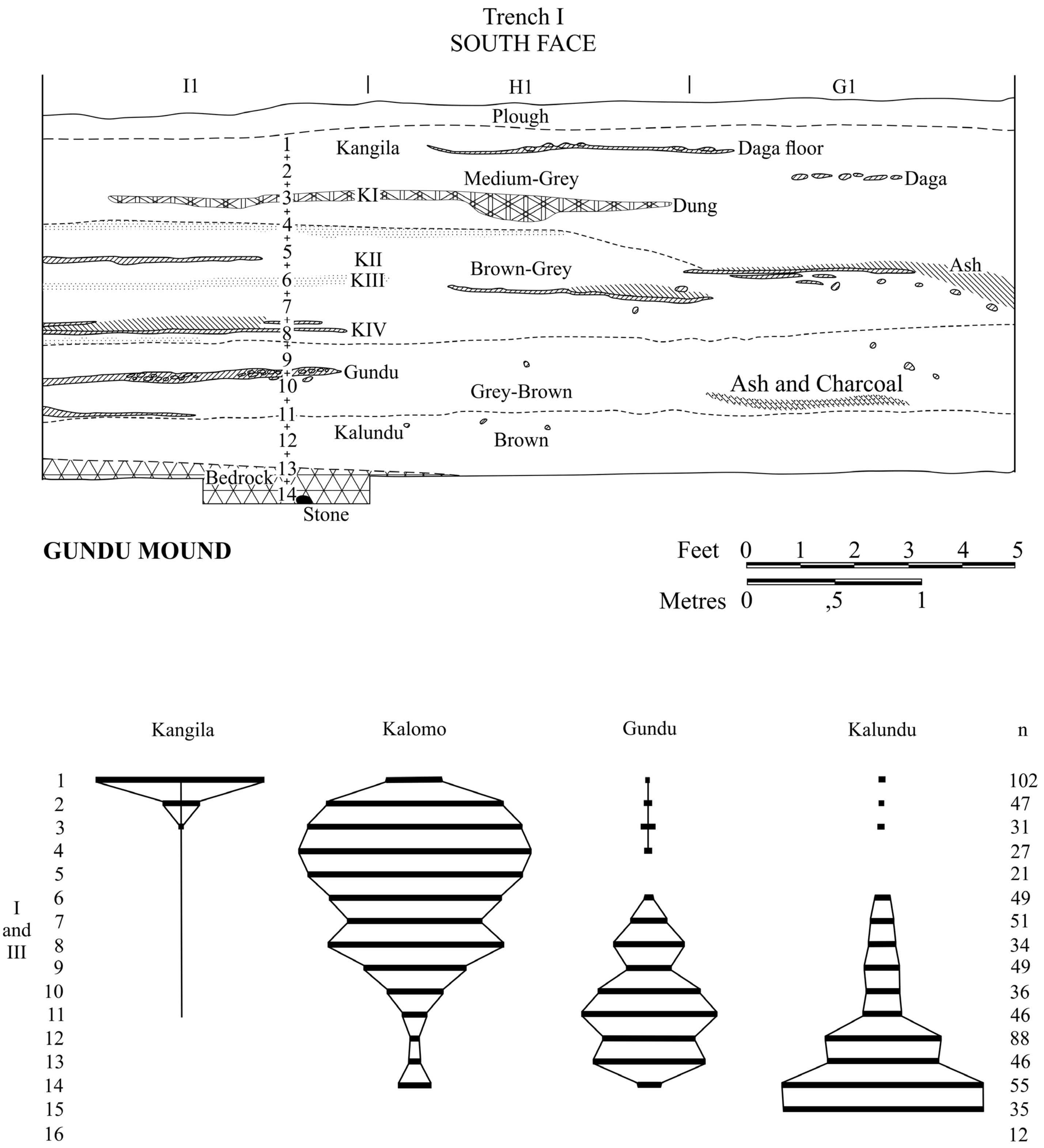

Fig. 3. Stratigraphic distribution of ceramic assemblages at the Gundu site in Zambia and section drawings of Trench I. (From Huffman 1989.)

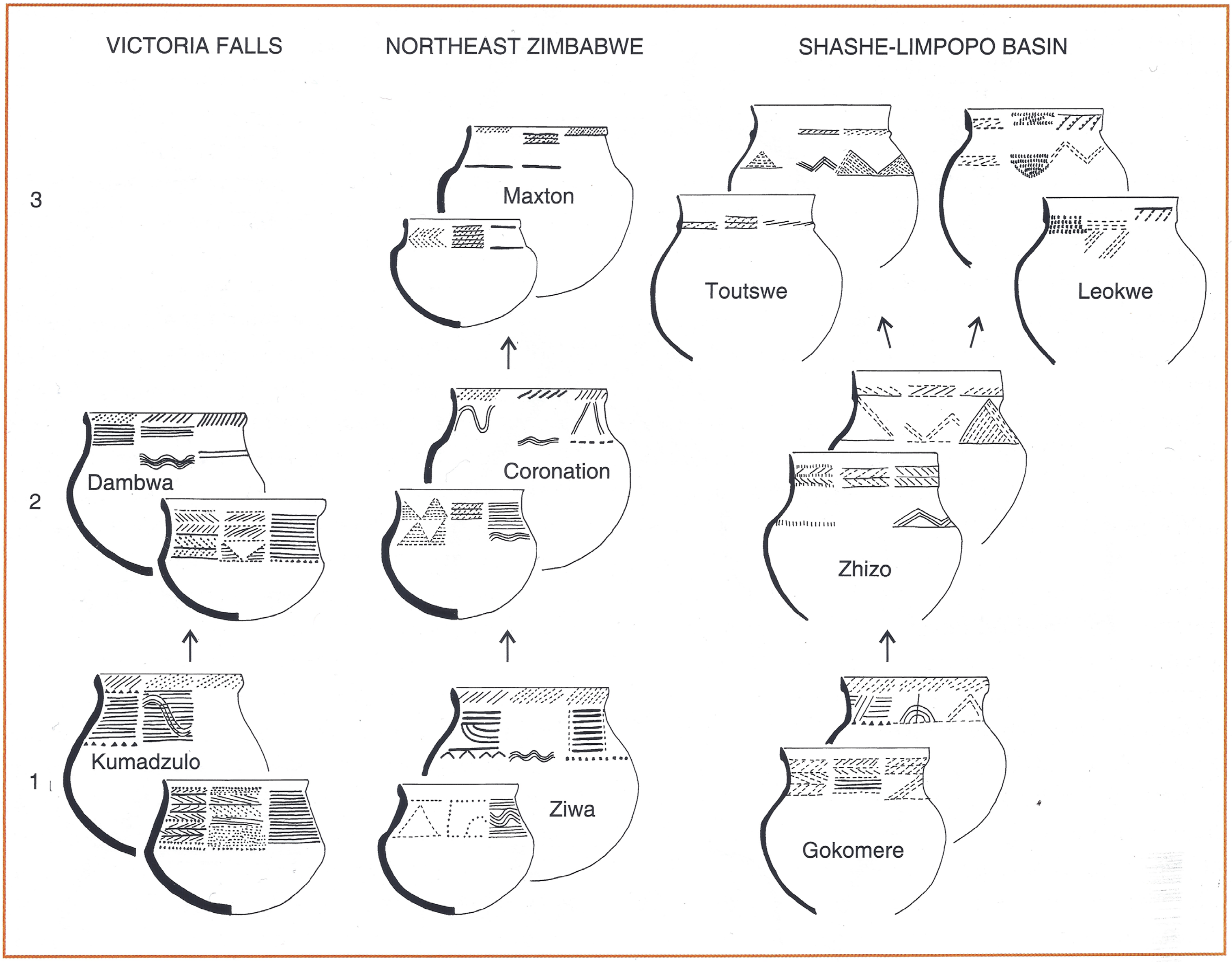

Fig. 4. Sequence of ceramic facies in the Nkope Branch of the Urewe Tradition; note the continuities. (From Huffman 2007: 114.)

position 2 (this was a common mistake of my students). Finally, compile a list of all complete motifs from the drawings. Here fragments can be useful. **Figure 2** lists the stylistic types for a Kalundu assemblage in Zambia (Huffman 1989); the range of motifs appears at the top, while profiles and positions of decoration are in the left-hand columns. Note how drawings are easier to understand than numerical codes.

Some analysts may wish to include plain vessels to be complete. One should remember, however, that plain vessels cannot form a multidimensional type because they lack a layout and decoration. Furthermore, a numerical comparison could create a spurious relationship between otherwise unrelated assemblages if both had many plain vessels (I return to numerical comparisons later). Plain vessels can nevertheless help to interpret site formation (See Assoko Ndong, this volume, pp. 120).

B. Stratigraphic distributions

Because much of a settlement is open space (up to 80%), overlapping village horizons are not always apparent during excavation. Ceramic distributions can help with this problem. First, large shards lying flat, or the location of reconstructed vessels, often mark a walking surface. Individual shards, on the other hand, can have a surprisingly wide horizontal and vertical distribution because of burrowing animals and because villagers themselves disturbed the ground by digging post holes, trenches and pits of various kinds (e.g. burial, soil and storage). This is another reason for refitting fragments. Furthermore, fragments of the same vessel in a midden, say, and house rubble link these two activity areas to the same horizon. But otherwise, the horizontal distribution of stylistic types reveals little about activity areas in a single village. Functional types based on shapes and sizes are better suited

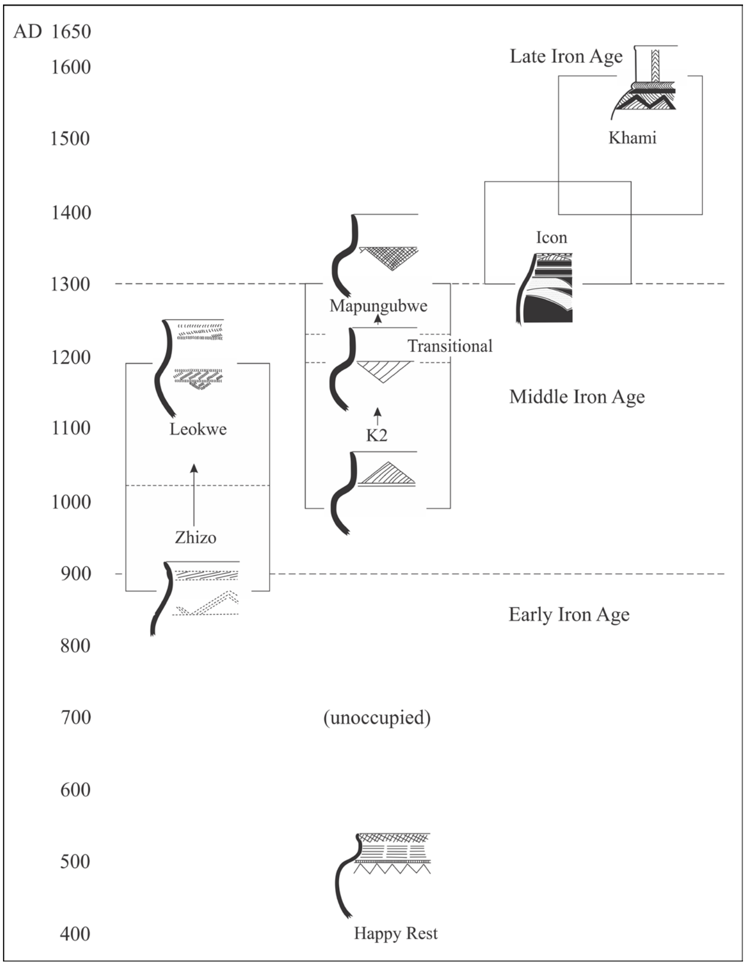

Fig. 5. Culture-history sequence for the Mapungubwe landscape.

for this purpose. In a large complex settlement, however, different styles in different areas at the same level may reveal group interaction.

Secondly, the vertical distribution of shards and vessels can reveal separate village horizons.In this regard, stratigraphic tables should replicate reality, so the deepest levels should be at the bottom. The oldest types will then be the lowest in the deposit. **Figure 3** presents one such plot for a site in Zambia with four components. Note that the proportions of each group are calculated in terms of the total for each horizontal level, not the vertical axis. Coupled with other excavation data, the Kalundu horizon in Trench I encompasses levels 15 to 14; the Gundu horizon levels 13 to 10; and the Kalomo horizon from levels 9 to 2. Other data show that the Kalomo horizon encompassed several separate village levels with the same pottery. Thus, the ceramic distribution needs to be coupled with other excavation data.

The vertical distribution of vessels can also help to determine whether a site was continuously or intermittently occupied. Fragments are not so helpful because of their mobility. In the case of reconstructed vessels and large fragments, vertically spaced clusters indicate that a site was not continuously occupied. **Table 1** presents a hypothetical distribution of vessels from three occupations: Group A from levels 11 to 9; Group B from levels 5 to 2; Group C in level 1. Note how the distribution of fragments suggests continuous occupation but not the vessels and large pieces. Rather than fragments, stratified house floors with the same pottery, as in the Kalomo levels in **Figure 3**, indicate continuous occupation.

The stratigraphic distribution of different styles at a number of sites forms the framework for a culture-history sequence: the who, when and where of the archaeological record.

II. CULTURE-HISTORY SEQUENCES

In areas with little or no previous research, a culture-history sequence is a primary goal. These sequences are basic to other studies, such as lifeways, paleo-environments and the explanation of change.

A. Continuity and discontinuity

A sequence is formed by comparing the ceramic styles from several sites and then arranging them in chronological order. Often, a visual inspection is sufficient, especially when the styles are based on multidimensional types. **Figure 4** illustrates a sequence of different facies in the same tradition. Note that the stylistic structure remains similar through time: changes occur in the popularity of specific layouts and motifs, and a reduction in the size of motifs and decoration positions. Clearly, ceramic change is not random: what occurred before conditions what is acceptable in the future. Ceramic change is also not random because it is constrained by the conventions of the larger design field

Besides visual inspection, it is possible to compare styles both quantitatively and qualitatively (see **Table 2**). In this case, one simply lists the types on one side of a table, put the styles across the top (either from sites or facies) and count the types in common, either by presence/absence, log scores or actual numbers: how one counts is not as important as what one counts. Table 2 presents a hypothetical example: here Style A is not related to either Style B (12.5%) or C (13.3%), but B and C are closely related (80%).

Figure 5 presents a sequence for the Mapungubwe

Level	Group A	Group B	Group C	Total
1	4 (1f)	11 (2f)	7 (5f)	**22 (8f)**
2	2 (5f)	7 (3f) large pieces	(3f)	**9 (11f)**
3	1 (5f)	6 (5f) large pieces		**7 (10f)**
4	5 (11f)	4 large pieces		**9 (11f)**
5	3 (7f)	3 (3f) large piece		**10 (10f)**
6	2 (9f)			**2 (9f)**
7	(3f) small			**(3f)**
8	4 (8f)	1		**5 (8f)**
9	14 (18f) large pieces	4		**18 (18f)**
10	5 (20f) large pieces			**5 (20f)**
11	7 (18f) large pieces			**7 (18f)**

Table 1. Hypothetical distribution of ceramic groups showing three occupation horizons: group A from levels 11 to 9; group B from levels 5 to 2; group C in level 1.

	Style A	Style B	Style C
Type 1	X		
Type 2	X		
Type 3	X		
Type 4	X		
Type 5	X		
Type 6	X		
Type 7	X		
Type 8	X	X	X
Type 9		X	
Type 10		X	
Type 11		X	X
Type 12		X	X
Type 13		X	X
Type 14		X	X
Type 15		X	X
Type 16			X
Total	**8**	**8**	**7**

A/B = 2/16 x 100 = 12.5%; **A/C** = 2/15 x 100 = 13.3%; **B/C** = 12/15 x 100 = 80%

Table 2. Hypothetical occurrence of types at three sites and their similarity indices.

landscape that includes unrelated facies. In this sequence, K2, Icon and Khami represent population movements because they have different stylistic structures (i.e. different layouts and motifs) and they occur earlier somewhere else. The sequence from K2 to Mapungubwe, on the other hand, represents an ethno-linguistic continuity (i.e. a continuity in history, language and cultural norms). Note that comb-stamping dominates Zhizo and Leokwe pottery in contrast to incision in K2, TK2 and Mapungubwe. These different decoration techniques are useful as keys to help identify different facies in the field. Field keys, however, do not define a ceramic facies because they are based on isolated elements; only multidimensional types serve that purpose.

This sequence illustrates a few other related points.

B. Boundaries and interaction

In Hodder's (1982) East African study, the degree of interaction did not create group identities: the identities were the result of shared histories, cultural norms and so on in contrast to other such groups. The boundaries between groups were most marked when there was economic competition. In the Mapungubwe landscape, the Motloutse River marked such a boundary during the Middle Iron Age: to the west Toutswe pottery was dominant, while K2 pottery characterised settlements to the east.

Because the origin of a style resides in group identity, when the makers and users are the same (and the style is complex), the distribution of the style mirrors the distribution of the group. But there are times when pottery of one style appears in another style area as a result of marriage alliances. In the Shona world, for example, a new bride is supposed to take various unused items from her maternal home to her new abode, and pots are one of these (Aschwanden 1982: 189-194). If the woman comes from a different style area, the marriage introduces a 'foreign' vessel into the husband's village.

In addition to marriage alliances, a ceramic style may not represent a single group. For various reasons, people may adopt another language and political identity. In such contexts, ceramic style may reflect the dominant group, while the social minority may retain other aspects of their material culture (such as household organization). In other contexts, material-culture signatures may not reflect a previous identity because the people were totally assimilated or because they merged to form new identities.

In complex social situations such as these, the relationship between ceramic style and real groups of people is not straightforward. This is why the study of group identity through ceramics is intellectually challenging.

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IRON OBJECTS

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INTRODUCTION

Metallic iron is not stable under atmospheric conditions; in the presence of oxygen and water it corrodes to iron oxides and hydroxides. Iron is more reactive than copper, and thus copper objects are generally better preserved than iron objects where these occur together in an archaeological assemblage. The rate of corrosion of iron is greatly increased by the presence of chloride ions, so iron from shipwrecks and from coastal archaeological sites is usually much more heavily corroded than iron from sites inland. Conversely, where humidity is low and chloride ions are absent, as in tombs of Egyptian elites, the preservation of iron may be excellent – as seen for example in the iron dagger (probably of Anatolian origin) in the tomb of Tutankamum (died 1323 BCE).

I. EXCAVATION OF IRON FORGING SITES

Forges at which iron blooms were worked into iron artefacts are often difficult to recognize in Africa, where many smiths worked in the open air – the remains of the forge fire may be as simple as a small pit in the ground surface, and the anvil just a flat rock. The most recognizable artefacts associated with forges are the small planoconvex or cylindrical slags that accumulated at the bottom of the forge pit. These formed by reaction between iron oxide scale that flaked off the hot iron and the clay and sand at the base of the forge pit. They may also incorporate slag that was squeezed out of pieces of hot bloom during forging. **Figure 1** shows a forge site in Senegal that has been excavated down to the base level of the slag pits. Each of these pits was formerly underneath a forge fire. When the pit filled with slag, the forge fire was relocated over a new pit. The area of compacted soil is presumed to mark the spot where a rock anvil was once located.

Not all iron forges form such distinctive slags (e.g. Soulignac 2014), but around all forges one can find tiny thin flakes of hammerscale, and tiny spheres of slag (1-2 mm) that were expelled as liquid from the hot iron by the impact of the hammer, and solidified in travel through the air. These flakes and spheres are strongly magnetic, so the soil around a suspected forge should always be tested with a strong magnet. Any material attracted to the magnet should be compared to the excellent illustrations of hammer scale and slag spherules in Allen (1986). Small scraps of iron that were cut off, or fell off, the objects during forging are also often found on the ground around forges.

Fig. 1. A forge site in Senegal excavated down to the base level of the slag pits. (Photo © D. Killick.)

II. TREATMENT AFTER EXCAVATION

A. Conservation

There should in theory be no metallic iron remaining in thin iron objects (blades, hoes, wires, etc.) after a thousand years in contact with tropical soils, but in fact there sometimes is a core of metallic iron within the object. This has survived because an impermeable jacket of corrosion had formed, preventing water and oxygen from penetrating further into the object. The corrosion jacket is however easily cracked during excavation, which allows corrosion to begin again. A strong response of an 'iron' object to a magnet does not necessarily mean that there is any metallic iron left in the object, as the first product of corrosion is magnetite (Fe_3O_4), which is also strongly magnetic. The best way to find whether there is iron in the core, and to infer the original morphology of a heavily corroded object, is to take an x-ray image – a conventional medical x-ray system works well for this. If this is not available, a very careful cut into the side of an object with a hacksaw blade can establish whether there is an iron core.

Iron objects tend to corrode rapidly after excavation because of cracks in their corrosion jackets induced by

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trowels and other tools. Conservation of archaeological iron is difficult and expensive. The usual technique is to remove all chloride ions by multiple changes of distilled water, preferably assisted by electrolysis, and then to dry the object thoroughly. It must then be stored in a room with constant low humidity, or packed in a tightly sealed container with silica gel, which absorbs water vapour (and must be baked out 3-4 times per year to restore its capacity to absorb water). Iron objects should not be stored in standard paper bags or cardboard (which are made of acid paper) nor placed directly on wooden shelves.

If long-term conservation of iron objects is simply too expensive, then they must be documented before they are completely destroyed by post-excavation corrosion – which in humid environments can occur in as little as five years. Many iron objects are unrecognizable when excavated because of an irregular coating of soil cemented by iron hydroxides from the corrosion of the object. This coating can be removed by gentle scraping, or by a small electric grinding tool, until the original morphology of the object is revealed, at which point it should be drawn and/or photographed. The original surface will not be metallic, but can be recognized by change of colour and the absence of sand grains.

B. Metallography and chemical analysis

Surface techniques of chemical analysis, such as x-ray fluorescence, usually yield no useful information on iron artefacts because they do not penetrate through the corrosion. Scientific study of corroded iron artefacts is done on cross-sections or longitudinal sections removed from artefacts with a hacksaw or wafering saw. The sections are then mounted in epoxy or bakelite resin, ground flat and highly polished for the metallurgical microscope (Scott 2014). Etching of the polished surface with very dilute nitric acid reveals the grain structure of the metal, and whether the material is pure iron (ferrite), steel (0.3-2.0% carbon) or cast iron (>2.0% carbon). It can also reveal whether the artifact was forged from a single piece of metal, or assembled by forge-welding two or more pieces together, and whether steel (if present) was placed where it would be most effective – i.e. on the cutting edges of knives and axes.

The metallographer can also distinguish between steel that was slowly cooled in air (pearlite microstructure) and steel that was rapidly quenched in water (martensitic microstructure) and subsequently tempered in a cool fire to achieve a good balance of hardness and toughness (bainitic microstructure). Quenched and tempered steel is much harder than air-cooled steel, but at present there is little evidence for such treatment of steel in precolonial sub-Saharan Africa. This may simply reflect the fact that relatively little metallography of ancient African iron has been done outside South Africa (for which see Miller 2002). Much more metallography needs to be done in other parts of Africa before any reliable conclusions can be drawn about the technical skills of ancient or historic African blacksmiths.

The oldest objects of forged iron on the African continent are from Predynastic Egypt and date to about 3200 BCE (Rehren *et al.* 2013). Although they are completely corroded, they are definitely identified as forged pieces of an iron meteorite by the relatively high levels of nickel, cobalt and germanium in the corrosion products. Any iron artifact in Africa that is dated to earlier than ca. 500 BCE should always have the concentrations of these elements measured by some sensitive bulk technique, such as neutron activation analysis, to check whether the object in question is meteoritic or smelted iron. Meteoritic iron also has a characteristic appearance in metallography (Widmanstätten structure), though this may be significantly distorted by forging. The presence of nickel alone in iron does not necessarily prove meteoric origin. Nickel is concentrated in ultrabasic rocks, which are present in many parts of Africa, and nickel may accumulate in the laterites that form over them. Since nickel oxide is more easily reduced than iron oxide, the smelting of these laterites will produce iron-nickel alloys.

C. Provenance

Unlike copper, iron cannot usually be traced to a particular ore source. This is because iron is a common element (7.06% of the earth's crust by mass) whereas copper is a rare element (75 ppm) (Killick 2014, Table 2.1). There are therefore relatively few copper ore bodies, and these are of limited spatial extent and generally well separated from each other. The iron ore used in many parts of sub-Saharan Africa was laterite, which formed in the soil by tropical weathering. Laterites may form continuous sheets over hundreds or even thousands of kilometres on the major African cratons, and there is no reason to believe that would be chemically distinct regions within these that could be realistically distinguished as 'sources'. There are however some less common ores that leave chemical traces in the metal, so it may sometimes be possible to recognize the type of ore used, if not the specific location where it was obtained. Abdu and Gordon (2004) have shown that some post-Meroitic iron in Nubia contains distinctive levels of arsenic and phosphorus. African iron artifacts smelted by the bloomery process always contain minute stringers of entrapped slag, and the composition of these can be measured by scanning electron microscope or by electron microprobe. Slag stringers in archaeological iron from the Lowveld of north-eastern South Africa sometimes show high levels of titanium and vanadium, which result from the smelting of magnetite-ilmenite ore from Precambrian igneous intrusions (Gordon and van der Merwe 1984).

D. Direct dating of iron and steel

In precolonial Africa iron was always smelted with charcoal, not with coal, and forges were fuelled by charcoal or wood – or, in some arid areas, with dung. Any steel produced in furnace or forges using biomass fuel will therefore contain radiocarbon, and thus steel artefacts can be directly dated if necessary. Usually iron objects are dated by association with radiocarbon dates obtained on charcoal (preferably from annual or short-lived plants) but if there are doubts about the association of the steel object with the charcoal sample(s), then it makes sense to date the steel objects directly (e.g. Kusimba *et al.* 1994).

CONCLUSION

African iron artefacts have been much studied by art historians, but within archaeology much more attention has been paid to iron smelting than to iron smithing, and forged iron artefacts themselves have received even less technical study. Iron artefacts are a potentially important source of information on technological knowledge and skills in past African societies, but these can only be inferred from chemical and metallographic data. Iron typically deteriorates rapidly after excavation unless treated by conservators. If the expense of conservation cannot be justified, then full documentation (cleaning, photography, illustration) and scientific study must be done as soon as possible after excavation.

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COPPER

Laurence Garenne-Marot[1]

INTRODUCTION

Copper's importance in sub-Saharan Africa was emphasised by Eugenia Herbert (1984) in *Red Gold of Africa*, an irreplaceable work on the metal's cultural, economic and technological history over the long term and across the continent. Copper recovered south of the Sahara has been circulating in the form of finished products and semi-finished ones such as ingots and other 'metal reserves' that, depending on the time and place, could be prestigious objects and other social status emblems, or monetary objects in the Aristotelian sense – that is, as a store of value, a medium of exchange, or even, in some cases, a monetary unit (see Nikis, this volume, pp. 197-201 and **fig. 1**). In some regions, its value was equal to gold's today. In the Muslim trans-Saharan trade, North African copper was, next to salt, the most sought-after product in exchange for gold, yet even its vast reach did not stop local exploitation of West African Sahelian deposits and perhaps even stimulated it (Garenne-Marot 1993 ; 2007).

Copper ore is much less widespread than iron ore, and modern mining often obliterated ancient remains, but deposits in West, Central and Southern Africa were largely exploited in the past.

Many remnants of ancient copper production exist: mines and ores, primary and secondary metallurgical installations, semi-finished (ingots) and finished objects. Copper metallurgical techniques all along the production chain vary according to region and period. Documenting all the chain's stages, from the mine to finished product, would of course be the ideal way of writing a history of copper metallurgy in Africa. But often the object, whether finished or semi-finished, is the sole witness of a metallurgical tradition. Nevertheless, if it comes from a dated archaeological context, the copper object holds information that targeted analyses will help to reveal.

I. MATERIAL CHARACTERISTICS

Copper has many qualities: hardness, durability, lustre but also sonority (it is the metal of bells!). Unlike ceramics, it is almost infinitely reusable with the same renewed capacities of plastic deformation. It is exceptionally resistant to being buried. Copper or copper alloy is often the sole evidence of long distance relations: in the case of the trans-Saharan trade, it is the main indicator of exchanges because salt, like other perishable goods, has disappeared from archaeological layers. On the other hand, copper-based metal's longevity and infinite reusability make its use as a chronological indicator highly relative.

A. Iron and copper: essential differences

Copper can be alloyed with other metals, altering its plasticity and aesthetic properties. This is different from iron. Before blast furnaces and the possibility of reaching temperatures high enough to melt and alloy iron with other metals such as nickel, chrome or aluminium, the only element with which iron could be alloyed was carbon, and steel types are determined by their amount of carbon content. Copper, however, is found in an entire range of metals known since ancient times: pure copper and alloys, whether binary (copper with lead, bronze or brass), ternary (bronze with lead, brass with lead) or even quaternary (**fig. 2**).

Copper's malleability allows a wide range of shapes and sizes. It can be formed by forging, hammering and stretching – the same techniques for shaping iron – but also by casting the liquid metal in open or closed moulds, which in the case of the lost wax (or latex) casting technique can produce a metal object of complex geometry (**fig. 4**).

II. CHARACTERISING METAL AND COPPER OBJECT PRODUCTION TECHNIQUES: AN 'AUTOPSY'

Studying metallic objects reveals their metal's characteristics and how they were made.

Visual surface examination can reveal signs of how the object was made, such as welds, casting defects, repairs, etc. The metal's appearance is, however, misleading: the archaeological object is covered with a layer of corrosion that completely masks its original colour (**fig. 3**). Pure copper is red/pink and becomes more or less golden when alloyed – though colour alone cannot determine with which metals. Only elemental analysis can determine the exact composition.

A. Metallic composition analyses or elemental analyses

These analyses determine the metal's composition. Two types of elements are highlighted: alloying elements, that

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[1] Heritage Studies service, RMCA.

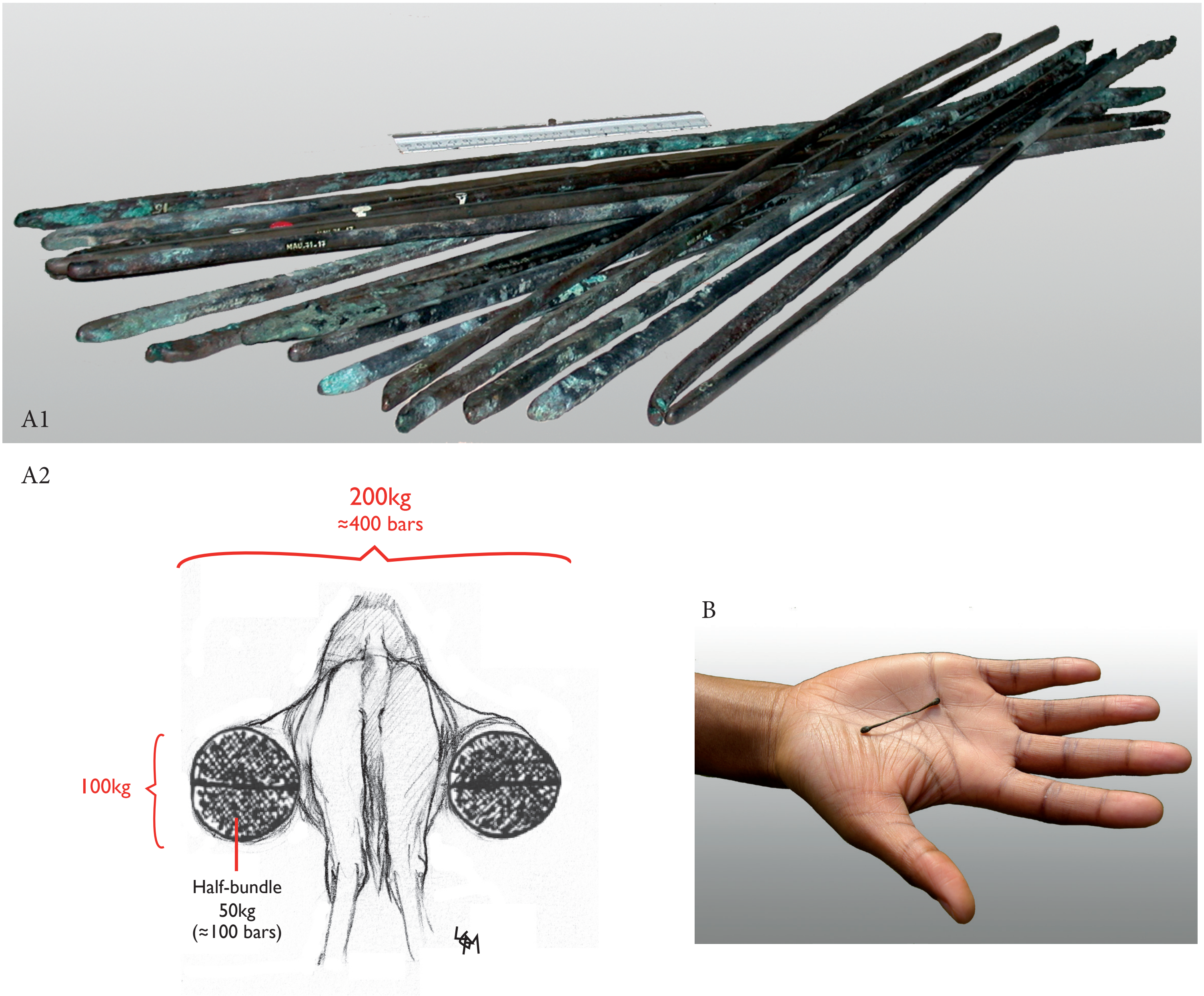

Fig. 1. A. 1: Some of the 2,085 brass ingots/bars from the Ma'den Ijâfen's lost caravan, discovered by Th. Monod in 1964 in the Mauritanian Sahara. Each bar is 70 cm long and weights about 500 g. **2:**They were arranged in bundles of about a hundred bars to be transported by camel. (Collection IFAN – Cheikh-Anta-Diop (Dakar); Th. Monod, 1969; photo and drawing © L. Garenne-Marot. **B.** One of the smallest forms of traded copper (averaging 35 mm long and weighing 4 g): the 'double-headed wires', interpreted as currencies, fractional 'coins' of low purchasing power, found in large numbers in the excavations of Koumbi Saleh (Mauritania). (Collection Centre d'Études des Mondes africains, Paris; photo © J. Polet.)

is, metals (tin, zinc, lead, etc.) deliberately added to the copper to modify its properties, and trace elements from ores. The analyses are conducted according to available equipment, the possibilities or not of obtaining a sample and working on the surface layers (patina, excavation conditions) or on the constituent metal.

B. Analysis of the metal's internal structure

1. X-rays

X-rays reveal the object's insides – whether hollow (with or without a core) or solid – how it was cast, presence of joining– welds, rivets, interlocking – and any repairs. In complex pieces, new techniques used in medical scanning, such as tomography, can provide a more precise reading of every structural feature without the interference of superimposing planes.

2. Metallographic analysis

This reveals the metal's microstructure and thus the thermal or mechanical processes it underwent, from which can be deduced how it was made (hammered or cast) and subsequent treatments (annealing and hammering).

Terminology	**Definition**	**Technical qualities**
Copper		
Rarely pure. It contains traces of other elements (zinc, arsenic, iron, lead, etc.) from ores		Malleability (copper lends itself remarkably well to bending and stamping operations), ductility. By hammering copper (to a lesser degree than bronze) can acquire a fairly high hardness. However, copper is a poor casting material.
Binary alloys		
Bronze	Copper is the major element and the rate of tin varies (on average 10%).	The mechanical properties of bronzes are an increase in hardness with the addition of tin to copper. The most notable qualities are those of foundry: bronzes flow easily. The melting temperature decreases as the proportion of tin increases (900° for a 20% tin bronze; 760° for a 30% tin bronze). Less than 13% of tin bronzes are cold workable. Bronzes with over 13% and less than 33% of tin can be forged hot. The properties of hardness, but also fragility and sound (the bronze of the bells is a 20% to 25% tin alloy), increases with the percentage of tin. Finally, the colour of the alloy varies with the composition: from a golden colour with 15% tin, it brightens to become almost white to the rates above 25% of tin.
Brass	Copper is the major element and the rate of zinc varies between 10 and 30% for ancient brasses.	Up to 40% of zinc, brasses have mechanical properties that are reminiscent of those of copper (e.g. ductility and malleability), well above that of bronzes. Thus they well tolerate processes such as hot and cold hammering, drawing, stamping, etc. Brasses have good casting qualities, especially for alloys with more than 25% of zinc. The melting temperature decreases when the percentage of zinc increases (1030° for a brass of 20% zinc; 950° for one of 30% zinc). The colour has a special importance: close to that of copper until about 10% addition of zinc, it gradually turns to a gold-like colour between 15 and 20%, with a more greenish gold colour around 25% and returns to a gold colour, of a clearer hue, around 40%.
Ternary alloys		
Leaded bronze	Same ratio of copper to tin as in binary bronze but with an addition of lead that could exceed 10%.	The amount of lead rarely exceeds 30% of the total weight of the alloy. This limitation is imposed by the difficulty in avoiding segregation of the lead (which isolates itself in fine globules during solidification), which grows with the percentage of this element. Beyond 2-3% lead, mechanical properties change rapidly: the alloy poorly resists the efforts of drawing, bending, and twisting; it is not very malleable when cold, and little more so when heated. On the other hand, it provides the alloys with two interesting properties: the melting temperature is significantly reduced when the percentage of lead rises; more interestingly, all methods that proceed by removing (or grubbing-up) metal shavings –working with limes and chisels, drilling, sawing, etc.- are eased (the phenomenon is probably related to the discontinuous texture of the alloy where the lead grains form a succession of weak areas that help in the removal of the metal shavings).
Leaded brass	Same ratio of copper to zinc as in binary brass but with an addition of lead that could exceed 10%.	
Quaternary alloys		
Copper + tin + zinc + lead	Varying proportions for tin, zinc and lead with copper remaining the major metal.	It is an alloy found regularly in archaeological contexts. The addition of alloying elements may be deliberate: this is the casting alloy of old and modern foundries. Indeed the zinc acts as a deoxidizer and improves the castability while lead improves the chiseling work. But it can also be the accidental result of a remelting of scrap material of different bronze and brass compositions.
In the art history books or those aimed at the general readership, one finds the term « bronze » often erroneously used to designate all non-analyzed objects of which copper is the main component while the 'true' bronze is an alloy of copper and tin. Comments on the technical qualities of copper and its alloys are inspired by Picon M., Boucher S. et Condamin J., 1966. Recherches techniques sur les bronzes de Gaule romaine, *Gallia* 24, 1 : 189-215. Of course alloys mentioned here are those known before the industrial era when other copper alloys such as the cupro-aluminiums, cupro-nickels, maillechorts (Cu, Ni, and Zn), etc. will be manufactured. Here are listed both functional and aesthetic qualities of the alloys because the criteria in the choice of a specific metal quality may not rely on just the mechanical or forming qualities but on other ones such as colour or sonority (e.g., the high tin bronze with over 13% of tin used for hammered vessels, requiring a difficult hot-forging forming but yielding white and sonorous cups and plates. Alloying was used for a variety of purposes: functional, aesthetic, ritual, and/or simply expedient. For example, the addition of tin to copper may have been done to increase strength and hardness for some objects, but may have been used to produce particular colors or fulfil ritual requirements in other objects. Or a mixture of alloyed scrap metal may have been the material available for a smith's selection. Also, different alternative exist to produce the desired effect such as hardness, colour, shape.		

Fig. 2. Table of copper and its alloys in the archaeological context of sub-Saharan Africa.

3. Specific analyses

The composition (clay, organic material) of any preserved core inside hollow castings can be analysed or even dated (using carbon-14 if carbon is present, or TL).

A good example of this kind of analyses of copper alloy objects was conducted by the British Museum Department of Conservation and Scientific Research (Craddock *et al.* 2013) in order to authenticate the 'Olokun head', which had been judged a fake in 1949. Scientists combined surface examination, metallographic, elemental and isotopic analyses, and analysis of its core – which identified specifically West African vegetation – to prove the sculpture's authenticity. It was indeed the original head discovered by L. Frobenius in 1910, and not a moulded copy.

III. ADVANTAGES AND LIMITATIONS OF THESE ANALYSES

A. Why analyse?

Analyses can identify some of the metallurgical techniques in question. Copper can be shaped in many ways: two objects seemingly identical in form could have been made according to very different production chains (*chaînes opératoires*). Choices of metal quality (pure copper, brass, bronze, etc.) and technical process are marks of past societies.

Analyses help describe the object in detail. Metal quality, technique and the *chaîne opératoire* constitute the object's internal typology. Comparing this with its external typology (shape and decoration) leads to a more accurate definition of typological groups.

Fig. 3. This statue of Montaigne, which faces the monumental entrance to the Sorbonne in Paris, replaced the stone original in 1989. This 'bronze' copy is more resistant to student pranks (and vandalism). Since then, several generations of students, out of superstition, habitually rubbed the statue's right foot on the eve of exams. As a result, the foot lost its patina and the metal – doubtlessly a quaternary alloy typical of modern foundries – remains its true golden colour, corrosion having had no chance to form between rubbings. More interesting, the acidity of hand perspiration acts as a chemical bath: up close the metal grain is fairly visible. To distinguish the microstructure, however, a microscope is necessary. (Photos © L. Garenne-Marot.)

These analyses establish relative chronologies. Metal characterisation can situate some objects in time in the case of objects deprived of an archaeological dated context.

Example 1: Jenné-Jeno (Mali) sequence, elemental analyses and relative chronology

Thanks to a deep-time stratigraphy in settlement context, Jenné-Jeno provided the first data on a sequence of alloys for West Africa. This series is based on only nine analyses yet gives an overview of the diversity of alloys used in a single place over centuries: copper in the oldest strata dating to around 400 A.D., bronze with 17% tin in the transitional phase of 800 to 1000, a quaternary alloy, and, finally, leaded brass in the phase beginning around 1200 (McIntosh 1994). This alloy chronology already presents, in the absence of comparable sequences, an initial ground for relative dating. Thus S.K. McIntosh remarked that the metal of the bronze bracelet from a Méma (Mali) burial dating to AD 780-1010, excavated by T. Togola, was consistent with that of the Jenné-Jeno sequence.

Example 2: the illustrative corpus of the bronzes from Igbo-Ukwu (Nigeria)

One of the earliest applications of these expertise techniques was conducted in the 1960s on some 600 copper and copper alloy objects from excavations at Igbo-Ukwu. Nearly a hundred elemental analyses divided the corpus into pure copper objects (with some rare examples of leaded copper) and leaded bronze objects. Metallographic techniques revealed a correlation between the

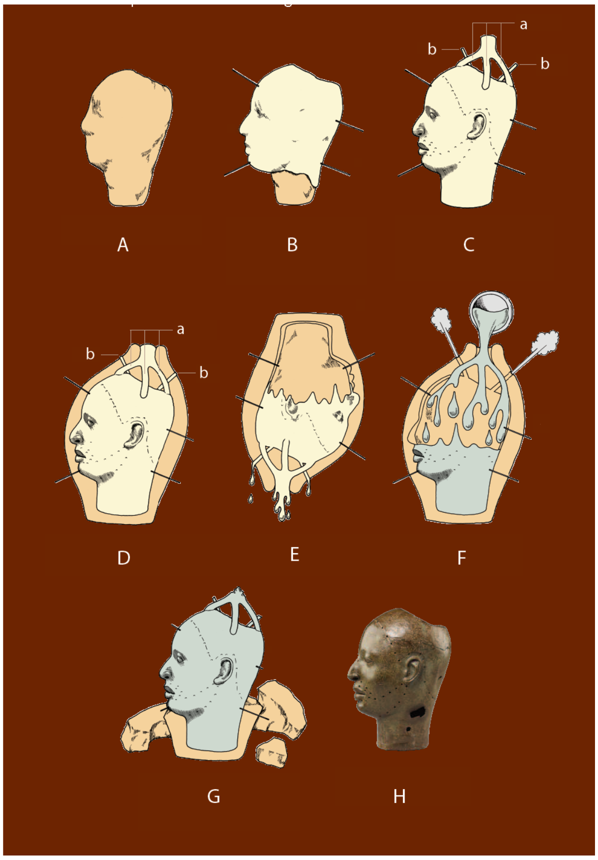

Fig. 4.1

Fig. 4.

1. Simplified sequence of direct hollow lost wax casting of an Ife (Nigeria) head. **A**. A core in the form of the sculpture is made in clay; **B**. The clay core is covered in beeswax. Iron rods are inserted through the wax into the core to prevent movement during firing; C. Fine details are sculpted in the wax. Tubes of wax, known as runners (a), are applied at the top. Separate wax vents (b) are inserted to allow gases to escape during casting; **D**. Layers of clay are applied directly to the wax surface, enclosing the vents (b) and runners (a) to form a mould; **E**. The entire mould is heated, melting the wax, which is drained away through the runners, and hardening the clay. The clay mould remains intact, retaining every detail of the former wax model; **F**. Molten metal is then poured through the runners into the gap between the outer clay mould and the inner core; **G**. After it has cooled, the clay mould is removed and the runners and iron rods are cut off to reveal the completed sculpture; **H**. The sculpture is polished to produce a smooth surface. (Drawing © The Trustees of the British Museum, 2010.)

2. Artisanal village bronze workshop near Ouagadougou (Burkina Faso), March 2008; **A**. wax work; **B**. making casting moulds; **C**. baking moulds close to a fireplace; **D**. metal casting; **E**. finishing statuettes. (Photos © L. Garenne-Marot.)

Fig. 4.2

composition of the metal and the technique of manufacture: pure copper objects were forged (hammered and twisted), leaded bronze objects were cast using the lost wax (or latex) casting technique. The choice seems to have been dictated by technical criteria: pure copper is easier to work by deformation techniques (hammering, twisting, stretching, etc., while repeatedly heating the metal to restore its ductility), whereas bronze alloy, and particularly leaded bronze (the lead makes the casting flow), lends itself better to casting than pure copper (see **fig. 2**).

One of the most beautiful leaded bronze pieces is certainly the 32-cm-high 'ropepot' – a vessel on a stand surrounded by ropework. Was this 'ropework' made separately and subsequently welded to the vase and pedestal? Metallographic examination of two sections in the vase wall where it meets the net revealed no welds but rather an assemblage of different parts via a special 'casting-on' technique. This technical trait, in addition to others, led P.T. Craddock (1985) to ascribe an indigenous character to the Igbo-Ukwu industry: everywhere else in the same period, from the 9th to 11th centuries A.D., the large bowls of Igbo-Ukwu would have been made more easily and directly by sheet metal work, and the decorative elements cast separately, then riveted or welded in place, instead of being cast in a single piece with the base.

B. Technical choices or cultural choices: the notion of 'technological style'

The choice of metal or forming technique for an object sometimes depends on something other than technical criteria. In some regions of Central Africa (see the example described by Childs 1991), the *chaîne opératoire* of copper-working is based on that of iron-working. Lost wax casting techniques flourished mainly in West Africa – the Cameroon Grassfields marking the south-eastern extension – with, for some workshops, variations in the technique, such as the joined crucible-mould method (Herbert 1984; Garenne-Marot & Mille 2007). The 'seated figure' from Tada hollow cast sculpture attributed to Ife culture (Nigeria, 14th century) is made of pure copper even though the material lends itself poorly to casting, as demonstrated by the many secondary castings intended to repair numerous defects. Colour could also determine metal choice, for cultural reasons (Garenne-Marot & Mille 2007).

C. Analytical limitations

1. Answering precise questions

Analyses have to respond to precise questions, because they are time-consuming, expensive and, in the case of metallographic analysis, highly invasive – that is, they damage the object to which they are applied.

2. Accounting for limitations inherent to the methods

The failure of provenance studies

Many attempts had been made to trace the origin of the metal of finished objects in order to establish the ore-metal-object link. The first were based on trace elements analyses, but failed (Pollard & Heron 2008). Indeed, several biases affect the approach:

- geographically separated deposits can have a similar geochemical signature (specific mineral associations);
- metalliferous veins are often heterogeneous;
- the spectrum of trace elements is altered at every stage of the *chaîne opératoire* (as shown in the pioneering work in experimental archaeology by R.F. Tylecote (1976)).

Some similar biases affect another method devised from lead isotope tracers. Recent work confirms changes in isotope ratios during ore preparation and reduction phases. (Baron *et al.* 2014). Other experiments show the significant transfer of the lead from the zinc ore in the final brass during cementation. This increase disrupts the copper's initial isotopic signature (Bourgarit & Thomas, forthcoming), which puts into question the validity of comparing measurements of isotope ratios between pure copper and alloys. Finally, recycling, which mixes materials of various origins, adds other disruptions.

Today these problems are unavoidable, though research to find better tracers continues. We must thus be circumspect concerning any grand synthesis on the origin and circulation of copper alloys in sub-Saharan Africa that relies essentially on the results of a single type of analysis and whose conclusions are based on a broad comparison and without accounting for the geological and/or archaeological particularities of the samples. Many archaeometallurgists and historians of metallurgical techniques base their arguments solely on alloying elements: for them, these added metals (tin, zinc, lead) are 'recipes' that echo the know-how of workshops and, as a result, potential production sites. Geochemical analyses, like those of trace elements and/or lead isotopes, provide additional support for these first 'composition typologies', by more accurately characterising groups of objects that could have been produced from the same metal supplies and/or workshops.

CONCLUSION

Analytical results should be inserted in a broader perspective. Remember that the copper object, which carries a history, is part of history: the research of Z. Volavka (1998) on a copper investiture object of Central Africa is a good example of what multi-thematic research that combines technical (object analyses but also surveys of mines and metallurgical sites), economic, social, ethnographic, or art history data can contribute to the writing of this history of copper metallurgy in Africa.

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CASE STUDY: COPPER INGOTS IN CENTRAL AFRICA

Nicolas Nikis[1]

INTRODUCTION

Copper has played and still plays an important role both economically and symbolically in various regions of Africa. Particularly in Central Africa, it once had a value comparable to gold's in other parts of the world, and controlling its deposits was a major concern for many political entities. It was used alone, without alloys, until the arrival of European brass and bronze, and distributed mainly in semi-finished form that could assume a wide range of shapes (**fig. 1**), whether 'classic' ingots, cross-shaped ingots in southern Central Africa, or *ngele* in the Kongo area. For the sake of simplicity, I will use the generic term 'ingot' when not referring to a particular shape. This case study focuses on this type of object, but it is necessary to keep in mind that this is not the only form of copper in circulation. The metal can also circulate as, for example, wire, finished objects such as bracelets, and indeed as ore.

Studying these objects can reveal a variety of information, such as economic or political history and the reconstitution of metallurgical knowledge and processes. An ingot studied on its own reveals very little information – at best a clue about the copper's use in any given place and time and, possibly, its manufacture. To address research questions concerning the morphology or circulation of copper ingots, an entire set of objects is necessary, whether they come from a site or, most commonly, a region or larger area. Furthermore, to address questions concerning manufacturing techniques, the object will have to be taken as an integral part of the manufacturing process and thus studied as a step in the production. This will entail studying ingots above all from the perspective of the first question: circulation. The data used in this type of study come mainly from archaeology but can also be completed by historical and anthropological sources.

CATALOGUING AND ANALYSING FINDS

Like all archaeological objects, the ingot has to be documented (description, photograph, drawing, context, etc.: see *ad hoc* chapter). Next, as with ceramics, object characteristics such as shape, weight and size can be studied. When a classification for the type of ingot already exists, it is preferable to refer to it in order to avoid unnecessary multiplication of 'groups'. Otherwise, a new one will be created; the 'birds of a feather flock together' principle is generally the most convenient. Attention must be paid, however, to certain simple shapes, such as bars, which can be in use in far apart regions without being the result of contact. In this case, weight and size will be the discriminating factors. At this stage of the analysis it is possible to identify a potential standardization of the objects that suggests control over production on a certain scale (local, regional, supraregional, etc.). This analysis can also highlight an evolution of the shape according to places and eras. If it concerns a set in which all types were not found in an archaeological context, such as, for example, via surface collections, a relative chronology can be hypothesized.

The study of cross-shaped ingots or *croisettes* in Central and Southern Africa by de Maret (1995) is a good example of this type of analysis. In this study, de Maret shows an evolution in the shape of cross-shaped ingots over time (**fig. 2**). According to this diagram, he hypothesizes that the undated ingots, types Ia and HI, may be the 'ancestors' of type HIH *croisettes* based on their shape. Moreover, he observed a standardization of these ingots over time (de Maret 1981), by studying the size and weight of type HIH, HX and HH *croisettes* from the Upemba Depression.

Obviously, the context of the object's discovery

Fig. 1. Examples of copper ingots. 1. cross-shaped ingots HIH (top), HX (middle) and HH (bottom), Upemba Depression (Katanga, DRC); 2. *Ngele,* Makuti (Mindouli region, Rep. of the Congo); 3. Ingots, Nkabi (Mindouli region, Rep. of the Congo); 4. Crosses HH attached by a plant fibre, Upemba Depression (Katanga, DRC); 5. 'Treasure' of cross-shaped ingots HH (Katanga, DRC).

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[1] Fonds de la Recherche Scientifique - FNRS, Université libre de Bruxelles and Royal Museum for Central Africa, Belgium.

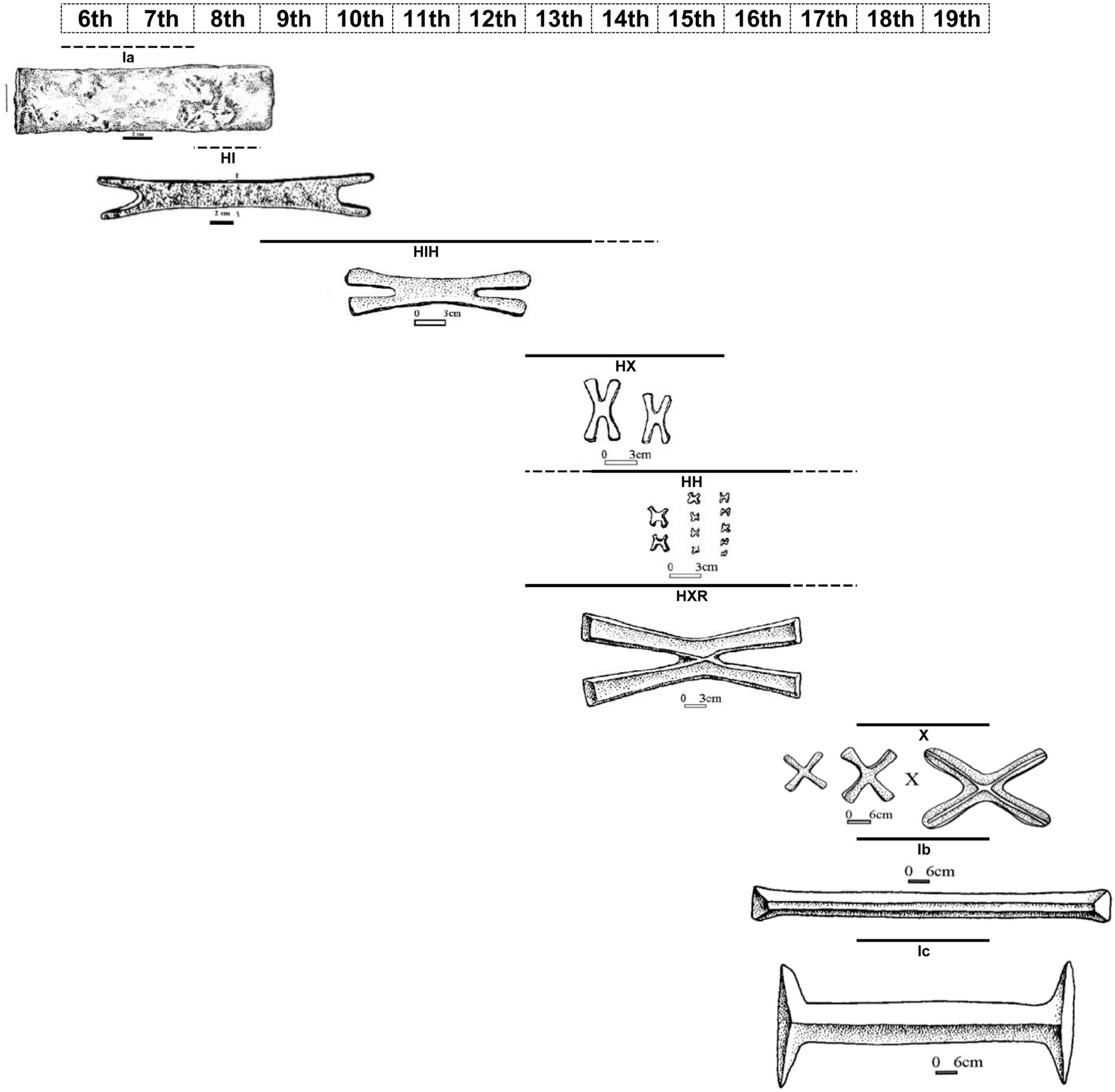

Fig. 2. Evolution of the form of ingots and cross-shaped ingots produced in the Copperbelt. The first two types are not dated and the dotted lines indicate uncertain dating, mainly concerning upper and lower limits. This figure takes no account of geographic location differences. (According to de Maret 1995)

provides information concerning its use. Thus in the Upemba, in a funeral context, according to the position and number of cross-shaped ingots, we pass from the use as status symbols of type HIH *croisettes* (they are located next to the chest and usually only one is found) to a more monetary use of type HX and HH *croisettes* (they are often placed in a group next to the hip or hand). This use is confirmed by the *croisettes* discovered in the form of 'treasure' or attached to one another (**fig. 1**). In absolute terms, group layouts could also reveal information on the population's system of numeration (decimal system, duodecimal system, etc.).

Mapping information concerning ingots makes it possible to define the distribution of the major types over time

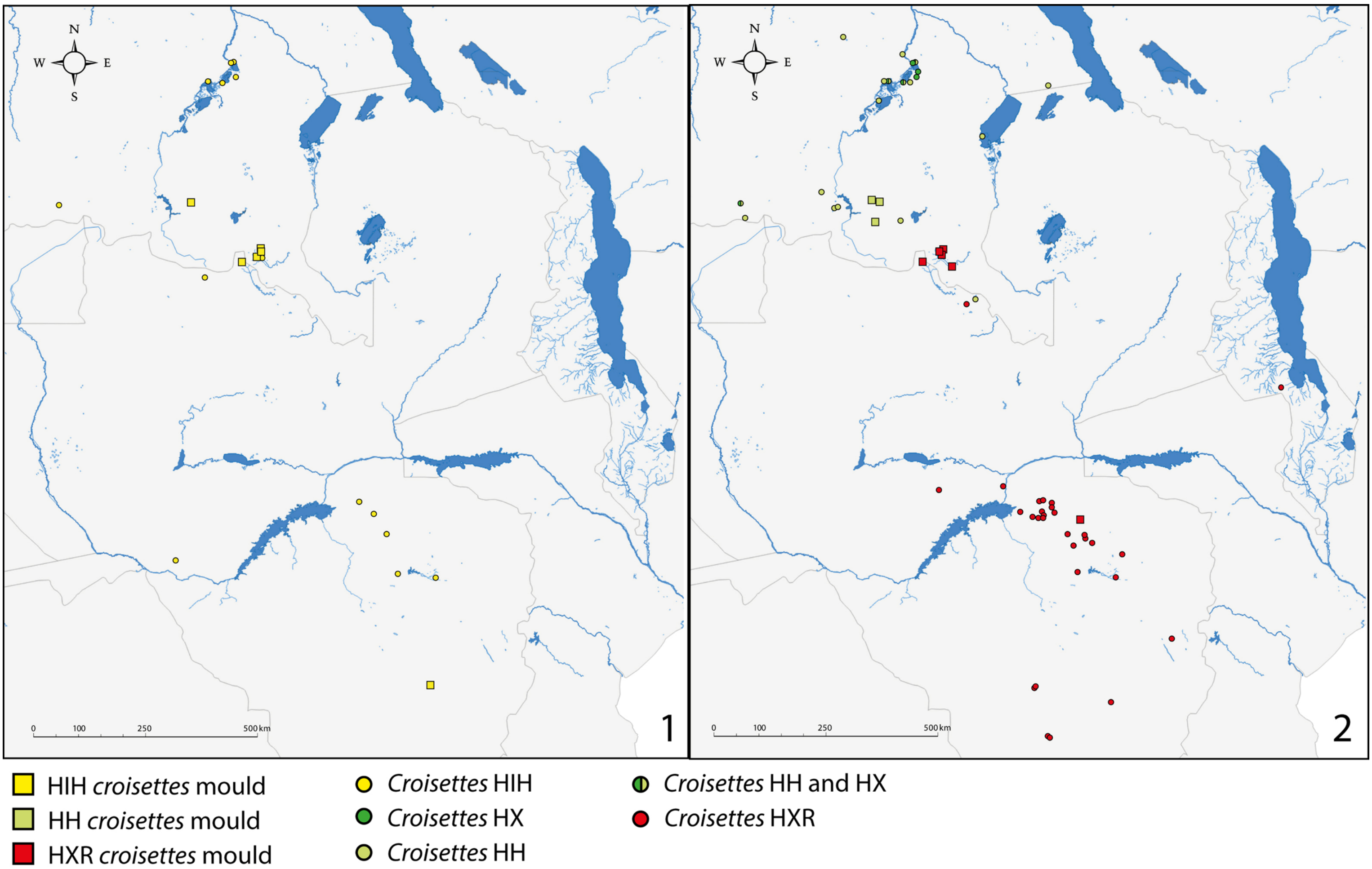

Fig. 3. **1**. Distribution of cross-shaped ingots HIH during 9th-14th centuries and **2**. crosses HX, HH and HXR during 13th-17th centuries.

and thus to clearly show socio-economic phenomena. Let us take the example of the distribution of cross-shaped ingots between the 9th and 17th centuries (**fig. 3**).[2]

The first map in figure 3 concerns the distribution of type HIH *croisettes* between the 9th and 14th centuries. We observe that this type of ingot is present from the Upemba Depression (Katanga, DRC) to Great Zimbabwe and that its production, attested by the presence of moulds, is located both in the Copperbelt (southern DRC, northern Zambia) and at Great Zimbabwe. We can therefore hypothesize an economic and cultural link between these regions, given that the same form was in use. However, as the production took place in several distinct areas, there was not necessarily regular and direct contact between the peoples of these regions.

The second map shows types of cross-shaped ingots in existence between the 13th and 17th centuries. The situation is different compared to preceding centuries, as this same area divides into two sets: in the south HXR type *croisettes*, and in the north HX type *croisettes* which evolve toward type HH. Likewise, production centres seem very distinct, with HXR type being produced in the east of the Copperbelt, in the region of present-day Lubumbashi and in the copper-bearing regions surrounding Great Zimbabwe, while HH type is rather produced in the centre of the Copperbelt. During this period, we therefore observe a clear demarcation, probably revealing the existence of two distinct zones of economic, cultural, and political influence, but also the regions toward which the production centres directed their trade.

Studying the geographic distribution of ingot types is thus already in itself extremely interesting. Ease of access to GIS (geographic information systems), such as Quantum GIS, now makes it possible to easily map other information and superimpose several levels of data. Consequently, for ingots, we can compare spatial-temporal data with historical, political, linguistic, etc., data and even with other aspects of material culture such as ce-

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[2] For a detailed interpretation of the phenomena presented here, see de Maret 1995; Swan 2007.

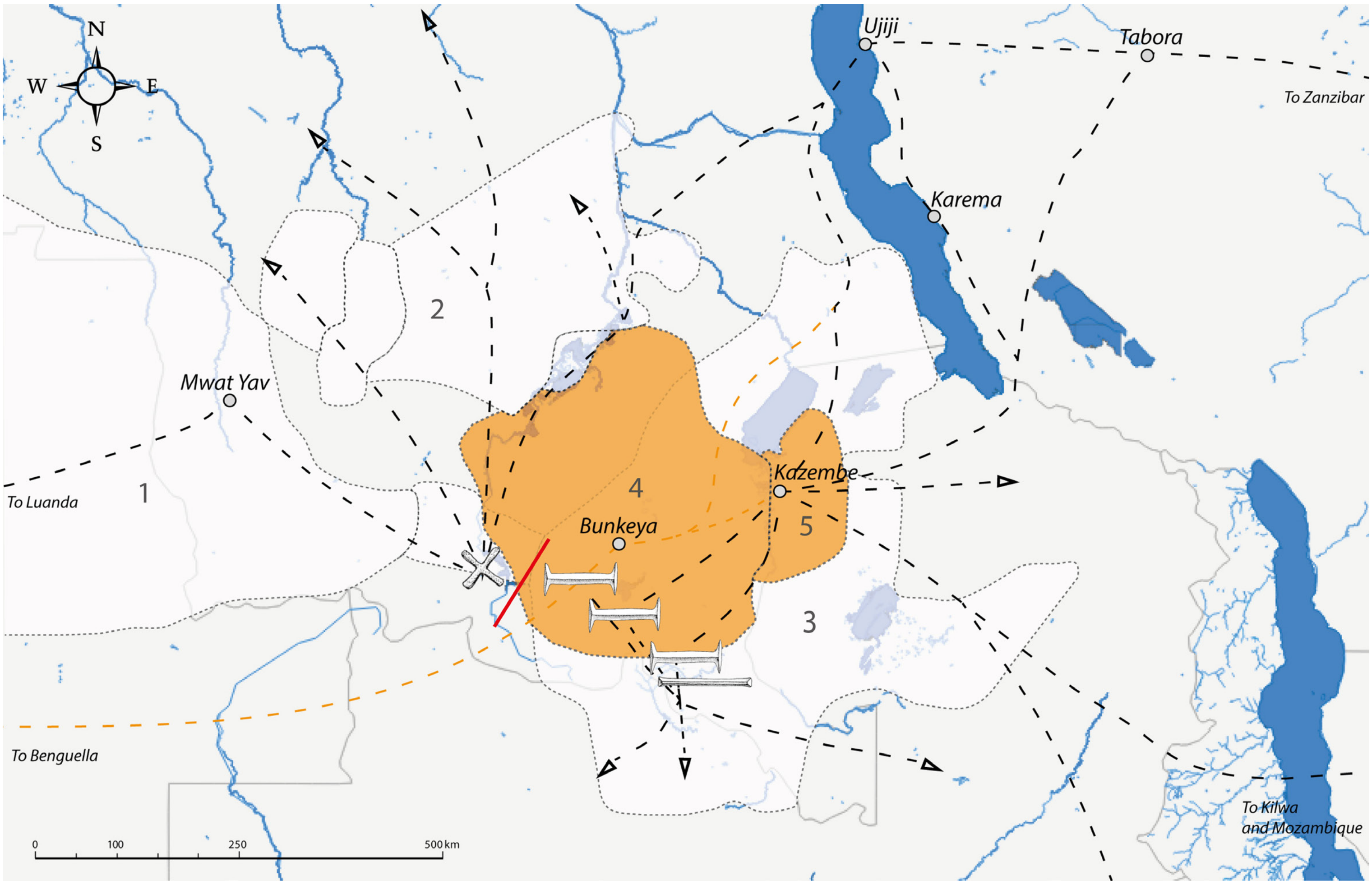

Fig. 4. Copper ingots and their trade routes in the 19th century compared with the boundaries of major political entities (1. Mwat Yav; 2. Luba; 3. and 5. Kazembe; 4. Yeke). The arrival of the Yeke in the second half of the 19th century and the decline of the Kazembe modify trade routes.

ramics. This makes it possible to visualize phenomena that would have been difficult to detect if data were considered in isolation.

In this way, for example, by examining the distribution of different types of ingots produced in the Copperbelt in the 19th century and their circulation routes, we observe, as in the preceding example, a boundary between X type *croisettes* and ingots Ib and Ic and that the routes taken to trade them diverge to some extent. By comparing this map with that of the major political entities of the time, it is clear that this boundary corresponds to two zones of influence, on one hand that of the *Mwat Yav* and Luba for the X type *croisette*, and on the other that of the Kazembe for the Ib and Ic bars. Furthermore, we see that the convergence of the circulation routes for different types is located outside these zones of influence and is explained by the fact that they join the Arabo-Swahili trade routes.

Nevertheless, it is necessary to avoid falling into certain traps in interpreting the data. The presence of the same type of ingot in several regions, sometimes spanning long distances, does not mean that populations had direct contact or migrated. An object, and all the more an object endowed with a certain commercial value, can travel via step-by-step exchanges over a long distance without the object's producer meeting its final holder. Likewise, some forms can be reproduced in regions far from the extraction centres by recycling old copper objects, as was observed for X type *croisettes*: some copper objects were remelted to cast new ingots in areas far away from the deposits (de Maret 1995).

Increasing use is being made of physical and chemical analysis of ingots, which can answer questions concerning, on one hand, the manufacturing process (especially possible additives to the ore as smelters) and, on the other hand, the metal's origin. Several methods exist to trace the ore's source, be it researching trace elements or – currently the most frequently used – analysing lead isotopes in the metal.[3] Objects of the same elementary or isotopic composition could have been manufactured using the same ore. However, things are not always as straightforward in practice, and many phenomena can skew the analysis: copper recycling, the addition or elimination of certain chemical elements during the metallurgical process, similarities of trace elements or isotopes between deposits, etc.[4] It is therefore recommended to perform these analyses with someone who knows the methods' limits and their applicability to archaeology. Moreover, when the goal is to solve a problem presented by archaeological data, it is essential, prior to undertaking costly analyses, to master the archaeological context.

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[3] For more details, see: Pollard, A.M. & Heron, C. 2008 or the special issue of *Archaeological and Anthropological Sciences* 1 (3) (2009).

[4] Concerning certain limits of the method based on lead isotopes, see Baron, Tamas & Le Carlier 2013.