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# Archaeological fieldwork techniques in Stone Age sites. Some case studies

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**Abstract**

Field techniques used in the excavation of archaeological sites are rarely specified in academic publications, under the tacit understanding that fieldwork methods are standardized enough to make their description unnecessary. Although that is probably the case in commercial archaeology, it is however an unwarranted assumption as far as academic archaeology is concern, and neglects the wide range of different field techniques used during archaeological excavations by each research team. In this paper, we outline field methods used by our research group in the excavation of Palaeolithic sites in Spain and East Africa, from the selection of localities for excavation to the digital processing of the resulting spatial and archaeological data. Our aim is to contribute to consolidating a corpus of standard practices in modern research archaeological excavation, whose quality control is essential to guarantee a successful collection of data used for the interpretation of archaeological remains.

**Keywords:** field techniques; laboratory; Datamatrix; Photogrammetry; GIS; Stone Age.

**Resum.** Tècniques d'excavació en jaciments paleolítics. Alguns casos d'estudi

Les tècniques d'excavació utilitzades en jaciments arqueològics poques vegades s'especifiquen en les publicacions acadèmiques, sota l'entesa tàcita que els mètodes de treball de camp estan prou estandarditzats per fer-ne la descripció innecessària. No obstant això, tot i que aquest és probablement el cas de l'arqueologia d'urgència, és una suposició injustificada pel que fa a l'arqueologia acadèmica, i deixa de banda l'àmplia gamma de diferents tècniques de camp utilitzades durant les excavacions arqueològiques per cada equip d'investigació. En aquest treball presentem els mètodes de camp utilitzats pel nostre grup de recerca en l'excavació de jaciments paleolítics a Espanya i a l'Àfrica oriental, des de la selecció dels llocs per a l'excavació fins al processament digital de les dades espacials i arqueològiques resultants. El nostre objectiu és contribuir a la consolidació d'un corpus de pràctiques estandarditzades en les excavacions acadèmiques modernes el control de qualitat de les quals és essencial per garantir l'èxit de la recollida de les dades utilitzades per a la interpretació de les restes arqueològiques.

**Paraules clau:** tècniques de camp; laboratori; matriu de dades; fotogrametria; SIG; paleolític.

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**Resumen.** Técnicas de excavación en yacimientos paleolíticos. Algunos casos de estudio

Las técnicas de excavación utilizadas en los yacimientos arqueológicos rara vez se especifican en las publicaciones académicas, bajo el entendimiento tácito de que los métodos de trabajo de campo están suficientemente estandarizados para hacer su descripción innecesaria. Sin embargo, aunque éste es probablemente el caso de la arqueología de urgencia, es una suposición injustificada en cuanto a la arqueología académica, y obvia la amplia gama de diferentes técnicas de campo utilizadas durante las excavaciones arqueológicas por cada equipo de investigación. En este trabajo presentamos los métodos de campo utilizados por nuestro grupo de investigación en la excavación de yacimientos paleolíticos en España y África oriental, desde la selección de los sitios para la excavación hasta el procesado digital de los datos espaciales y arqueológicos obtenidos. Nuestro objetivo es contribuir a la consolidación de un corpus de prácticas estandarizadas en las excavaciones académicas modernas, cuyo control de calidad es esencial para garantizar el éxito en la recogida de los datos utilizados para la interpretación de los restos arqueológicos.

**Palabras clave:** técnicas de campo; laboratorio; matriz de datos; fotogrametría; SIG; paleolítico.

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## Introduction

Discussions regarding methodological and best practice issues in archaeological excavations are as old as the discipline. Great effort has been spent in defining, describing and implementing a standard set of excavation procedures which allows for maximum recovery of data from an archaeological site (e.g. Wheeler, 1954; Kenyon, 1961; Barker, 1993; Drewett, 1999). In addition, ever evolving technical innovations have a huge impact in archaeological excavation and recording techniques, which are constantly modified and elaborated upon in line with new advances. This is especially true for the last two decades, in which developments in digital technology have triggered a revolution in Archaeology as a discipline (e.g. Daly and Evans, 2005).

Despite these efforts, however, a great disparity exists in field archaeology methods within the academic environment, with practically each research team applying their own separate data recovery techniques. Heterogeneity and lack of standardization in field techniques in academic Archaeology is in acute contrast with other disciplines which incorporate field work, such as Geology, where standard protocols of data recovery are shared by most of the international community (e.g. Lisle et al, 2011; McClay, 1991; Coe, 2010). Given that archaeological excavation is a destructive process, the lack of standardization in field recovery techniques as well as the academic and some countries' permit-granting agencies permissiveness towards starkly unequal excavation practices, where an 'anything goes' consensus prevails, should be a cause of concern.

On the other hand, the impossibility of delivering a 'one size fits all' recipe for archaeological excavation should be acknowledged, for field techniques are necessarily dependant on research design, time period, sedimentary context, and budgetary and logistical constraints, among others. Therefore, the need for standardized, rigorous and systematic field techniques should be reconciled with flexible strategies of data recovery adapted to each particular case study.

In this paper, field methods practiced by the Stone Age Archaeology Group (SAAG) of the UCL Institute of Archaeology are outlined through case studies of Palaeolithic excavations in Spain, Ethiopia and Tanzania. Our review of SAAG's methodology, which relies heavily on previous advances developed by CEPAP (Centre d'Estudis del Patrimoni Arqueologic de la Prehistoria; see Mora et al, this volume), will focus on field data recording during excavation, and will also outline field laboratory and data processing procedures.

## Fieldwork techniques

### *Location of trenches*

Palaeolithic archaeologists usually excavate in caves/rockshelters or in open air sites. Data obtained during preliminary

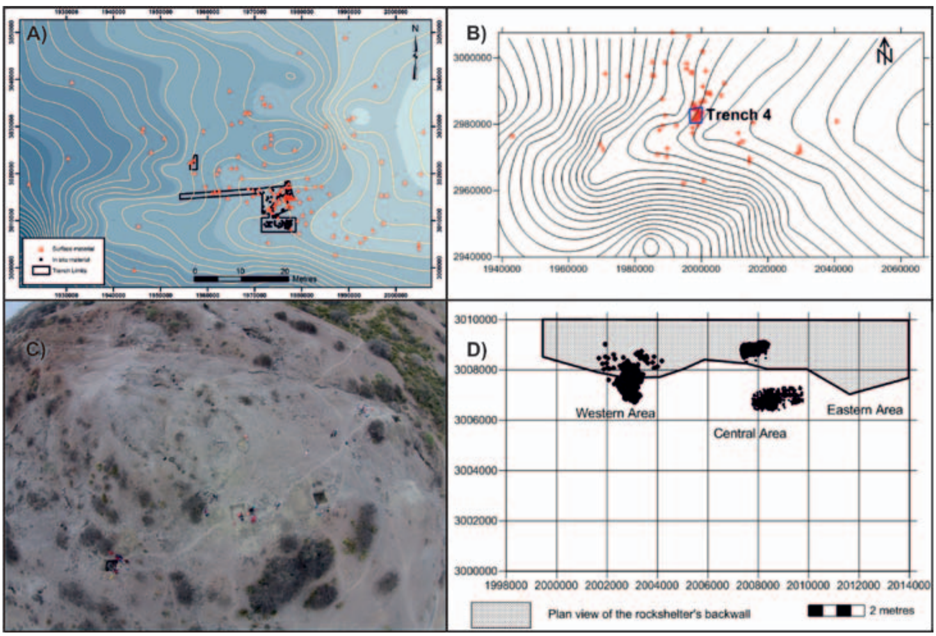


**Figure 1.** A) Trenches excavated in Mieso 7, an Acheulean site in Central-East Ethiopia. B) Despite the abundance of surface material in Mieso 4 (red dots), no archaeological items were found in this test trench. C) Random test pits across the early Pleistocene landscape of FC East (Olduvai Gorge). D) Excavation grid at the Buendia site aligned with the rockshelter's back wall.

visits to fixed points in the landscape such as caves and rockshelters, or during foot surveying across open-air sedimentary outcrops, will inform on the potential areas of interest. In some instances, it is the presence of fossils and stone tools that will strongly influence the optimum location of a trench. For example, during fieldwork in the Middle Pleistocene of Mieso (Ethiopia) (de la Torre et al, 2014), our field strategy was to locate outcrops with higher densities of stone tools and fossils on the surface, and then to place test trenches around such clusters in the hope that they would yield material in situ. Sometimes this strategy was successful, such as in the case of Mieso 7 (Figure 1A), where presence of material in the test trench led to its enlargement in order to recover more artefacts. In other instances, however, significant numbers of surface artefacts were not matched by preservation of material in situ, and hence test trenches were logged after excavation, but not extended (Figure 1B).

Complementary trenching strategies can also be used; for example, Potts et al (1999) in Olorgesailie (Kenya) and Blumenschine et al (2012) at Olduvai Gorge (Tanzania) placed test trenches across outcrops irrespectively of the presence/absence of surface materials, for their objective was to investigate the general distribution of artefacts across ancient landscapes beyond clusters of archaeological materials. This latter strategy, which is to some extent similar to random sampling, has also been applied by our group at Olduvai Gorge (Figure 1C) in combination with the more traditional excavation of high- density clusters in large trenches, and has the advantage of providing quicker and better knowledge of wider areas within the same stratigraphic interval.

### *Coordinates and grid system*

Once the general area and/ or site/s for trenching have been located, we frame the area within geographic (absolute) and arbitrary (relative) coordinate systems. Given the relatively small-scale nature of an archaeological excavation, we normally set up a grid based on a relative system of Cartesian coordinates, rather than using geographic coordinates. This grid is used to position the archaeological material and features within a Cartesian system with 'x' 'y' and 'z' coordinates, and should preferably be oriented to the geographic north (see Figure 1A and 1B), as alignment of the 'y' axis of the grid with the geographic north will facilitate nomenclature and comparison with other data (e.g. compass bearings). However, occasionally this may result in burdensome outcomes; for example, in the case of rockshelters and caves, or where a prominent features exists, it might be more convenient to align the grid system in relation to the orientation of such particular feature. Thus, during our excavations at the Buendia rockshelter (Spain), the 'x' axis of our relative coordinate grid was aligned parallel to the roof dripline, and the 'y' against the bedrock back wall (Figure 1D), and hence the grid was offset with respect to the geographic north.

This grid is set up with a total station once a minimum of two 'base stations' (i.e. concrete beacons) have been positioned in the local landscape. One of these base stations becomes the reference point used to triangulate and create the relative grid system with the total station.

The location of these base stations are also recorded using differential GPS, in order to position the Cartesian relative coordinates in an absolute reference system. There are no limitations to the number of base stations that are suitable, as this is highly conditional on the local topography, visibility and requirements of field work. It is indeed good practice to set up several base station backups (Figure 2), as it is often the case that beacons become unsuitable due to erosion,

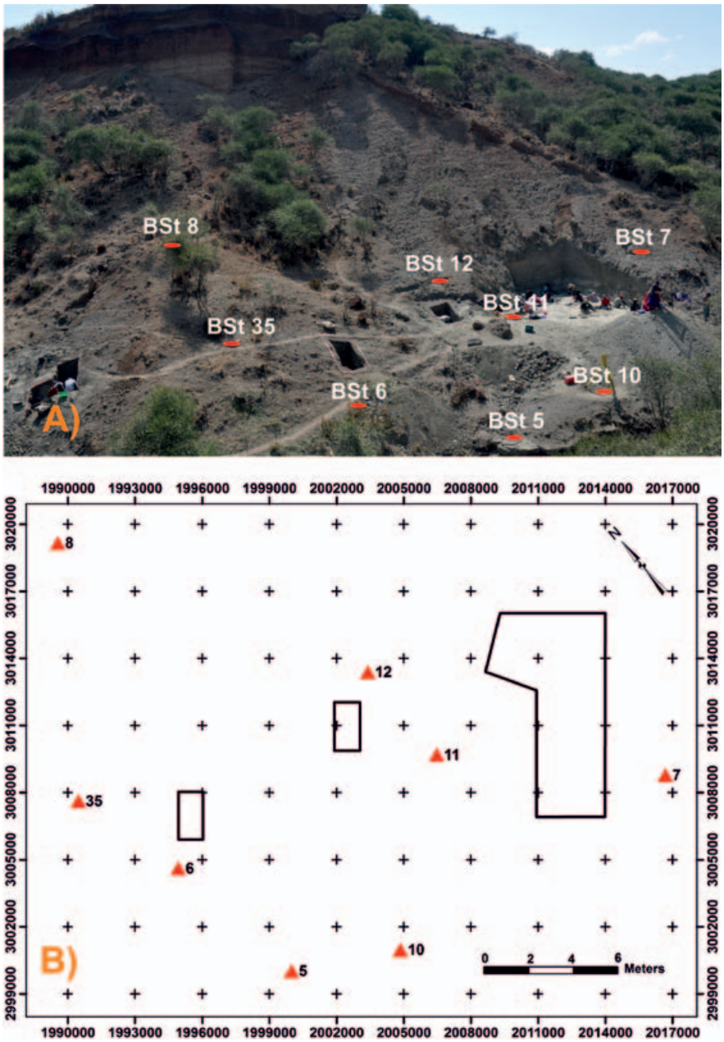


**Figure 2.** A) General view of the base stations (BSt) location at HWKEE (Olduvai Gorge). B) Location of base stations within a local grid system based on relative coordinates.

vandalism or burial by recent sediments. Once the base stations and trench location(s) are set, the limits of the trench to be excavated are established, a process that is automatized with the total station.

## Artefact collection and excavation

Once the virtual grid has been established, surface material is collected and mapped with a total station. This process helps to quickly identify major clusters of artefacts and locate their possible provenance, and may also contribute in deciding where to position the test trench. In addition, surface material mapping may help in understanding erosional processes. For example, in the Mieso 31 site, we were able to conjoin surface-collected artefacts with stone tools found in situ (Figure 3), thus gaining important insights regarding the dynamics of dismantlement of the Pleistocene deposits by modern erosive processes.

A wide range of tools can be used during the excavation of the trench, and selection depends on the type and density of archaeological material, geological context, expected closeness to the archaeological unit, and other factors. Thus, large picks and shovels are used to remove the upper and/or sterile layers, while trowels, small picks, screwdrivers,

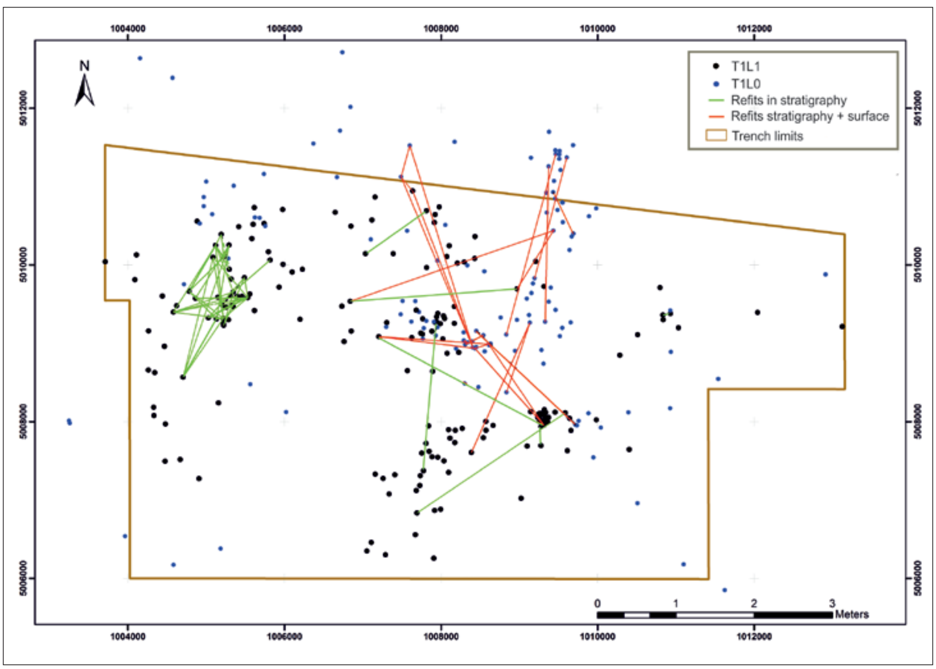


**Figure 3.** Plan of refits in Mieso 31, an Acheulean site in central-east Ethiopia (de la Torre et al, 2014). Green lines represent conjoining sets of stone tools in stratigraphy. Red lines refer to refits between surface and in situ artefacts.

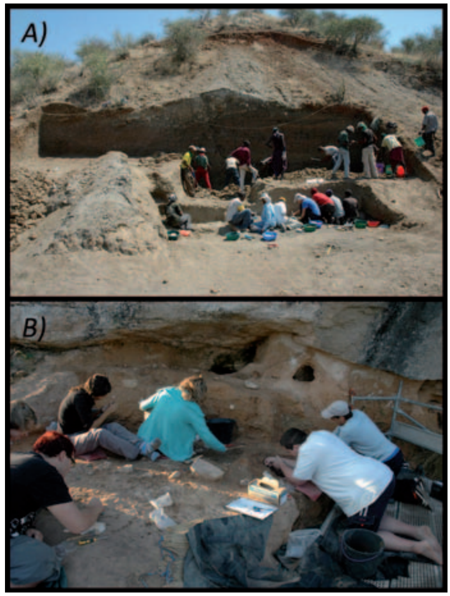


**Figure 4.** A) Process of excavation at EFHR (Olduvai Gorge); excavators at the front are close to the archaeological unit and thus dig carefully with screwdrivers and hand picks, while the crew at the back is using large picks and shovels to remove the overburden sitting on top of the archaeological unit. B) Excavation crew in Buendia in the 2010 field season, digging with screwdrivers, wooden sticks and brushes.

dental tools, wooden sticks and brushes of varying size are used to carefully excavate delicate and fragile artefacts and features. It is often the case that different tools are used within the same trench, according to the stage of progress across the excavation area. Figure 4 shows an example of the various rhythms involved in the digging of a single trench; at EFHR (Figure 4A), several meters of archaeologically-sterile overburden were removed with large picks and shovels, followed by smaller hand picks and screwdrivers, which were used to excavate the main archaeological unit. In Buendia (Figure 4B), the high density of artefacts required archaeological units to be slowly excavated with screwdrivers and brushes only.

When possible, SAAG avoids definition of archaeological units based on arbitrary vertical spits, as this method does not provide data on site formation dynamics. Instead, the excavation follows litostratigraphic layering and, within such levels, archaeological units are defined where vertical aggregations of artefacts can be distinguished from other archaeological units and/or lithostratigraphic layers by archaeologically-sterile sedimentary gaps. Identification of archaeological units from vertically- clustered materials relies heavily on map plotting and computerized monitoring of artefact distributions, which will be discussed below.

Normally, all artefacts found in situ (irrespectively of their size) are given an individual identifier, composed of a label that contains the archaeological unit and a correlative number, and which is placed alongside the artefact in an individual plastic bag. Sediment removed during the excavation of archaeological units is sieved in order to recover small fragments which were not spotted while digging. This is done through the screening of sediment in a suspended metal sieve through a range of gauges from 0.5 to 2.0mm. Each excavator is given a 'level bag' or 'non-coordinates bag', where all artefacts retrieved during sieving of their bucket are kept, and then collectively ID'd with one of the same labels used for items found in situ. Correlative numbers assigned to each in situ artefact and excavator's level bag are synchronised with the counter of the total station, which records the 'x' 'y' and 'z' coordinates of each item and files such Cartesian coordinates according to the ID dictated by the labels.

In situ stone tools and fossils unearthed during excavation are not immediately removed or loosened, but remain in the sediment and in their original position until they have been adequately documented. On occasions, poor preservation of some artefacts and fossils requires on-site conservation and consolidation in order to be successfully recovered, and further conservation (when needed) is undertaken in laboratory conditions. The strike and dip of objects with an identifiable length axis longer than the width are taken with a compass and a clinometer respectively, and entered in a digital context sheet on a tablet computer. These bearings are important in order to understand the effects of natural agents on the assemblage, which it has been argued are particularly prevalent in sites such as Olduvai Gorge (Benito-Calvo and de la Torre, 2011; de la Torre and Benito-Calvo, 2013).

While a single point shot by the total station (Figure 5) is enough to record the 3D position of smaller artefacts (normally < 4 cm), it is often important to also document the original layout of larger items. In these cases, the stone tool or fossil is either drawn by hand or photographed with a digital camera to produce an orthophoto. This image is then downloaded onto an on-site laptop computer, printed with a portable printer and added to a field notebook (Figure 6). This plan view, be it a drawing or a photograph, acts as a map where total station coordinates are taken around its outline. Once bearings and outline of the artefacts have been recorded, each artefact is allocated a sequential finds number which correlate to the identification number registered with the total station.

3D positioning with the total station is not only applied to archaeological artefacts, but also used to record a wide range of other relevant features, such as sedimentology samples, landmark points and paleoreliefs across the surface of the excavation, trench stratigraphy and the wider landscape. The latter, for example, helps to produce detailed Digital Elevation Models (DEM) of the modern

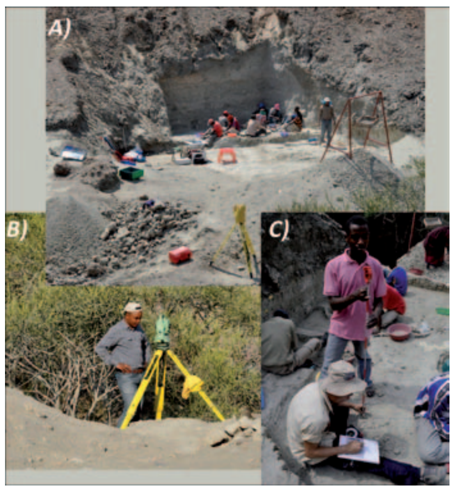


**Figure 5.** Excavation of the HWKEE main trench during the 2014 field season; A) the total station is positioned a few meters away from the trench to ensure full visibility and safety of the instrument. B) Mr. Patrick Ngalo operates the total station at HWKEE. C) Mr. Elias Lazaro centres the head of the prism against which the total station's laser will reflect while Mr. Adrian Arroyo holds the pole over the artefact to be 3D positioned.

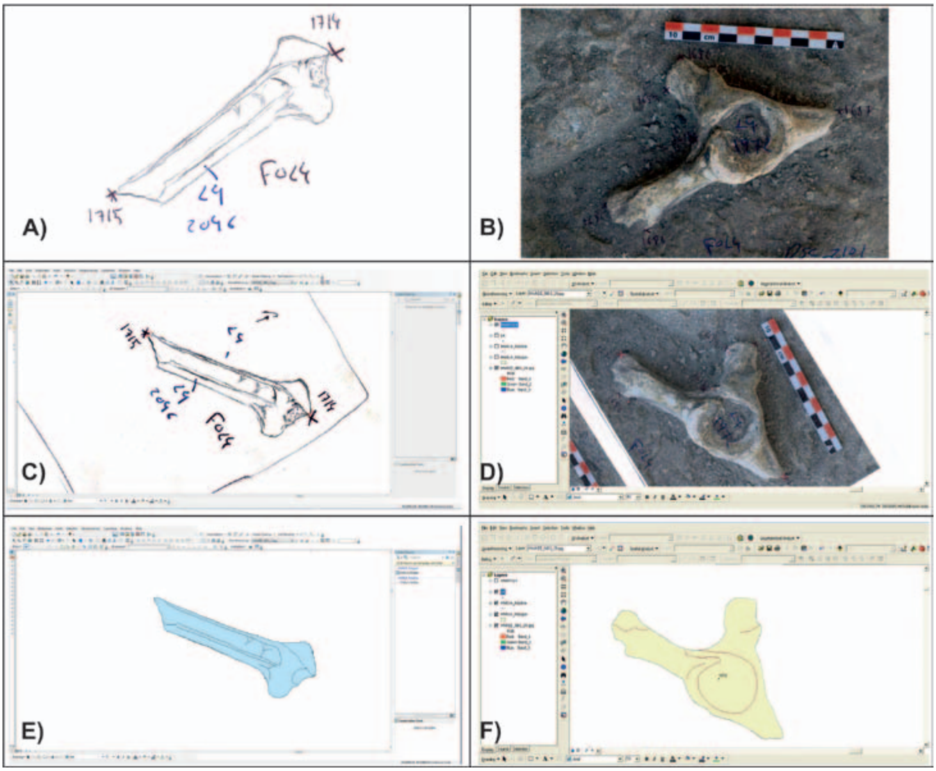


**Figure 6.** Total station points are taken over the outline of a hand drawing (A) or a photograph (B), and then georeferenced (C and D) within the site's grid system in order to create vector polygons (E and F). Both examples from excavations at HWKEE (Olduvai Gorge).

topography surrounding the site (Figure 7A). The use of total station measurements to map stratigraphic contacts (Figure 7B) is essential to accurately position archaeological units within their lithostratigraphic context. Detailed surveying of paleosurfaces (Figure 8A) enables documenting features that will eventually be destroyed during the excavation process, and is important in order to better contextualise the archaeological material within its geological unit. The same applies to sedimentology samples (Figure 8B), which are positioned with the total station and then collected with a separate code string from that used for the archaeological material, but which are added to the same database and georeferenced system, therefore allowing for an accurate spatial correlation between different datasets.

Finally, it is good practice to update a daily field notebook with notes regarding stratigraphic issues, sedimentary changes, characteristics of the archaeological levels under excavation, description of the codes created with the total station, sketches of relevant features, and others. In addition to photographing artefacts during excavation, it is also important to take general pictures of trenches on a daily basis, which will contribute to documenting the progress of the excavation and might be of help if problems of interpretation arise. At the end of the daily work, the archaeological material is taken to the laboratory for processing, and the total station and the tablet computer data are downloaded and centralised into the general database of the site.

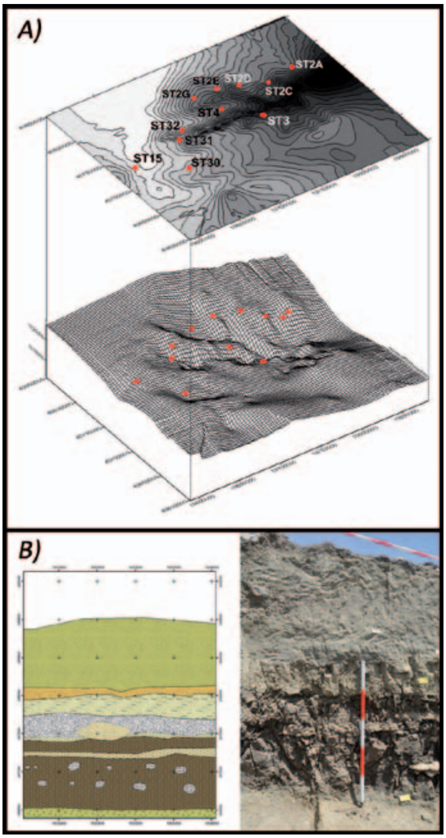


**Figure 7.** A) DEM of modern topography around some of the Lower Pleistocene localities of the Type Section in Peninj (Lake Natron, Tanzania) (adapted from de la Torre and Mora, 2004). B) Right: back wall of a trench dug in FC East (Olduvai Gorge). Left: georeferenced sedimentary contacts of this trench, mapped with the total of station.

## Laboratory and artefact processing

Laboratory work during the field season is an integral stage in the production of an accurate excavation inventory, and as stressed elsewhere (Glassow, 2005), assists in the recognition of possible mistakes incurred on site during the excavation process. Recognizing the importance of readily processing material collected in the excavation, part of the SAAG team works in the laboratory on a daily basis during the field season, focusing on the cleaning of artefacts, labelling of the material, and database entry.

### *Artefact cleaning procedures*

Cleaning and labelling are critical tasks in an archaeological laboratory, since any error in the process, such as misplacing a piece from its original label, involves a fatal loss of information (Banning, 2008). In the cleaning stage, an assessment of the artefact preservation is undertaken in order to evaluate appropriate conservation strategies. The choice of cleaning either by dry brush or water immersion will depend on the level of artefact preservation (Figure 9A). For example, although most of the artefacts from Olduvai Gorge stand up well to soft brushing with water, fossils and some stone tools made on lavas can react when washed, so dry cleaning is desira-

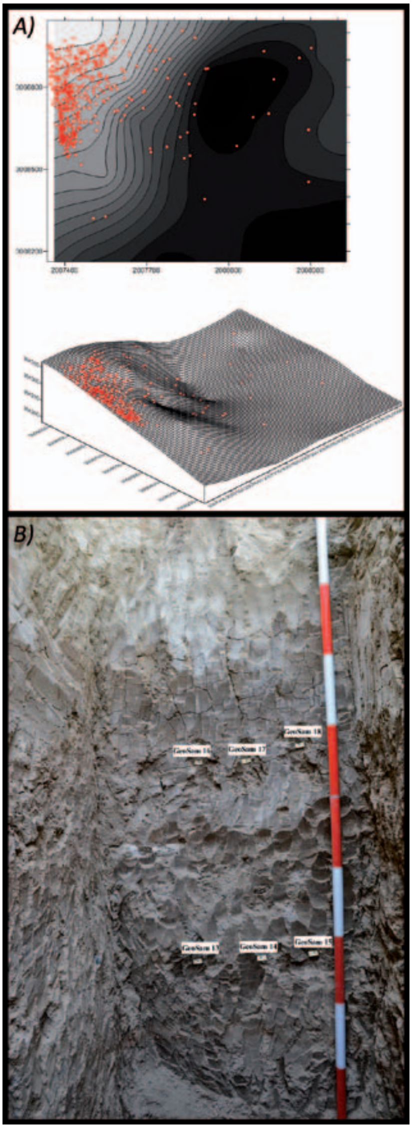


**Figure 8.** A) 3D reconstruction of 1 $m^2$ of the paleosurface over which archaeological unit N1C is laid at the Buendia rockshelter (red dots are artefacts recorded during the 2005 field season). Figure 8B: Back wall of a deep trench in MNK (Olduvai Gorge), with labels indicating the location of the sedimentology samples positioned with the total station.

ble. In other cases (e.g. Buendia, where most of artefacts are made of chert), water immersion did not affect pieces and hence lithic artefacts were all water washed. In addition, morphological characteristics of archaeological items will influence the selection of the washing technique. When washing small fragments, the use of a strainer is helpful to avoid losing the smaller pieces. After cleaning, material should be completely dried before labelling or bagging, as condensation inside storage bags can cause damage to the artefacts over time.

### *Artefact labelling procedures*

Once items are washed and dried, they are placed on tables protected with foam to avoid potential damage caused by contact with hard surfaces. Each fossil and stone tool is individually labelled using two methods: hand labelling and the attachment of data-matrix (DM) codes (Figures 9B and 9C). The combined use of both labelling systems allows the hand label to act as a backup in case the barcode is lost, if there is a failure in the barcode scanner, or in the event that the required technology to scan the DMs is not available.

Hand labelling begins with the application of a thin layer of a gloss acetone-free varnish over the artefact. This thin layer should be applied before writing on the piece, for if writing is made directly over porous materials such as bone or lavas, ink is absorbed by the artefact and labelling becomes irreversible. A black permanent marker is normally used to label over the varnish, although sometimes the dark texture of the pieces requires using a white pen or a white pigment, which should be mixed with Paraloid B72 (Koob, 1986).


**Figure 9.** A) Stone tool cleaning with water in a bucket. B: Labelling of artefacts. C) Close up of hand and barcode labelling process. D) Scanning of barcode label during data entry.

Although this can vary, the hand label will normally contain the name of the site/trench under excavation, the archaeological unit, and a unique ID number.

During the hand labelling process, the writing should be as clear and small as possible. Artefacts are normally labelled with both handwritten and DM labels in areas which are going to least affect the analysis. The location will depend on the kind of material; for example, on flakes and flake fragments labels are placed as close to the centre of the ventral surface as possible, while on cores and handaxes these are located as far as possible from all edges. In all cases, it is important to ensure that the label is legible, stable and reversible (Banning 1955).

Over the last few years, the application of digital identification systems has increased in field and museum work. Within these initiatives, the use of DM codes has been successfully tested on artefacts from modern excavations, providing some advantages over traditional hand labelling (Martínez Moreno et al, 2011). Thus, it has been attested that DM codes make the labelling process more systematic, accurate and less time consuming (Martínez Moreno et al, 2011). Another advantage of DM codes is that they are readable even if printed in small size, affecting a much smaller area of the artefact. In addition, DM code labelling removes human error produced during hand labelling, thus dramatically reducing the number of inventory problems occurring during field laboratory work.

The use of DM codes also offers advantages in undertaking data recall from a barcode- enabled database such as ArqueoUAB (Mora et al, 2010), making this system convenient for inventorying and cataloguing; DMs contain the same information as the hand labels (i.e. site name, archaeological unit and unique correlative ID), and when scanning the DM code into a database software, the data for each single artefact is accessible and editable (Figure 9D), thus accelerating the data entry process and removing human-error during retrieval of artefact IDs in the database.

Equipment needed includes a dedicated DM printer, barcode scanners, as well as specifically-designed software —namely ArqueoUAB (Mora et al, 2010), in the case of SAAG—. Following similar methodology as with hand labelling, an adhesive made of Paraloid B72 or B44 (depending on weather conditions) mixed in a 20% with acetone is used to attach the DMs to the archaeological items. Each DM is fixed to the artefact between two layer of this adhesive which, once applied and dried, is completely translucent and resistant, but at the same time, easy to remove with acetone if rectification is needed.

Once artefacts are washed, cleaned and labelled, stone tools receive a preliminary techno-typological classification, and fossils are taphonomically analyzed. Basic information is then introduced on the ArqueoUAB database by the laboratory crew, including general measurements (length, width, thickness and weight) and the preliminary classification made by the specialists. Finally, stone tools and fossils are once again individually bagged to prevent damage or dust, and packed away until a full analysis is conducted.

## Imaging and management of spatial data

### *Photogrammetry*

In recent years, photogrammetry (or more specifically structure from motion techniques) has become more prevalent within archaeological excavations (De Reu et al, 2014, Verhoeven, 2011, Verhoeven et al, 2012, Pollefeys et al, 2000), thanks to the development of cost-effective high resolution digital cameras and automated 3D photogrammetry software. SAAG is currently exploring its potential in the archaeological excavations at Olduvai Gorge, to produce 3D models of the individually excavated trenches, and detailed reconstructions of in situ artefacts within their original archaeological levels.

This method entails the extraction of 3D data from 2D photographic records, where 3D models derived from photogrammetry can be utilised in a number of ways. These include the ability to produce highly accurate digital elevation models of archaeological horizons, the integration of 3D models of trenches or archaeological features into overall GIS maps of the excavations, the ability to accurately reproduce an archaeological horizon for presentation and education purposes, and the possibility to undertake 3D analysis of artefacts and contexts.

Due to the nature of the archaeological record at Olduvai, a combination of handheld and remote shooting allows for maximum accuracy in obtaining the relevant photographs. For all horizontal photographs of trenches, where it is physically unfeasible to use a handheld method of photography, the camera is fixed to a right angle tripod and photos are taken remotely with a wireless adapter and a tablet computer (see photogrammetry workflow in Figure 10).

Unlike 3D laser scanning, photogrammetry does not capture the target object at full size. It is important therefore that both scales and georeference points are incorporated into the photographs intended to be used for photogrammetry. Georeferencing the 3D models also allows their integration within the Cartesian grid system used for artefact recording with a total station during excavation, and will enable the final 3D model to be correctly scaled. At least three separate known reference points must be incorporated into the model, with additional reference points increasing the accuracy level of the final georeferenced model. Photographing is usually undertaken in stages. Firstly, the overall scene / trench is photographed; this is followed by detailed overlapping images of the back and sidewalls in order to document the stratigraphy, and finally any large or complex artefacts within the scene / trench. In order to achieve the highest quality textures for the final model, it is also important to ensure that the scene is photographed under consistent lighting levels, and that each photograph overlaps by at least 60%.

During the field season, medium powered laptops are used to produce low quality models, in order to provide on-site feedback on the quality and level of coverage of photographs. In a number of cases during our excavations at Olduvai Gorge, it has been possible to

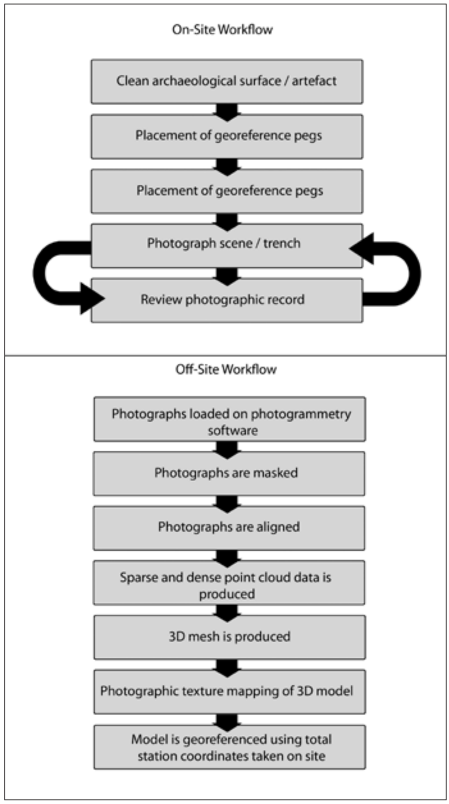


**Figure 10.** The on-site and off-site workflow for recording archaeological scenes using photogrammetry. *On Site*: **-** The surface of the trench is cleaned as usually done prior to photographing. - Placement and georeferencing of pegs with a total station. - The trench (target object) is photographed from as many different angles as possible ensuring at least a 60 percent overlap. - Digital images are downloaded onto a laptop on site and a low resolution model is produced in order to ensure sufficient overlap. Extra photographs are taken if needed. *Off Site*: **-** Photographs are loaded into dedicated software where the photos are aligned, and sparse and dense point clouds, 3D mesh and texture of the 3D model are produced. - Once the model is complete, positions of pegs recorded with a total station are tagged to georeference the model within the excavation grid system.

identify areas which did not have a sufficient number of photographs and allowed additional images to be taken. Checking the overlap and quality of the photographs on site is an important part of the photogrammetry workflow, as this stage cannot be revisited once the excavated has completed. Once the correct photographs are taken, full resolution 3D models, which can take a considerable amount of time and require high computer power, can be produced off site (Figure 11).

### *GIS management of spatial data retrieved during excavation*

Nowadays, GIS techniques are widely applied to Archaeology (Connolly and Lake, 2006), from mapping of site distribution across the landscape (Siart et al., 2008; Espa et al., 2006), production of digital elevation models (Wheatley and Gillings, 2002), to the analysis of orientation (Benito-Calvo and de la Torre, 2011) and traces (e.g. Bird et al, 2007) in artefacts.

From the point of view of the day-to-day excavation process, SAAG uses the spatial data collected with the total station to produce plan views of the artefacts and cross sections of archaeological units, in order to analyse the spatial distribution of artefacts. These maps are produced on a daily basis in order to recognise clusters of artefacts and their horizontal and vertical distribution, and help in identifying distinct archaeological units.

With respect to plan views, our priority is to reproduce as faithfully as possible the original layout of archaeological remains, inspired by the superb maps drawn by Leakey (1971) at Olduvai Gorge, whose painstaking detail and quality have enabled studies based only on her artefact plans (Davis 1975; Benito-Calvo and de la Torre, 2011; de la Torre and Benito-Calvo and, 2013). Thus, our methodology includes the use of orthogonal photos and drawings of fossils and stone tools taken during the excavation. Artefacts larger than 4-5 cm are normally either photographed or drawn. The total station is then used to record the ID of items and to delimitate their overall limits, noting the information on the photo/drawing. Back in the laboratory, each photo/drawing is imported and georeferenced into GIS software along with the total station points. This is followed by the production of a polygon based on the outline of the item's shape, which retains the same ID as the piece (Figure 6).

While horizontal plan views are important to capture the original location and orientation of excavated items, vertical plots are produced on a daily basis during the field season in order to check the progress of excavation. This is necessary due to the intrinsic difficulty of identifying distinct archaeological units during digging of Palaeolithic sites; while on occasions lithostratigraphic changes enable isolating vertical clusters of artefacts, one single lithostratigraphic layer often contains several archaeological units. When this is the case, a vertical view of the distribution of artefacts offers information about their spreading throughout the litho-stratigraphic layer, and represents a valuable tool to identify the presence of individual levels of artefacts, separated by gaps where sediments are void of archaeological items. Routinely production of these vertical plots is thus essential to ensure correct progress of the digging, and often dictates decisions on the attribution of materials to particular archaeological units. Using GIS software, such plots can be produced from different perspectives, therefore enabling to capture 3D views of artefact distributions (Figure 12).

Additional spatial and orientation data can be obtained from these plots,

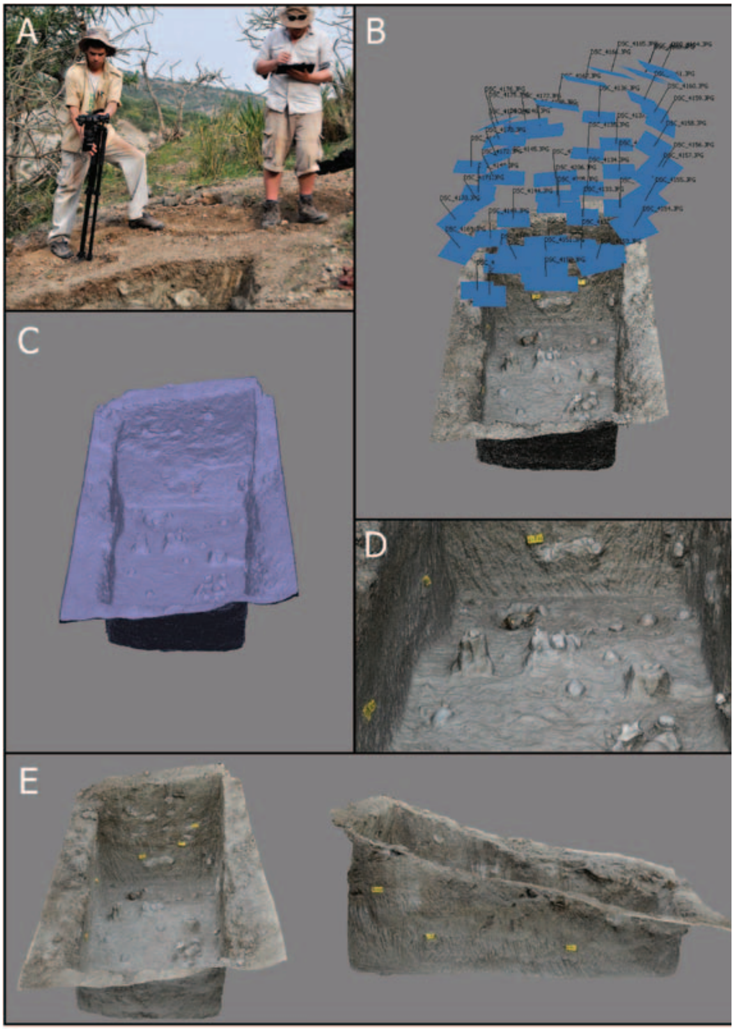


**Figure 11.** Building a photogrammetry model at HWKEE (Olduvai Gorge). A) Setting up the camera for wireless photographing. B) Location of the photographs used to create the 3D model. C) Wireframe 3D model of the entire trench. D) Dense point cloud detail of the archaeological unit. E: Final textured 3D model of the entire trench (front and side views).

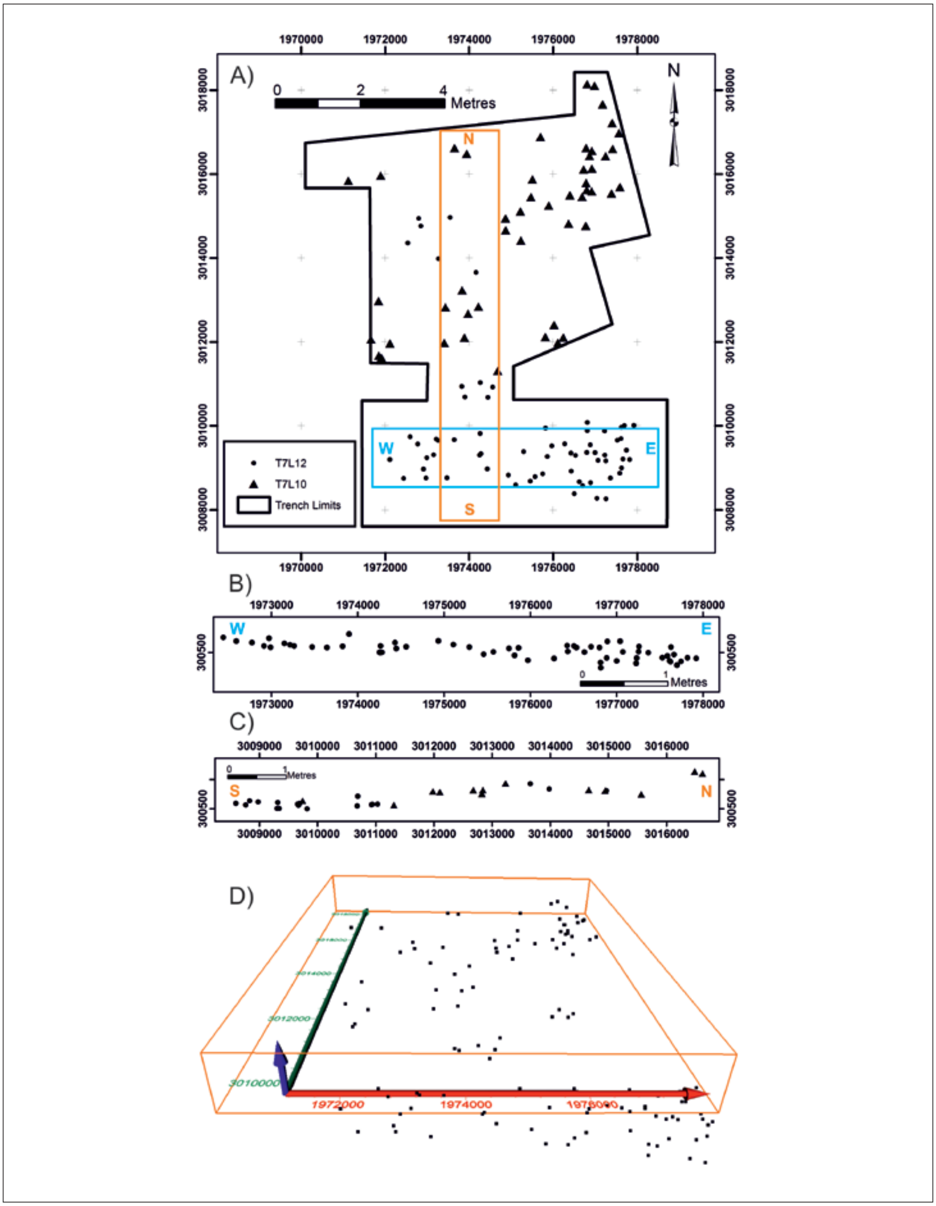


**Figure 12.** A) Plan view of artefact distribution in Mieso 7 (de la Torre et al, 2014). The two boxes indicate location of the cross-sections shown in Figure 12B and 12C. B) Transversal cross-section (that is, East-West view, which represents the X and Z coordinates) of box E-W in Figure 12A. C) Sagittal cross-section (that is, North-South view, which represents the Y and Z coordinates) of box N-S in Figure 12A. E) 3D cross-section (X, Y, Z) of the artefacts from Mieso 7.

providing information about, for example, the paleo-relief where artefacts were sitting on, possible post-depositional disturbances, and others. In addition, the artefactual spatial data obtained can be combined with one or more 3D photogrammetry models, allowing a full 3D reconstruction of the original position of fossils and stone tools as well as of the overall site. The latter are nonetheless spatial tools that are more related to the analytical, post-fieldwork stage of the archaeological process, and hence are beyond the scope of this paper.

## Conclusion

This paper has summarized methods of excavation, data collection and finds processing during fieldwork, practiced by SAAG in a number of projects in Spain and East Africa. We certainly do not intend to reinvent the wheel here, and in fact it should be mentioned again that our field methods draw heavily from those developed by CEPAP over the last three decades (e.g. Mora et al, 2001; Mora et al, this volume; Martínez-Moreno et al, 2004;). It is also important to emphasize that methodologies are case-specific, in which human and funding resources, logistics, time constraints and the nature of the site itself, dictate the pace and achievable quality of field data collection. In the same vein, it cannot be overstressed that field methods can and must constantly be updated, especially at present when digital advances offer a seemingly endless technological progress.

On the other hand, it is also true that archaeological field recovery techniques are often poorly described in scientific publications, where there is a tacit (and sometimes unwarranted) understanding that such techniques are so standardised that no explicit statements are necessary. As we have argued above, that is not the case, and indeed huge variability exists in the archaeological methods used by each field director. These must have a considerable impact in the type and quality of data recovered, and therefore will affect substantially interpretations that are presented eventually in publications. Thus, we maintain that although fleshing out archaeological fieldwork methods may be going over old ground, a detailed description of such techniques is important in order to qualify interpretations based on field data collection.

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