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An Integrated Implementation of Written and Material Sources – Conceptual Challenge and Technological Resources

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1. Introduction

The potential of new technologies in informatics and communication opens great and unrevealed chances in the procedures for developing historical research. This challenge is as much concerned to the instrumental aspects of research as to the opportunity of carrying out multidisciplinary and teamwork researches within a completely new framework for the implementation of information.

When trying to benefit from these chances in technology, researchers are expected to make some changes in research that actually overcome the mere use of technological media. In fact, the matter to discuss is not the creation of new tools, but an innovative conceptualization of historical research overwhelming the discursive fragmentation coming from the different sources in use depending on their archaeological or documental nature. Unfortunately, the confusion between *speciality* and *discipline* still imbues a considerable part of historical works.

On the other hand, dealing with the incorporation of the great potential of the new technologies to the historical research without overcoming this fragmentation we are speaking of would lead us into a simple technological fascination, and would add a new element of disorder: the confusion between the *tool* and the *goal*, which would not help to improve the research quality and efficiency at all.

Consequently, the standpoint that we will articulate our thought from leads us before anything else to the identification of the "raw material" for the historical research. In our theorization this raw material is just the information, whatever is the source that provides it. It means that the dichotomy between archaeology and written sources disappears because both of them are sources for us to obtain historical information. But, what are we speaking about when mentioning the terms *historical information*? To answer this question we need to talk about two key concepts: *time* and *change*.

Perhaps the concept of time has not deserved among scholars the required attention, maybe because of the confusion between time and chronology or maybe because of the consideration of time as an absolute independent magnitude that acts as container of phenomena. This understanding has revealed itself as an insufficient and useless concept.

What we are looking for through the historical research is the identification and characterization of a sum of factors such as environmental, ecological, economic, social, cultural, political, etc., that are conditioning human life within a particular period of time. By means of this characterization of factors we aim to define and set up a model to detect and measure the permanence in front of the change. This rhythm or cadence between what happens before and what comes later is what can be understood as historical time[1].

As mentioned before, the conceptual confusion between speciality and discipline has been quite an unsolvable barrier when trying to define work methodologies in order to make the processes of recuperation, register and exploitation of information work as integrated elements, leaving aside the nature of the sources whether they are archaeological or documental evidences. Consequently, one of the main objectives of this proposal is to design an integrated system for the implementation of information that enables to consolidate a real network of scholars working in a multidisciplinary way.

Accordingly, we aim to present the conceptual and methodological concept to make this possible followed by an exemplification of its development in a second step: the study of landscape and its evolution, archaeological register, documental data exploitation, study of archaeological materials, etc. This process is needed to be strongly linked with the possibilities of new technologies and that is why we present as well some concrete experiences for each application.

Furthermore, this exemplification pays special attention to some pieces of information that sometimes have been considered to be worthless or insignificant from an historical or archaeological standpoint in order to show some satisfactory results obtained from the application of the proposed methodology and tools. We also will discuss about the optimization of the research works by incorporating new technologies.

2. The conceptual and methodological framework

2.1 The theoretical context of archaeology

The work of Edward C. Harris *The stratigraphic sequence: a question of time* (Harris, 1975), which was soon enlarged with the publication of *Principles of archaeological stratigraphy* (Harris, 1979), marked a turn point in the movement of methodological change in archaeology by resetting the main objective of the archaeologist's work. The title of his first abovementioned article, although it was a brief work, clearly focuses the attention in the keyword of his thought: the importance of time as central element in the archaeological study. Particularly, Harris sets up the identification, register and analyses by means of temporal relation diagrams (matrix) of what he calls Stratigraphic Units as the axe of the archaeologist's activity. We can concisely define Stratigraphic Unit as the evidences or remains of actions succeeded in time, whatever they are stratigraphic layers, erosive processes or destruction remains. Again we are speaking of permanence and change.

Within this insight, Harris not only offers a major contribution to the definition of register systems in archaeology but he rearranges the position of archaeological studies in the context of historical research. Strata, structures, objects, etc., gain significance as they contain

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[1] To deep inside this matter of historical time, see Aróstegui: 1995.

by themselves evidences of actions that took place in a concrete time. From this standpoint, the work of archaeologists and the register systems become more objectives and give an answer to the main exigency of science in general: the possibility for other scholars to read again and reinterpret the data, if needed. Consequently, we take into account that Harris does not focus in chronological aspects when speaking about time, which has been always one of the interests of archaeology from many years before, but in the temporal information provided by the relation between different Stratigraphic Units, represented into a matrix.

"*As it is concerned with people and artifacts from pas societies, archaeology is a four-dimensional discipline dealing with observation of physical (three-dimensional) remains throuh time*" (Harris, 1992:100). "*The goal of archaeology... is to produce historical knowledge; it does mean, to produce properly contrasted information about the structure, the running and the changes of human societies. Consequently, this objective is just the same that those of scholars that carry out their research uniquely by means of written sources. Archaeology produces knowledge from the archaeological register and prospection without leaving aside written sources, which are seriously limited. The archaeological register as well is limited.*" (Barceló, 1988:11; translation by E.Travé).

These considerations have a direct consequence: the fact that the study of objects and architectural structures must not be dissociated from or prevailed above the information around them in the research process. Furthermore, the value of a stratigraphic unit must neither be prevailed above another one. In a similar way, the settlement cannot be considered as closed entirety, but it must be treated as a single sample to represent a whole that we only know partially and we always will; to some extent because of what we have convened to call settlement.

The study of the objects, building techniques, and architectural features, etc., is necessary and compulsory but has to be integrated within the knowledge of Stratigraphic Units and its historical significance. When considering these thoughts, we notice that historical research has turn out to be a four-dimensioned matter, instead or three-dimensioned one. As a result, the wrong assimilation between archaeology and excavation is broken and this new conception opens a new way to prospection or landscape studies and –what is more– the avoiding of random location and excavation of sites. Therefore research will overcome its false division depending on the specificity of the information source used.

2.2 The sources for historical research and its treatment

Unfortunately, historical studies built upon written sources have not get through a similar transformation as the one we have described for the field of archaeology. The neglect of information coming from archaeological sources is still too frequent in historical studies, especially when written sources are rich. It also must be taken into account this deficit related to archaeological research in periods with documentary evidence.

The improvement of words and expressions like information and communication technologies, P2P, Internet, network, implementation… and a long etcetera, could sometimes result overwhelming. In fact, we still wish for the renewal of language and working procedures according to the possibilities that these technologies really offer, coming through the simple turn of ancient ways of working into a new performance or the occasional use of informatics.

Certainly, the potential of these new resources and the high speed of their evolution might be shocking, but focusing on the problems we aim to solve instead of getting obsessed on these new tools by themselves is crucial to avoid this shock. As it has been said in the introduction, the main question to clarify is the articulation of an implementation system for processing information that makes possible simultaneously the enlargement of efficiency and cooperation and promotes scientific transparency.

According to these objectives, we are able to define the compulsory requirements for the perfect running of this implementation system:

- It has to allow an integrated management of the information whatever be the origin of the source.
- Historical sources must be able to be exploited at different levels and depths, without an enforced scale.
- There has to be the chance of registering spatial references.
- Spatial associations among different sources must also be taken into account.
- It has to gather chronological references.
- It has also to allow the description of successions, series or sequences.
- Contextualization metadata and the proper assessment of information must be able to be registered.
- The restitution of the original structure of the source must be allowed.
- Researchers must be allowed to share their work or to set up teamwork.
- The data independence must be assured respect of the computing platforms.

2.3 Some concepts for an integrated exploitation of information

Several paragraphs before, we spoke of the concept of information as the "raw material" for the historical research. We evidenced as well the range of sources to gather information from. In order to achieve the goal of an integrated implementation, we should describe a theoretical and instrumental framework that gives as some tools to process information. Let us outline in this subheading the theoretical body. We will use three key concepts that must be accurately defined:

- Topographic Units (TU)
- Actors (AC)
- Stratigraphic Units (SU)

In addition, we have to ensure the ability of registering and making use of the relationship that is likely to be between them.

Topographic Unit (TU):

The information gathered from historical sources is referred to the TU in the sense that every single fact has its place within a spatial and temporal framework, so as to be represented in space and time. All the variables composing a system and the oscillation of their values some time long will be considered as TU; and also the assemblage of Stratigraphic Units (SU) defining a whole phase of a settlement. Actually, the goal is not to register physical evidences only but facts placed in space and time. As a result, their identification with material evidences is not compulsory at all.

A TU has to be understood as the evidence of an action or situation that can be located in space and time, whatever is the specificity of the information source and its biotic, non biotic or anthropic origin.

Examples:

The existence of a vegetal specimen in a determined area; the documentary evidence of the consecration of a church; the documentary evidence of the transaction of a property; the archaeological evidence of a necropolis; the remains of a pathway…

Actors (AC)

TU and SU are the result of biotic, abiotic or anthropic activities. When these units are the result of anthropic activities, we have to identify the individual or corporative agents of these actions.

An Actor has to be understood as the individual or corporative protagonist of an action that has been identified by means of a TU or a SU.

Examples:

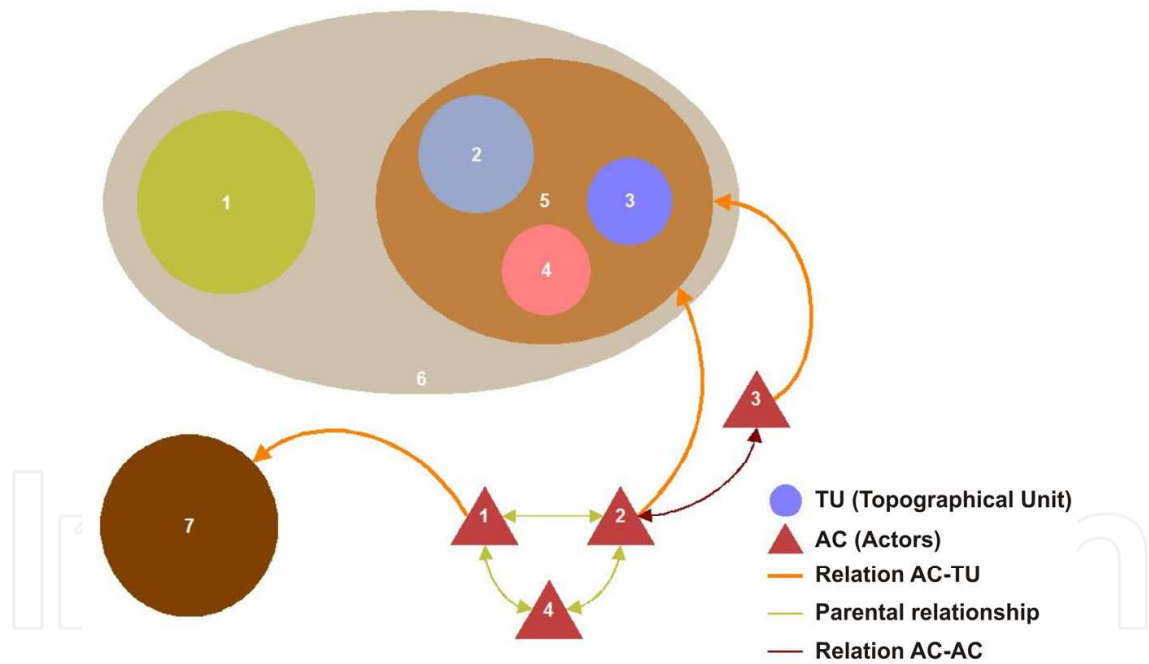Ènyec Bonfill; the monastery of Sant Cugat del Vallès; etc.

Fig. 1. This graphic shows a scheme exemplifying the relation between TU, TU and AC, and between AC. TU 6 includes 1 and 5, that contains at the same time 2, 3 and 4. None of them keeps any relation with 7. In the case of actors, 1, 2 and 4 are relatives whereas between 2 and 3 there is a transactional (buyer – seller) relation concerning the TU 5. Each identification number is unique for each TU and each AC.

Stratigraphic Units (SU):

SU are, as well as TU, the results of biotic or anthropic activities but they are always identified as a result of material evidence in an archaeological context.

A SU has to be understood as the material evidence of an action that can be located in space and time.

Examples:

The digging of a hollow for a burial, the building of a wall, the spoliation of constructive elements…

In each context, several relations are possible to be made: between different TU, between TU and SU, between both of them and AC and between different AC *(fig. 1)*.

3. The system of register and data assemblages

While the main objective is the integration of the information, it is true that the specificity of each source requires different procedures for the data identification. Therefore, written sources exploitation, archaeological prospection, studies of structures and buildings or archaeological excavation will require different methods.

In the following subheadings we show some examples in order to facilitate the comprehension of practical arrangements of what has been previously exposed: first concerning written sources and second with reference to archaeological sources. In this case, we will focus on the study of ceramic materials and its methodology. The register of spatially located TU and SU will be exemplified in subheading 3.3 by means of showing the database system and spatial registering.

It should be noticed, before deepening into the concrete examples, that those working cases proposed are part of a development still in process. Consequently, they not always show the integration degree exposed in the previous methodological discurse. Despite of this, the examples proposed are quite valid and claim to be a serious standpoint to to the data registering and exploitation.

3.1 The treatment of textual sources

Let us take as an example the document related to a sold (Puig: 1991. document 170). See on the transcription below the identification of different pieces of information and its classification depending on their correspondence with TU (numbered and remarked in purple) or AC (numbered ad remarked in green) as needed. We also highlight in yellow, the relations between them:

In nomine Domini. Ego Semplizia[1] et sorori mea nomine Cixolo[2], nos simul in unum uinditores sumus tibi Guilara[3] presbiter emptor. Per hanc scriptura uindicionis nostre uindimus[1] tibi terra[2] et uinea[3] et arboribus[4] et oliuaria[5], hec omnia francum nostrum (pro)prium qui nobis aduenit, ad me Semplizia per ienitores meos et per compara et ad me Cixolo per ienitores meos et per ullasque uoces. Et est hec omnia in comitatum Barquinona[6] infra termine de Terracia[7] in locum uocitatum Monte Agudo[8]. Afrontad ipsa terra et uinea cum ipsos arboribus qui ibi sunt fundatos de oriente in aragallo[9] et in terra[10] de Godmar[4] et suos eredes, de meridie in terra[11] de Ego[5] femina, mulier de Eruiio[6] et de Guisado[7], de occiduo in uia[12] et in terra[13] de te emptor, de circi in terra[14] de Guisad[8]. Quantum istas afrontaciones includunt, sic uindimus tibi ipsa terra el uinea et arboribus, in ipso aragallo ficulnea[15] I cum pruneras[16] et uides[17], in alios locos prunera[18] I et ficulneas[19] II et nogaria[20] et pecera[21] et glandifero[22] I et oliuera[23] I ab integre cum exios et regresios earum ad tuum proprium propter precium solidos VI et denarios IIII ex moneda grossa, quod manibus nostris

accepimus et est manifestum, et de nostro iuro in tuo tradimus dominio et potestatem ad faciendum quod uolueris. Quod si nos uinditrices aut ullusque homo qui contra hanc ista carta uindicione uenerit pro inrumpendum aut nos uenerimus, non hoc ualead uindicare, set conponad aut conponamus tibi oc quod supra insertum est in duplo cum omnes illorum inmelioraciones, et in antea ista carta uindicione firma permanead omnique tempore.

Facta carta uindicione VI kalendas februarii anno XXII regnante Rodberto rege.

Sig+num Semplizia. Sig+num Cixolo. Nos, qui hoc fecimus et firmare rogauimus. Sig+num Godmar. Sig+num Mir. Sig+num Issarno

SS. Ansemundo presbiter scripsit cum literas superpositas in uerso V die et anno quod supra.

The contents remarked on the transcription identify a sum of eight actors [AC], twenty-three Topographic Units [TU] and some complementary data such as the price, parental relations between some AC and the date. We have not registered three actors that appear at the bottom sign of the document, one of them being the scribe. It does not mean that these have to be omitted; we just exemplify the possibility of a partial register of the content, but always recording clearly what has been registered and what has not, and which labels have been adjudicated to each piece of information. Hence we make transparent the work onto the source, which allows coming back to the source later ourselves or any other scholar in order to enlarge what needed and extract data in a structured way in order to smooth the progress of exploitation.

TU and AC must be sequentially numbered. Therefore, TU are numbered in the example provided from 1 to 23 and AC from 1 to 8. When studying a new document, new TU and AC will take the following numbers, 24 for TU and 9 for AC, so as each element has a unique identification. The digital registration of this process is made by means of a database as the one shown in *fig. 2*. There we will see the unique identification of TU, its spatial

Fig. 2. TU register example.

location when possible, the territorial and administrative limits which it is included in, the relation with other TU, the attribute system, the date, etc. and the precedence of the source.

The link between a TU or AC register and a Geographical Information System (GIS) allows obtaining spatial illustrations *(fig. 3)*, crossing data between different sources concerning the same event or action and making spatial analyses. When speaking of integration and crossed data, we not only refer to the TU identified from written sources, but any kind of evidence. For instance, the existence of a church can be identified by the documentary evidences but also by the existence of the building. It actually means that the building is susceptible to provide a great assemblage of complementary data, recorded as TU and SU, by means of an archaeological and architectural approach.

AC register is made as well in a data base and the relations identified as a result of the information gathered from AC and TU are also registered in the same way.
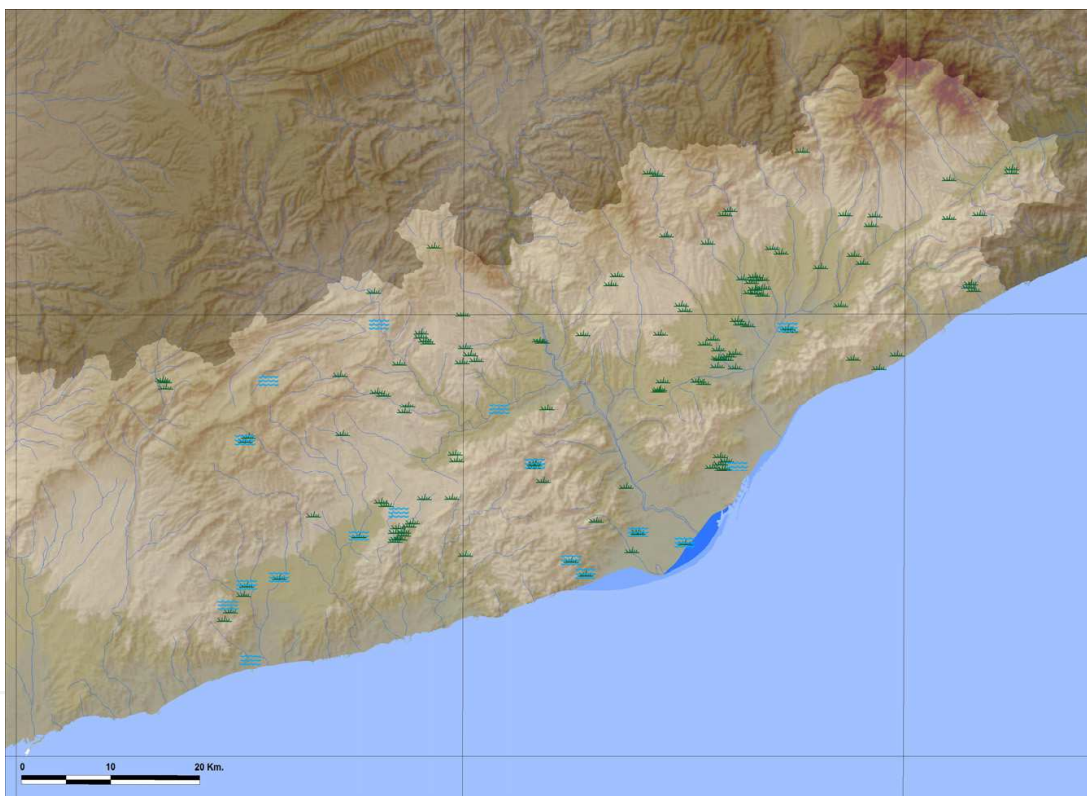

Fig. 3. View of the spatial distribution of written references to meadows and lakes in the County of Barcelona at the end of 11th Century, obtained from the TU register. This distribution could be analized individually or crossed with other TU identified from documentary/archaeological sources, depending on the research interests.

3.2 The treatment of archaeological sources

The requirements of data integration to the perfect running of the implementation of the information system must be solved by designing and developing scientific tools which, as mentioned before, are still in developing process in order to be integrated in a whole system. So, let us now focus on the treatment of archaeological materials and we will keep the SU register for the discussion in subheading 3.3.

In our theoretical design, the detailed analysis of archaeological materials is also considered as a key element. Building our analyses upon a complete database, registering as many variables as possible from the element studied enables us to develop a real interpretative corpus of a settlement, frequently related to an insight of landscape studies. Therefore, we present and propose as an example a procedure for registering archaeological materials focusing on analyses and study of ceramic material.

3.2.1 Techniques for gathering information

The general classification of archaeological materials groups the whole collection in four general assemblages:

1. Specific ceramic materials,
2. Nonspecific ceramic materials,
3. Specific non ceramic materials and
4. Nonspecific non ceramic materials.

Each one of these assemblages is considered in a slightly different way depending on the potential of data exploitation that each sort of material is able to offer. In this sense, each one of the fur assemblages has a particular register *(fig. 4)*. Registering models for specific materials, whatever if they are ceramic or non ceramic, imply the need of linking one or several illustrations and photographs.

Fig. 4. Specific ceramic materials register example.

While the register of non ceramic materials follows a plain procedure, the study of ceramic materials requires the major effort because the grade of detail when analysing pastes. The main goal of this detailed register is to facilitate the research in a later phase: actually, when scheduling an analytical approach by means of Ceramic Petrography, X-Ray Fluorescence, X-Ray Diffraction, Scanning Electron Microscopy, etc., the sampling process is really trouble-free if we can search into a detailed database. Within a tight budget, promising results will be obtained and further analyses will rarely be needed if there has been a correct sampling before. For these reasons, we must distinguish between formal description of

ceramics and paste analysis. On one hand, formal description includes the typological and morphometric study of specific ceramic materials and, on the other hand, paste's analysis is made with petrographic criteria both of specific and nonspecific ceramic materials.

We should bear in mind that, if it is actually true that paste analyses must be made both for specific and nonspecific ceramic materials, the procedure for each sort of ceramic is slightly different: In the case of specific ceramic material, each pottery sherd has an individualized register, whereas nonspecific ceramics are grouped in paste groups from the macroscopic observation, in our case with the help of a geologist 20x magnifying glass and a binocular.

Although nonspecific ceramic's paste description follows the same criteria than specific, nonspecific descriptions are usually made for more than one individual. That is why we choose a generic description focusing on the similarities and those features more representatives of the assemblage. These descriptions are generally included in the observations gap.

3.2.2 A registering procedure for specific ceramic materials

Once the general classification of materials has been done and nonspecific and non ceramic materials have been inventoried, it is time to proceed with the specific ceramic materials catalogue. A correlative inventory number must be given to each sherd after the SU number and a new record opened whose gaps must be filled in three different moments depending on the three phases of study described below. This proceeding considers as well the graphic documentation of the sherd obtained from photographs and archaeological illustration.

The steps we propose could be ordered as follows:

a. Sherd's identification and location: As it has been noticed before, each individualized sherd receives an inventory number formed by the settlement capitals followed by a dot and the SU number and followed by a dash and the correlative three-digit-form inventory number (Example: *SME.22-005*).

b. Sherd's description: This phase comprises the first approach to the material study properly speaking. The fields proposed in the database (material, category, type, preserved fragments, number or quantity, paste featuring, paste components, firing type, type of finishing, decoration, etc.) are related to the first insight of the sherds observed at naked eye, following traditional archaeological criteria.

c. Macroscopic analysis of the paste: In this phase, we ought to carry out quite a deeper approach to the ceramic paste with petrographic criteria, sometimes with the aid of a magnifying glass. The main goal of this phase –also called technical analysis[2]– is to characterize the materials in detail in order to facilitate a sample selection if required for further archaeometric approaches. In that sense, the main variables to be analyzed are in pottery pastes are (1) colour, (2) inclusions, (3) porosity, (4) clay matrix and (5) fracture.

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[2] "The term of *technical analysis* describes the study of main elements of a ceramic paste allowing us to interpret the evidences of the sherd's productive process, opposed to formal and functional criteria, which pay attention to the result of the process, or what is the same, the pot itself. The technical analysis also looks for the provenance of pottery or the raw material sources. We consider as elements of the technical analysis those referring to the paste, the surface treatment, the sort of fracture and firing and the possible evidences of use." (Travé, 2009: 258).

Consequently, during the description and classification of pastes, we make an individual approach to the three key elements of pottery: inclusions, clay matrix and porosity, observed in hand-sample. Descriptions must summarize briefly the colour of the paste that allows us to determine the firing atmosphere; the nature of inclusions – type, abundance and sorting–, the features of porosity and the surface treatments, by using the terminology taken from mineralogy, petrology and soil micromorphology. As an example, to determine the sorting of inclusions we usually use the tables proposed by Compton (1962) and to determine the features of porosity we follow the guidelines proposed by Whitbread (1995).

d. Sherd photography: We usually take one or more pictures of each ceramic sherd. It must be taken into account that these pictures are not only a traditional element for obtaining data, but also a main tool for the archaeological draw because the final illustrations of ceramics frequently show pictures as a support to describe graphically the texture of the sherd paste.

e. Archaeological design: The technical drawing of the sherd at a real scale sets up the basis for the morphometrical study developed in the next phase. When speaking of archaeological draw, we can consider both the traditional hand-made design and maybe more sophisticated proposals. We will notice below the employment of a 3D digitizer for drawing ceramics, according to the use of digital and technological resources.

f. Size calculation and *vectorization* of archaeological designs:
    - Calculation of top, bottom, minimum and maximum diameter of the vessel.
    - Calculation of the minimum, medium and maximum thickness.
    - Calculation of the height (total, preserved or recreated).
    - Profile *vectorization*: The register file we showed before includes some gapes for data obtained from the generatrix line *vectorization*.

    We understand as *vectorization*, the method consisting on defining the generatrix of a vessel in function of a three-digit combination indicating the type of line that will be vectorized, followed by a five-digit number that will allow us to place on a plan the ends of the line and one or two turning points of this line, depending on the case. The five-digit number obtained allows us to get a quick picture of the line form in our brain and, consequently, a rough idea of the sherd's size and the information that can be gathered from it (Travé 2009: 219). This process is made by using a pattern as the one in *fig. 5*. We will not get into details about the measurement process in this chapter as the reader will be able to deep into it by reading the abovementioned publication (Travé 2009: 219 – 224). Anyway, we must point out that the obtained result is a digit combination that follows the scheme BCYXD, where B, C and D correspond to the definition of vectors outlined by the pattern and YX relate to a Cartesian coordinate (x, y) marking a turn point within the line.

g. Data arrangement: This seventh phase implies, to some extent, a previous and immediate stage to data analyses. This data arrangement, that will facilitate the results attainment in a typological view, starts from two sorts of arrangements that have to do one with another: morphometric tables and typology lamina.
    - Elaboration of morphometric tables: This type of tables can be considered as nothing else but a search in the database for all the ceramic material overlooking the references to pastes. As a result, what appear in these tables are the measures,

the vectorization results and optionally the chronology of materials. Morphometric tables are a useful tool to order data for further analyses.

- Preparation of typology lamina: Morphometric tables set up the basis for vessels ordination. They allow glimpsing the main groups of forms in order to show them joined in the same illustration. Each lamina must show a coherent group of materials generally at a 1:2 or 1:3 scales. They are the last step in the data publication and the most eloquent way to explain the materials analyzed.

3.2.3 Data analyses

The study of data obtained both from size measurements and vectorization procedure allows us to better order the materials in a more precise way and to make an approach to their fragmentation degree. Concerning typologies, the vectorization data arrangement in function of BCYXD combinations allows as grouping the materials in different clusters usually symbolized in roman numbers. This cluster analysis is an abstraction exercise in order to interpret correctly the results so that each cluster has particular features that make it unique, unitary, relatively homogeneous and clearly distinguishable from the others.

On the other hand, the detailed register of paste petrographic description and the grouping procedure imply a first approach to technical analyses that can be enhanced with further archaeometric analyses to go deeper into the materials. In that case, we should only search in the data base for the determined groups and select a proportional number of samples from each assemblage.

3.3 The databases and spatial information register

We have made reference from the beginning to a four-dimensioned archaeological research where the fourth dimension is time. This archaeological stand point is not different to the one for the entire historical research. Consequently, the integration tools to gather information have to offer a particular insight to the spatial significance of data assemblages. We believe that incorporating Geographical Information Systems (GIS) to the implementation system is the most suitable way to face the need of offering an integrated approach. We show below what is referred to this running, centred by the moment in the archaeological view, but with a coherent insight with the treatment of data obtained from other sources.

A GIS can be defined as an assemblage formed by the hardware, the software and the georeferred alphanumeric data. They are designed to gather, store, actualize, operate, analyze and reproduce these georeferred data overwhelming the concept of map understood as a graphic. Within a GIS, what we call map is a representation and analysis of information also from its significance and its spatial and temporal relations.

As a result, a GIS includes, on one hand, the facilities and functions of a relational database and, on the other hand, the particular facilities of assisted cartography and, to some extent, of spatial analyses.

Basically, a GIS can offer:

- Functions for the uploading of graphical, textual or numerical information.
- Functions for the graphic and cartographic representation of information.

- Functions of information management and running.
- Analytical functions.

Again, we need to remind the reader about the requisite of not fail to differentiate the tool and the goal, falling into the technological fascination. We never have to lose the perspective that what we have in front is nothing but a tool. A GIS gives a clear answer to a previously defined question that would be extremely difficult to reach without this tool, but the preceding interrogation must never be avoided.

Sometimes, some efforts to implement the use of GIS applications fail because of the profile overlooking of the users expected to execute this software. The high level of GIS complexity, the high learning difficulties and the great period of time between the data recording and the obtaining of first results sometimes are the main reason for researchers' abandonment. To avoid these errors, is fundamental to dedicate almost a 5 – 10% of the total cost of a project to the analysis, evaluation and planning.

Specifically, the risk factors in the development of a GIS implementation project are:

- Wrong definition of the system because of weak or poorly defined hypotheses.
- Difficulties on forwarding the changing needs of the GIS management.
- Unrealistic analysis of costs and benefits.
- Interest conflicts between different participants of the project.
- Incapacity to obtain the support of implied institutions.
- Wasted previous experiences.
- Difficulties in the continuous funding for long-term projects.
- Insufficient comprehension of the hardness and technical complexity of the project.
- Frustrated expectative on the selected system.
- Aiming unrealistic goals that do not take into account the material and human resources of the work-team.
- Overlooking from the beginning further enlarging of the GIS, which originates the creation of closed structures, hardly ever enlargeable.

3.3.1 GIS and archaeology

During latest years, GIS have been increasingly used in a considerable amount of both scientific and management disciplines. Archaeology has summed to this improvement and there are several pieces of research, proceedings of scientific meetings, workshops and publications that refer to the use of GIS in our discipline. Our objective is not to expose a detailed state of the art concerning this area as the reader could easily find some papers summarizing these efforts and pondering the experiences carried out during these latest years (Bermúdez, 2000 & Baena, 2003) for a deeper insight. Nevertheless, within the application of GIS to the historical studies, we are able to distinguish between two great approaches to GIS depending on the subject matter.

Spatial studies (Sáenz, 2000 & Palet, 1994) relating original patrimonial data with the landscape starting from a territorial data structure, usually from the physic environment. As a result, two different levels of data exploitation are linked: on one hand, the landscape and its variables and, on the other hand, the physical manifestations of the anthropic system. Usually, the technological resources used in this kind of research is limited to a GIS as a

product, it does mean, commercial GIS software[3] where only the functions required for these approaches are used *(fig. 5)*.
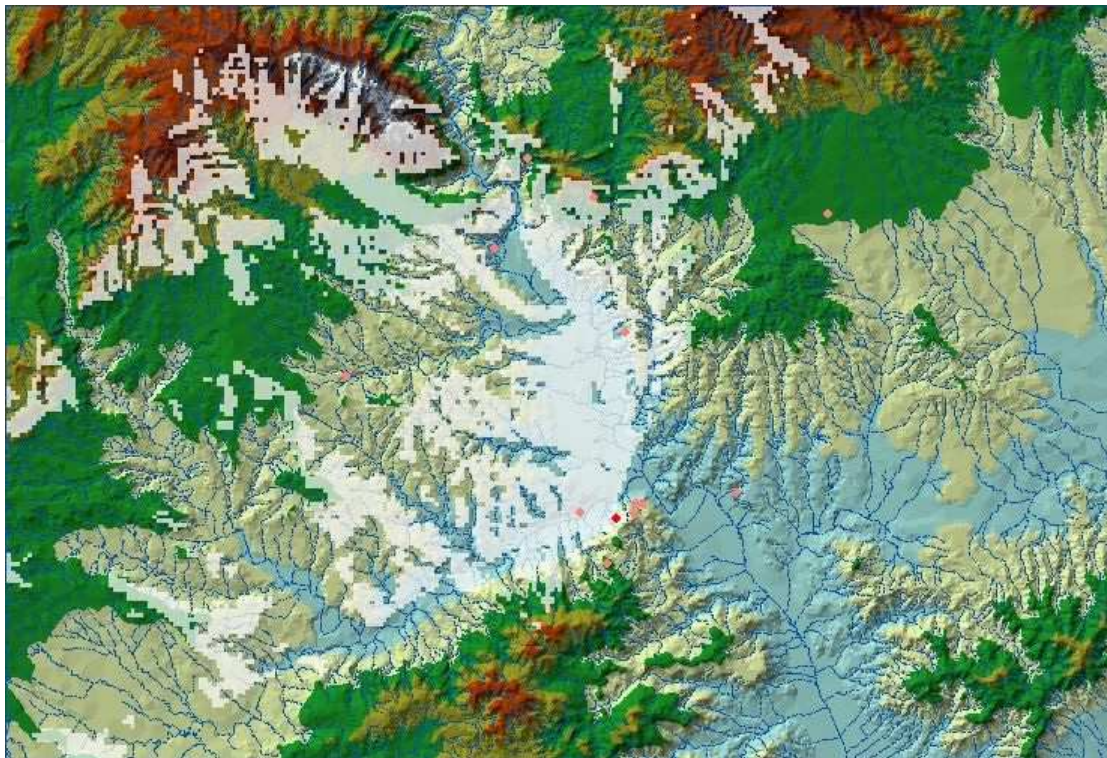

Fig. 5. Interpretation map showing a spatial study of the visual basin from the monastery of Sant Genís de Rocafort (Catalonia), made with a common commercial GIS.

Stratigraphic studies or management. In this case, GIS allow running the information produced in an archaeological fieldwork. In some cases, the common use of a GIS as a product is clearly overcome and specific applications[4] are developed in order to get a better data management or a better showing of results *(fig. 6)*. In that case is really interesting to bear in mind the open discussion (Duque, 2000 & Stallman, 2004) about the use of free software and open code[5].

We must bear in mind that our research is always based upon the information partially known about a preexisting reality. Consequently, the main goal of researcher is to shape the subjective reality they perceive when acting with an information source whatever its origin: the excavation of an archaeological site, the prospection in a determined area, the constructive sequence of a building, the evolution and transformation of a landscape…

Archaeological practices have traditionally focused on the settlement and its excavation. This framework has been progressively overcome by means of the application of non-

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[3] Some commercial programmes are: ArcGIS (ArcView, ArcInfo), Mapinfo, Maptitude, Geomedia, Geoconcept, GenaMap, Autodesk Map, MicroStation Geographics, GeoWeb Publisher, SmallWorld, Manifold, Idrisi, MapPoint, TatukGIS, TNT mips, or MiraMon.

[4] Projecte Life Tiermes. http://mapas.topografia.upm.es/tiermes/arqueologia/; *SIA+*, GONZÁLEZ PÉREZ, 1997.

[5] Tax-free software: GRASS GIS, JUMP, MapServer, Quantum GIS, gvSIG, SAGA GIS, MapWindow GIS, Kosmo.
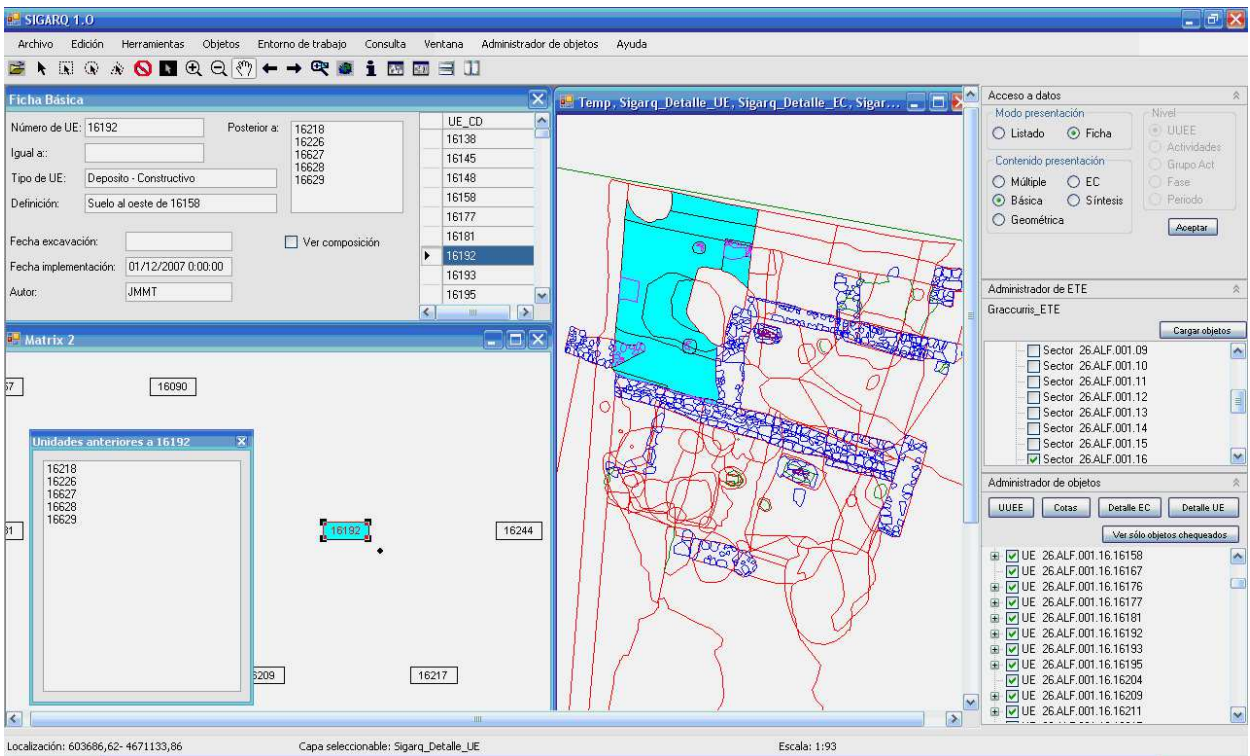
Fig. 6. Screen view of SigArq project showing the main issues in stratigraphic management. In this case, SigArq s.1.0., which will be explained in detail before, is a GIS specifically created to give a solution to the archaeological fieldwork running.

intrusive prospection techniques not only in a settlement area but also in extended regions, so as to generate a new sort of archaeological information that suits properly the concepts of TU and SU exposed above. The wideness of these works and the increasing number of excavated sites strongly require the implementation of new formulas allowing task sharing to the uploading, management and access to the information for a better scientific development of research and for a more efficient administrative running of heritage to its whole extent.

The project SigArq[6] (Archaeological Geospatial Information System) was born to offer an answer to these challenges. It aims to put forward a tool for the management generated in archaeological fieldworks, without regarding the nature of the heritage element to study, the scientific technique used –but also related to the concept of SU (Harris, 1979 & Carandini, 1997)–, the size or the chronology of the site. Furthermore it points toward the interrelation of archaeological sites between them and with the landscape within an extended period of time. Therefore, SigArq allows the management of information coming from archaeological fieldwork as well as prospection, territorial studies or landscape archaeology.

The goal is not only to facilitate the data collecting during the fieldwork but also guarantee their reliability and to give them uniform criteria allowing comparisons between data

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[6] The project **SigArq** takes its name from the Spanish form "Sistema de Información Geoespacial ARQueológica"and it has been developed by two archaeological companies *Sistemes de Gestió de Patrimoni (SGP)* and *QarK (Arqueología i Gestión del Patrimonio Construido)* in association with the *Laboratori d'Informació Geogràfica i de Teledetecció (LIGIT)* from UAB and with the support of *Diputación Foral de Álava*, the *Gobierno de la Rioja* and the Town Council of Alfaro. For more information, visit the website www.sigarq.com.

obtained in different fieldworks. In other words, it looks for a group of recording standards, indispensable for the proper running of any work discipline aiming to be scientific (Carandini, 1997:3) and it does it by using common criteria, procedures and tools that allow an agile, easy, and trouble-free register.

The subjacent idea is that the archaeological site by itself is not the highest unit of register, so the boundaries of a settlement are not a barrier for historical research. Hence the integrated data management from many different settlements and fieldworks of quite a wide variety joint to the landscape will allow the transformation of mere data in historical knowledge. This knowledge is expected to be a new resource which could be exploited by public administrations in the framework of heritage management, research communities whose goals are historical and archaeological research and private companies needing a detailed awareness of the environment in order to design projects that might affect heritage elements.

Actually, the design of a tool for heritage management does not seem a new challenge as so many efforts have been done in this sense and some of them have really improved in the management of patrimonial data in a homogeneous way. Within this framework, which ones would be the innovations of **SigArq**? In our opinion, this project shows some incomes that would make it different from other attempts:

- According to the philosophy of its development and its authors, the distribution of this software will be tax-free.
- This project might be used by research groups and scholars with a tight budget that can find in this application a chance for synergy and collaborative tasks. Their experience and particular needs will enhance the possibilities of enlarging the project by including new functions.
- The uncomplicated software will allow GIS-non-specialized users to run an application designed by historians and archaeologists to satisfy their needs.
- This is also a tool for the administrative management of heritage, designed from an archaeological standpoint but taking into account the requirements from the administration in charge.
- Register systems have been standardized from a four-dimensioned perspective enlarged to the territorial components.
- An integral and integrated treatment both of the territorial and stratigraphic information enables the data exploitation related to all historical sources: archaeological register and documentary evidences.
- This application is structured into modules so as to develop this modular distribution in order to incorporate new modules if needed. For example, modules designed for the spreading of knowledge to a non-specific public could be incorporated.

From the beginning, this software has been designed for a two-dimensioned treatment of cartographic information. Our perception is that the vast majority of research projects will see fulfilled their purposes of management and spatial representation at this level. Despite of this, the project could incorporate 3D data exploitation as the main interpretation model proposed will not be questioned.

3.3.2 Database structure

We will not make a detailed explanation about the structure of the SigArq database, which would overcome the objectives of this chapter. Nonetheless, let us point out the main

development lines, where the concept of TU discussed before structures and makes coherent the application design.

SigArq shows a series of information domains according to the language used by different user profiles and to their particular needs. The key elements always are TU or SU but specifically structured in order to solve different problems. The main information domains incorporated by this system are:

- Data related to people and institutions
- Territorial administrative data
- Fieldwork formalities and official procedures
- Territorial archaeological data
- TU register and management
- SU register and management
- Burial anthropological data
- Archaeological material data
- Analytical sampling data
- Stratigraphic synthesis data
- Stratigraphic sequence data
- Heritage documentary data

The idea organizing the entire arrangement is the archeological fieldwork understood as a systematization element, in other words, the application is not related to any particular object from the archaeological register but to a work process temporary limited (a process that has a beginning and has an end) and developed on a key element of the archaeological register (Parcero Oubiña, 1999:8). As a result, we bump into a TU contemporary to the research process that joins the entire data assemblage, structures it and ensures the wholeness of the information. Furthermore, the archeological register taken into account depends on the different sorts of fieldwork and all of them are considered:

- Territorial Fieldwork: It has to do with inventory, control and research processes without affecting the subsoil. This fieldwork is not constrained by the limits of a settlement and it is defined as a determined Study Area (SA).
- Preventive Fieldwork: It consists on control and evaluation approaches to areas that will be affected by performances non related to archeology. Their implementation may or may not affect the subsoil and its extension is not limited by the boundaries of a settlement. In these cases, we speak of an Affection Area (AA) whose limits are determined by the abovementioned non archaeological performances.
- Stratigraphic fieldwork: It is a research work in a determined archaeological settlement (SET). It can affect totally or partially the site and may or may not affect the subsoil. In any case it is always developed by using the archaeological stratigraphy to set up the basis for registering the fieldwork.

3.3.3 The protocol for stratigraphic register

The structure of the system proposed implied a review of the registering process from the beginning of the fieldwork. Consequently, the archaeological concepts and methodology used has been re-examined in order to get a better suitability to the information system. As a result, a new protocol for stratigraphic register has been created.

This protocol aims to regulate the process of gathering information from the beginning, by opening a new SU register until the integration of this register to the stratigraphic scheme. The main goal is to guide the user through this process by offering a batch of procedures that will gradually allow them to complete the registration task. In order to assure the concordance of data with the structure of the system and the particular requirements of the archaeological method, the user will find when needed some restrictions, obligations and register possibilities previously delimited. The objective is to reduce as much as possible the risk of introducing wrong or incoherent data.

3.3.4 The application's network

The particularities of the archeological discipline, in other words, the great amount of information obtained from fieldworks, their chronological extent and the wide range of people in charge of this data exploitation, make relevant the advantages of working into a corporative system. Developing all tasks in a shared framework enlarges extensively the meaning and significance of the information shared and contrasted by all system users.

To fulfill the main goals of this project a whole corporative network is set up to a net server that lodges the data from several research projects. This net server is managed by a principal system administrator, allowing the joint work of users geographically dispersed and offering the chance of working off-line. In this scenario we are able to define different kind of users with specific functions depending on their status within the general organizational structure. Broadly speaking we will distinguish between:

- Group users: These are the final users of the system. They are expected to develop all edition, analysis, search and publication tasks related to their own archaeological data when working off-line and they can obtain and process the data from their group when working on-line and once the group administrator has validated them.
- Group administrators: Each network has a person in charge expected to control the different versions of a work, to contrast the information and validate it before uploading it to the main net server and to make it available for all group users.
- Central administrator: They would carry out the administration tasks but at a final level that controls the entire network.

4. Digital and technological resources

4.1 Their use for keeping a record of stratigraphic units

The incorporation of digital technology to the topographic and photographic tools has opened a new range of possibilities in the procedures of archaeological register and data exploitation. The improvements experienced both in the phase of scientific approach and the spread of knowledge have raised levels never imagined before. Here we will briefly consider the application to fieldwork of topography and earth photogrammetry.

The availability of total stations able to read without prism by means of laser technology enlarges precision and reduces considerably the time spent during the fieldwork. We will not deep into its running, which may be well-known or easily found in specific texts. What we are interested in is the chances topography and earth photogrammetry and particularly, those resulting from the combination of both procedures.

Measurement by means of using a total station offers a data compilation easily exploitable with adequate software. In addition to the traditional plans of an archaeological site, this measurement allows obtaining digital models of the landscape suitable to feature a wide area and also to define the detailed SU register. As a result, new forthcoming approaches to three-dimensional graphics *(fig. 7)* could be explored in order to get a better representation of archaeological evidences.
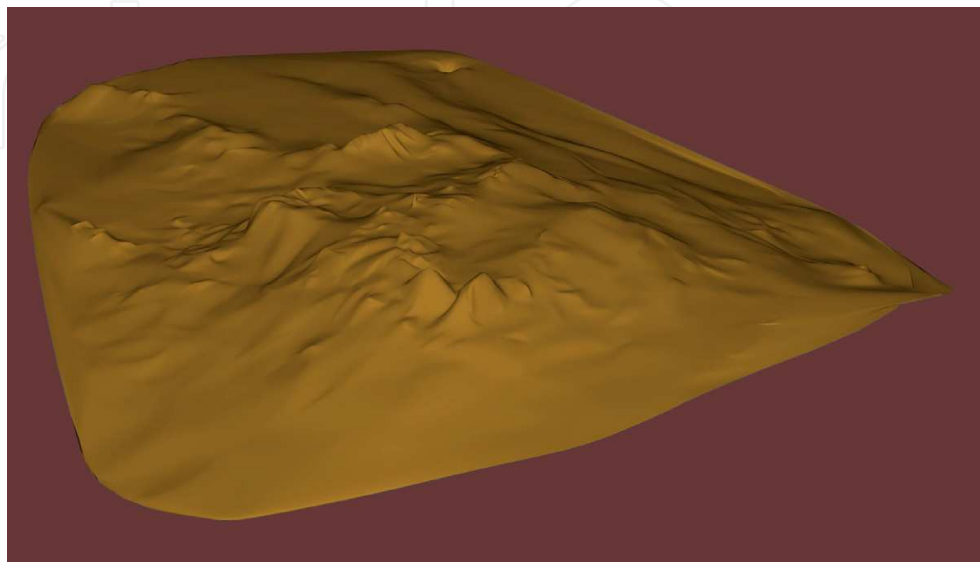

Fig. 7. Three-dimensional view of the archaeological site of Sant Llorenç de la Sanabra (Catalonia) obtained from the topographic measurement and registering of the area.

The development of new techniques related to digital photography allows obtaining orthoimages from traditional photographic equipment. This procedure consists on correcting (or "orthorectifing") digital images by using specific software such that the scale is uniform and the resulting orthophoto has the same lack of distortion as a map or an elevation draw. This method is applicable to the SU documentation within the archaeological excavation and also to the study and SU register when studying buildings *(fig. 8)*.

4.2 Their use for the study of ceramic materials

Finally, we would like to show another way to benefit from the use of technology applied to the study of archaeological materials as a tool to gather as much information as possible from pottery vessels. Designing ceramics through 3D Scanning and photography has been a turning point in morphological analyses of ceramic materials. This new way of drawing implies a considerable lessening for measuring and drawing tasks as well as data introduction in databases.

Our proposal suggests leaving aside hand-made draws and drafts and incorporating the use of a 3D digitizer to the daily designing methodology. In our case, we regularly use a 3D designing hardware *MicroScribe Digitizer* run by a 3D-image processing software *Rhinoceros 4.0. (fig. 9)*. Using this kind of software we are able to record with high reliability the vessels size and especially their diameters and proportions. Draws are generally made in two different moments clearly defined: (1) Profile digitalization and (2) vessel's image edition:

Fig. 8. Orthoimage of the main façade from the Castle of Penyafort (Catalonia) with the SU registers representation.
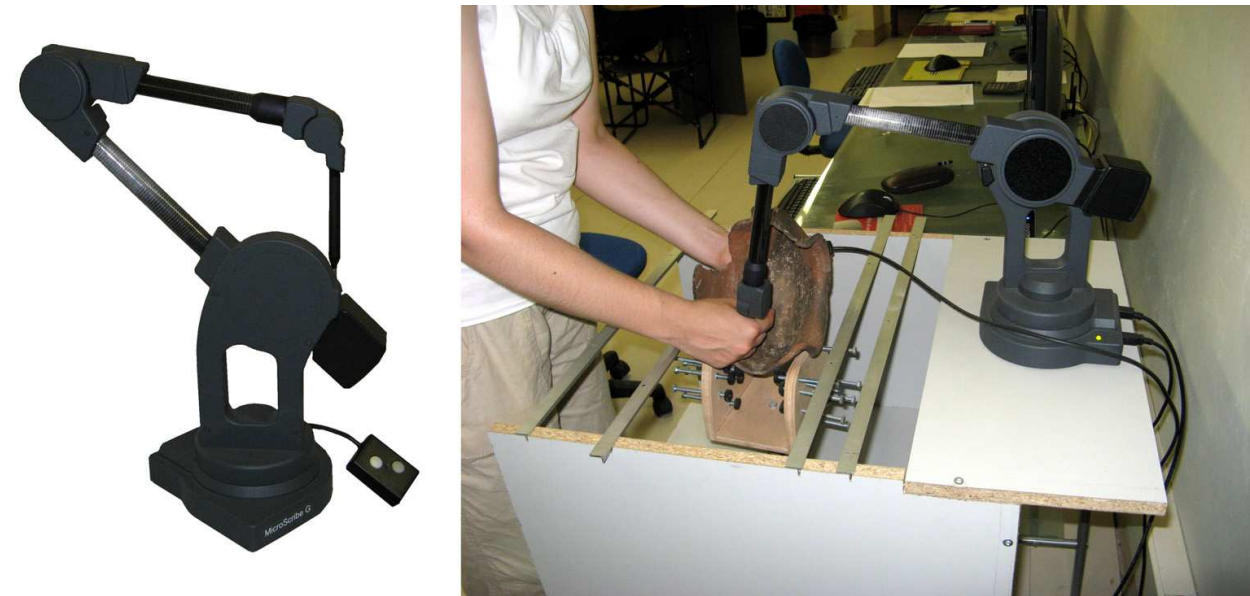

Fig. 9. Picture of a 3D *Microscribe Digitizer* (left) and view example or its employment (right).

- Profile digitalization: It is the key element for the vessel's digitalization. It is a measurement process by means of 3D digitizer in order to obtain the generatrix line of the vessel and their top, bottom and maximum diameters *(fig. 10)*. Obtained results are the basis for abovementioned profile *vectorization*. We strongly recommend saving these pictures in a double format: in 3DM format, used by *Rhinoceros* software, and in WMF format. This second one is easy to import from most of image processing software and will always be on hand as a common record for computers where Rhinoceros is not available.
- Vessel's image edition: From the generatrix line obtained and calculated diameters, we are able to obtain the archaeological depiction of a pottery vessel with the vast majority of image processing software[7] just following the traditional standards. Bear in mind that these illustrations must be exported to TIFF or JPG format for their incorporation to the database. It should also be taken into account that these pictures will be viewed from the database, therefore they have to include a scale bar and their identification number.
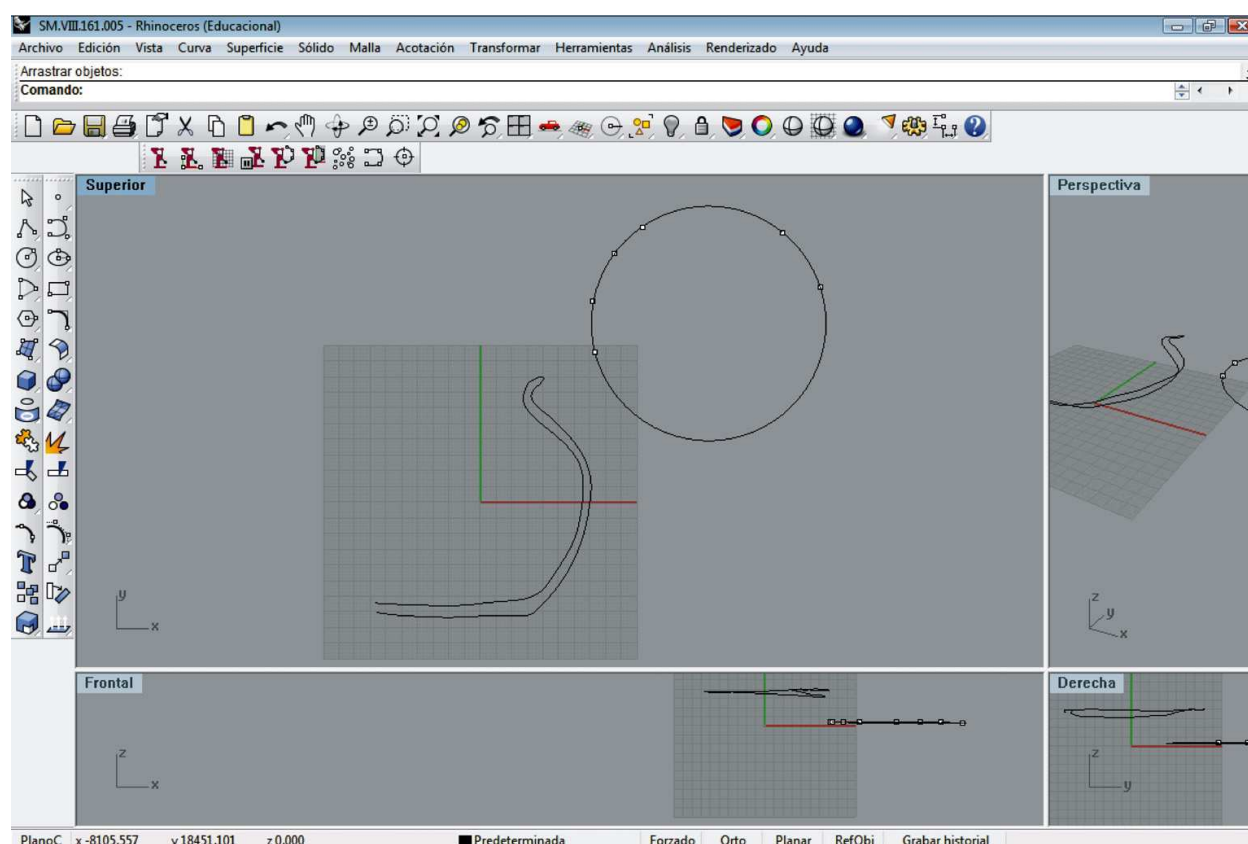
Fig. 10. Screen view of the result obtained from the digitalization of a pottery vessel's generatrix line and its diameter.

When possible, it is really interesting to enrich these depictions with the photography. We cannot forget that photographs are the best way to solve a minor lack of 3D digitalization, which is the ornamentation. To make possible the incorporation of a photograph to an archaeological vessel depiction, there are some practices to keep in mind during the photography session:

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[7] E.g. Adobe Illustrator, CORELDraw, AutoCAD, FreeHand, etc.

- Two types of photographs are needed: what could be named *traditional pictures* and what we call *front view*. The first one is a photograph that will not be modified or used for anything but the real view of the pottery sherd (or any other archaeological material). The second one is a photograph that will be incorporated to the archaeological depiction by cutting off the vessel profile and removing the background *(fig. 11)*.
- To take traditional pictures, we always have to include in the scene a scale bar and a label with the sherd's identification number. The background must be clear and as much uniform as possible, trying to place a back color clearly distinguishable from the sherd.

The *front view* is the picture that will be incorporated to the archeological depiction, so the only rule to consider is that the sherd must be correctly placed in order to take a picture from the frontage. Remember that the background will be removed, so do not hesitate to use any support as clay, for instance, to secure and fix the sherd.

Fig. 11. 3D-Digitizer-made archaeological depiction of a ceramic vessel with and without front view.

5. Conclusions

We strongly believe that the outlining of a methodology that allowed incorporating territorial and written evidences from an archaeological standpoint was a much-needed effort. To sum up, we searched for an integrated management of historical sources broadening the mere settlement or monument interpretation and looking for a further use of cartographic tools.

The difficulties to obtain and interpret archaeological information and the dissemination of written sources and published studies imply a great inefficiency of research processes. That is why we are forced to look for solutions and take advantage of new communication and information technologies. Once we have planned a regulated and integrated register, researchers are able to set up new team work formulas where each scholar contributes to the system enlargement instead of working by oneself; and this is the only way to transform juxtaposed information into an integrated resource to increase research efficiency.

What could have been a high-priced proposal some years ago now is an available organization model by using daily technological facilities. Information management processes, database running, GIS and network information spreading are easily shared by the Internet and common software. Technological development gives an incomparable chance to optimize time and to work faster and more precisely.

This process is what we have tried to exemplify. We actually are not able to present a completely developed schedule, but a conceptualization in process where the precise definition of concepts allows developing a new methodology and the employment of new tools enlarges efficiency and efficacy without leaving aside research objectives. As a result, we aim to consolidate archaeology as a scientific discipline in order to reduce conflicts when intervening in urban environments and to potentiate divulgation, which will significantly contribute to a better understanding and social concern about heritage.

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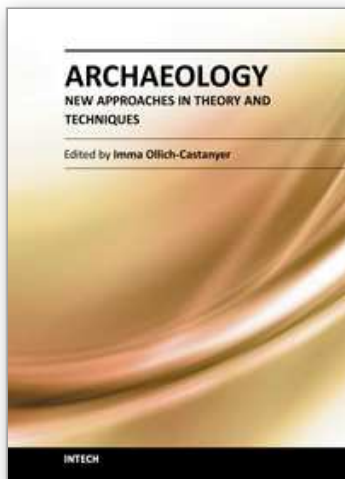
Archaeology, New Approaches in Theory and Techniques

Edited by Dr. Imma Ollich-Castanyer

The contents of this book show the implementation of new methodologies applied to archaeological sites. Chapters have been grouped in four sections: New Approaches About Archaeological Theory and Methodology; The Use of Geophysics on Archaeological Fieldwork; New Applied Techniques - Improving Material Culture and Experimentation; and Sharing Knowledge - Some Proposals Concerning Heritage and Education. Many different research projects, many different scientists and authors from different countries, many different historical times and periods, but only one objective: working together to increase our knowledge of ancient populations through archaeological work. The proposal of this book is to diffuse new methods and techniques developed by scientists to be used in archaeological works. That is the reason why we have thought that a publication on line is the best way of using new technology for sharing knowledge everywhere. Discovering, sharing knowledge, asking questions about our remote past and origins, are in the basis of humanity, and also are in the basis of archaeology as a science.

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