Archeologia e Calcolatori
7, 1996, 887-899

ARCHEOGRAF: AGILITY FOR THE DOCUMENTATION OF ARCHEOLOGICAL EXCAVATIONS

1. Introduction

During the archaeological digging process, independently of the period, the archaeologist faces absolutely necessary documentation steps that slow down the removal of earth, which is already slow of itself. Of these processes, the graphic documentation of sections, planes, profiles, topographies, etc. is one of the most costly in time and, consequently, money. Its resolution is achieved through decisions influenced by the present in most absolute terms and these may have a second short, mid and/or long term consequence depending on the determinations we decide on.

The analysis of the technical task of documenting an archaeological digging is composed of a series of steps systematically repeated in any manual, university class or lecture to new candidates to work as assistants at a site: «*Surveying and staking out the reference grid, removal of earth, documentation of evidence, classification of remains, studies of sets, writing of reports, publication of results,....*» Within these points, we sequence our activity and add to it the scientific rigour with which we deal with these delicate remains from the past. Nevertheless the archaeologist assumes that there are moments in field work that become a "bottleneck" and hold everything up. But these delays are not always accepted with the same scientific rigour and subconsciously or consciously we tend to find a faster way to get through them. We all know that an important part of our field activities are performed almost as if we were being timed with a stop watch, with small or ridiculous budgets and with social and administrative apathy or even negative attitudes. In a word, archaeology does not awaken maximum social interest a priori. Reactions usually accompany latest finds and, even then, the administration's interest quickly falls off once the "family photo" has been taken.

It is within this scenario that we archaeologists struggle to carry out our research as ethically as possible and in the best, or at least the most acceptable, technical conditions possible. Archaeology is not a professional sphere that moves enough economic capital to interest industry enough to approach us and see if there is a need for their products with or without technical adaptation. The researchers' restlessness leads them to test and expunge sundry and myriad "tools" to recycle and adapt them to our needs. Sometimes we need to physically adapt the tool. Other times we have to adequate our modus laborandi to the characteristics of the tool and sometimes we apply the tool directly.

We must recognise that archaeologists' training for field work is very lacking in areas of know how that could stand us in good stead or from which we could make use of certain tools (industrial design, programme design, third generation languages, chemistry and physics, electricity and electronics, etc.) and by this we do not mean that the archaeologist must be some sort of Leonardo Da Vinci. No, but there are intermediate stages that could be of interest. Of course there are professionals in the areas I have mentioned; there have been and there will be in the future but we cannot always pay for their services nor are they willing to collaborate with the same disinterested attitude of the archaeologists. Thus we believe that either the mentality of scholars of antiquity (sensu lato) and administrations change a lot or our technology deficit will go on impeding the progressive rationalisation of our working procedures.

Our discipline is economically poor in general and modernisation usually results from a kind of "rebound" when a tool appears in a researcher's path and its discovery, modification and application spread among the other researchers quite quickly but not without misgivings, mistrust and sometimes even hardly justifiable or justified rejections. There still exists the widely extended hope of finding the "touchstone", the "essential tool" that permits the unequivocal acquisition of all the lacking data and the exact interpretation of the problem all in one step. But not all equally admit partial solutions and we must, however, settle for advancing with small steps, one at a time.

All of us that are participating in this Colloquium, one way or another, are interested in advancing the mechanisms that facilitate research work, management of data, safeguarding of data or streamlining its gathering wherever necessary. We know that some of them are effective; we are here precisely to talk about the achievements and ideas that have taken shape since our last meeting in Bilbao, which we organised in 1993. Since then we have seen some products marketed. The last one that I have heard about is Dr. Daniel Arroyo's ARQUEODATA for registering and documenting S.U. (Stratigraphic Units). I know that Dr. Carmen Olaria's work on lithic materials and ceramics with a specific sphere of application in Neolithic culture is very advanced as well as GEPRAN of the University of Granada; but here we shall be hearing of other computer products and of applications of commercial programmes to research. But, will they be accessible? Will they be sufficiently disseminated, sold or given away? Will they become standard? Will we dare to create a market place where the results are not only science but also solutions and even commercial activity?

We have said that there exists an important imbalance between needs and economic budgets. We can also state that there exists a numerical imbalance between professionals dedicated to generating "scientifically interpreted history" and those dedicated to generating "formally complete" tools within the "service circuit" that sustains the improvements and streamlines the processes of acquisition of data or their processing.

The maxim, "time is money", must generally be taken into account although we also know that, in our work, there are times when it is not possible to think in these terms. Society could not pay for it. But, indeed, there are aspects in which we can advance. Only 10 years ago a personal computer was a luxury item for a free lance archaeologist and even for some universities and museums. Today it is still a "luxury" in archaeology for each work place to be outfitted with a computer and for these to be technically up-to-date and adequate for the needs. Many diggings lack a portable for the field with programmes that facilitate documentation tasks. But, at least, this is a problem that can be compensated by working in a more traditional way and that is how the archaeologists of my generation, at least, and earlier solved the problems before we had the first computer.

Nevertheless there are some elements that are more essential in field work than being able to keep our diaries, notes and registers in the computer. I refer to the many topological data of our diggings that must be preserved so that, at any time or in the future, we or any other researcher can reconstruct the sequence of the digging and study new options, check hypotheses or undertake new research with the documented material. Drawing and the time it requires is, however, an important conditioning factor of the activity that limits the carrying out of all the documentation possible and, thus, gives rise to a selection of the data. If we add to this the special conditions that a site can present and the limitations of time, money and personnel shortages, we are influencing in a "non positive" way the preservation of pure data free from interpretation or selection.

We have been reviewing, one by one, points that highlight weak links in archaeological field work. One of the aspects that most worries us is on-site documentation. We must state that topographical equipment is still considered a luxury at a digging and I do not refer to stations that are connected through ditches or cribs or directly transmitting data via modem or any other communication system. Even the commissioning of a topographical survey and the placing of reference points in UTM coordinates within the work area are considered an "unjustified" expense not only for some administrations but also for some archaeologists that need that money to invest in other digging tasks. It is a first selection of the documentation that is supported and justified by the existence of 1:25,000 or, in the best cases, 1:5,000 scale drawings although this is usually very poor or unacceptable baseline data.

It is an all too common fact that there is no microtopographical survey with 0.25 m. or less level curves prior to the digging of a site, which we have found to be revealing at some diggings. By omitting this at the beginning of a dig, we are proceeding to the selection of what material is to be documented graphically (drawing) during the work process. It is likewise a common practice to proceed to the selection of which parts are to be drawn and which are not due to time (= money) masquerading under very common attitudes such as "This does not provide information." But are we the research ceiling of the XXIst century to be able to make this decision? Those that did not keep the animal bones, the remains of carbon, did not take samples, did not stake out the site, did not co-ordinate the findings, did not take photographs or draw sketches have been and are currently criticised and so will we be. These criticisms are levied based on today's methodology and means and considering that not all the necessary information has been conserved from an old deposit which has been "destroyed" to be researched. Back then there were other reasons and motives for proceeding thus and, although we may understand them, we also know that they limit the possibility of restudying and reinterpreting the data. Often times it can be due to a lack of appropriate technology and other times the result of not foreseeing the possibilities of the future but still other times it can be due to cost cutting in terms of "less time invested in documentation", e.g.; graphic.

The time that must be dedicated to drawing the evidence is a general problem at all archaeological diggings. According to our experience, it is at least one third of the digging time that is dedicated to drawing.

There have been those who, years ago, undertook trying out faster ways of working like photogrammetry and photographic montage or by developing adequate systems for this problem. In the First Colloquium on Archaeology and Computers held in Saint-Germain-en-Laye in 1991, Gruel and Buchsenschutz presented an interesting tool conceived to solve and streamline on-site drawing since the process was computer based. On that occasion, we saw that it provided good solutions for flat terrains while problems could arise in more irregular zones like the ones in which we habitually work. The size of the utensil was a problem.

2. The idea of ARCHEOGRAF

An archaeologist's constant desire is to be able to manage the information of the drawings of a digging, to be able to make as many drawings as one wants for each work zone and later compose new views according to the hypothesis or the working ideas. It is a strong desire to be able to see the drawn data in 3D and even be able to vary the viewing angle. It would be greater support yet, if, to all of this, we added the information of the material found, the edaphological analyses, etc. But this is impossible unless we have the drawing and topography information in a flexible computerised system combined with data bases and graphics. Evidently this is inconceivable with traditional drawings.

We had been working on the idea of a tool for inputting the data from the terrain directly to the computer, but in the simplest way possible. With that aim, we thought that the work space (the digging) should be like a digitalisation tablet, but furthermore it should be capable of being a three dimensional space behaving like a digitalisation tablet. On the other hand, the help available at a digging are not qualified to work with programmed mechanical devices and sometimes not even with commercial design programmes. Therefore another feature it should have is that of being very simple to use.

But what features must our desired tool have? It must be an easy to use utensil under any conditions at any site. It must be easy to transport, small in size, easy to install, light and resistant, with minimum maintenance, mechanical and use the fewest possible additional systems for functioning in the field. It must require the most standard qualifications possible to be used.

We have been working on the protohistoric Sanctuary of Gastiburu, Arrazua, Bizkaia. There is a set of 4 large structures (diameter: 24 m) shaped like horseshoes and laid out with the arms facing the central space, a square. Each structure has a large sized stairway and the perimeter is made up of rubblework walls. Under the stairway in one of them, we have discovered a chamber built with rubblework walls. This set, together with another made up of a line of 4 tumular shaped structures that are inserted between two of the former, are smaller (diameter: 18 m). The slopes and drops that have to be solved in order to draw the different pieces of evidence are sometimes important.

Within the parts that have been dug since 1985, we have found numerous remains of working of the stones and of decorative motifs. Documenting all this information has meant a very large investment of money-time in drawing. But this was the decision that we adopted right at the beginning and that drove us to seek ways to accelerate the drawing process. At first we multiplied the number of teams of on-site drawers. During the years 1987 to 1994, we incorporated a 1:20 set scale German field pantograph with a resolution of approximately 5%. The result has been satisfactory inasmuch as the work performed with this utensil meant a very large time=money savings in the field. We can quantify this improvement in the proportion of 12 m^2 for every 1 m^2 done with the traditional system in the same time and with evident improvements.

But, in spite of everything, under the heading of documentation, we had not solved all the processes; others continued being slow and costly. The drawings had to be mounted, then retouched and copied onto general drawings and later inked in and, in the end, we had one single, single-scale drawing on a semitransparent material and it was totally "rigid". It is impossible to get equal (1:1) reprographical copies without distortion, at least with the industrial apparati that we have tried out. Therefore we kept coming back to a limitation of time=money and rigidity. So we began a process of CAD digitalisation of the drawings. We soon saw that, although we gained, with the process, in flexibility in combining the information, we were not managing to perfectly integrate the contour elevation data obtained in a conventional way into a system that permits three dimensions. This was because the mentality with which the whole process had been carried out up until then had been with references taken to visualise contour elevation data on one plane and not for recreating 3D. We had not contemplated some of the needs that the CAD system would ask for. So we stopped the process until finding a more satisfactory solution to the whole planimetry problem that we had accumulated from the beginning of the digging to today. Our problem is not essentially different from what has happened at other diggings throughout the world.

In this state of affairs, we chanced upon a relationship with a young engineer in search of a topic for his degree qualifying project. Our problem turned into something that might get solved. ARCHEOGRAF was born with a theoretical study of the possibilities and the design of a prototype that permits evaluating the foreseen results by working directly with the computer, in the field, at real scale and in three dimensions.

3. Description of the ARCHEOGRAF

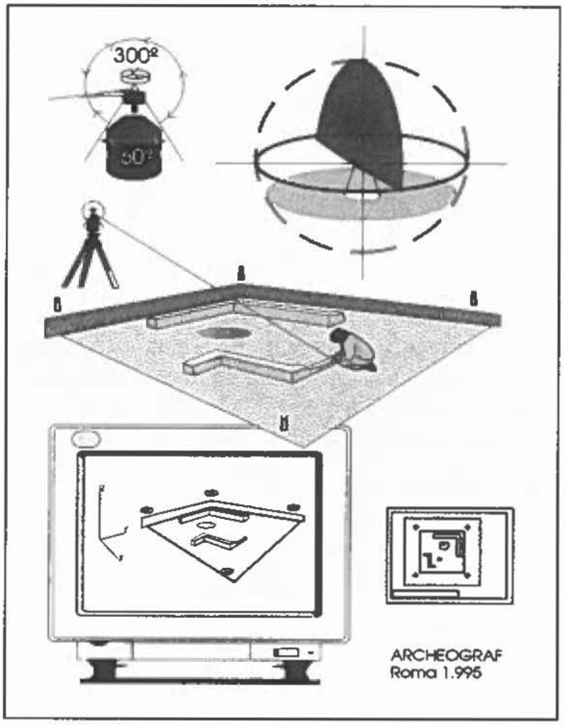
The ARCHEOGRAF system is conceived to perform the automatic gathering of Cartesian coordinates in 3D of the points of the polylines that reflect the structures or the objects that we wish to document (Figs. 1-6). The desire for speed and reliability led us to look at the available commercial design software. We consider that this has advantages over specific software for this application. The choice will be made based on the greatest flexibility, reliability and ability to create complex routines to be executed automatically as well as the possibility of calling up data bases or inserting elements from other software. Using this type of element is a way to eliminate a barrier between the tool and the user since, in many cases, the latter may be accustomed to using it.

The system consists of three fundamental parts: mechanical system, hardware and software.

3.1 *Mechanical system*

The mechanical system consists of a framework of armatures, gears and pulleys mounted in an aluminium structure. The whole mechanical system is activated by the forward, backward or turning movement on the horizontal and/or vertical plane of a turnbuckle with an expansion coefficient of practically 0. Those movements are converted into electrical impulses that permit calculating the three dimensional Cartesian coordinates of the point or of each of the points along a polyline.

The system is capable of gathering points from within a 10 m radius sphere but this sphere contains a dead space caused by the body of the apparatus. This zone is the equivalent of a 30° angle beneath the apparatus.


300º
ARCHEOGRAF
Roma 1.995

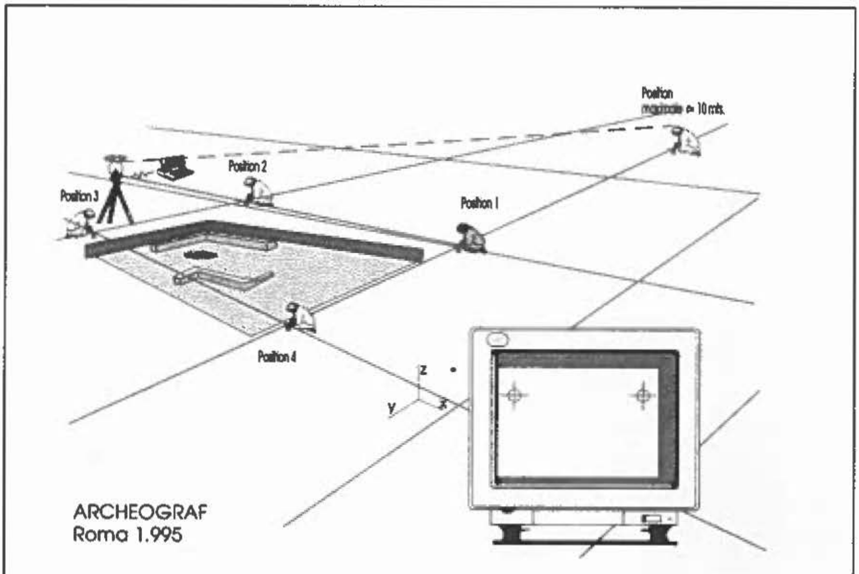

Position 3
Position 2
Position 1
Position 4
Z
Y
X
ARCHEOGRAF
Roma 1.995

Fig. 1

3.2 *Hardware*

The hardware is a system based on a computer connected to the PC through the Rs-232 port. The function of the hardware is to carry out the measurements and transmit them to the PC when asked to.

Functioning of the hardware (pantograph)
- mechanical system
- measurement block
- computer control
- Rs-232 port to the PC

The measurement block converts the turns and movements of the mechanical framework into binary numbers that can be handled by the computer. This block is linked to the computer. The control block, besides performing the principle operating functions of the system, carries out another two:

– it receives the numbers that represent the positions of the pointer and converts them into adequate forms to be transmitted to the PC;

– it controls the communication protocol with the PC.

The Rs-232 port is the interpreter that is used to carry out the communication series with the PC.

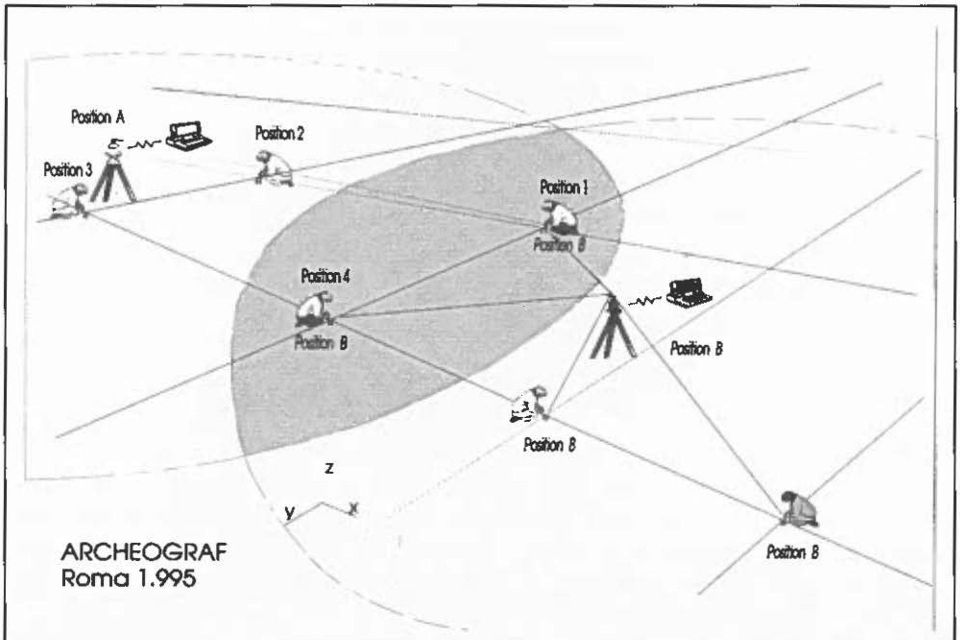


Fig. 2

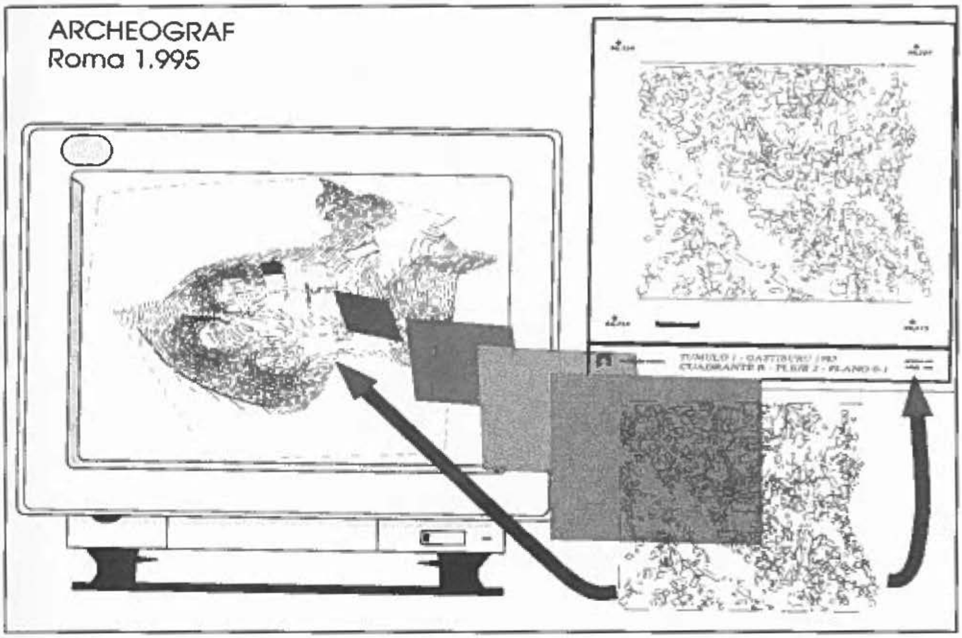


Fig. 3

3.3 *Software*

The software is an application that works from within Autocad. The principal characteristic of the system is that the points gathered by Autocad can be introduced by the ARCHEOGRAF. Thus the reality can be represented as virtual reality. The points can be introduced in 2D or 3D.

The most important feature of the software is that it is programmable. This means that sequences of orders that Autocad will execute sequentially can be created by an ASCII file. This little programming language is similar to that used by Autocad's "script files", but with orders that enable inputting points from the pantograph. This "programmability" feature makes it possible to generate complex structures by importing the data directly from reality.

Another important function of the software is to position itself over a reference system. That is, given four points, they are captured and, by means of the self-positioning algorithm, we obtain the position occupied by the pantograph in space. This function saves time when the pantograph is moved from one place to another to do a new drawing and can accede to far away zones that are difficult to get to from the previous position. At the same time that the different sectors of the digging get linked together automatically, they get documented in the X,Y coordinates as well as in their real position through the Z.

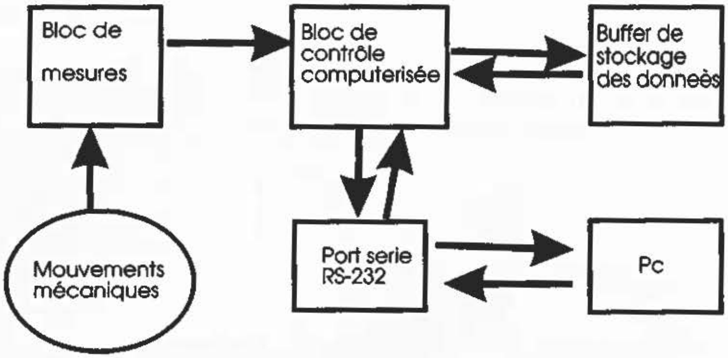


Fig. 4

The software developed so far meets the minimum requirements to carry out the previously mentioned characteristics. But there are already some concrete functions foreseen for specific applications. That is, specific function software can be created to construct complex three dimensional geometric structures from data asked of the user. These data could be inputted from the keyboard or from the ARCHEOGRAF. For example: drawing of a stone given the the contour and extrusion thickness no matter how the stone is oriented in space.

4. Characteristics of the equipment

Scope: 10 m radius sphere. On the surface in the maximum radius plane: 3, 14, 102 - 314 m^2 minus the dead angle, which can be recovered from another position of the apparatus.

Resolution: in 10 m, the maximum error possible is estimated to be 3.8 mm. This error has increased from an error base of 0.7 mm in the first meter with errors in 3 m = 1.14 mm and in 7 m = 2,66 mm at real scale. The percentage would be 0.038% at a scale of 1:1; at the usual scale of 1:20, the error would be 0.0019% or, in millimetres, = 0.19 mm for 10 m.

5. Functioning mode

The equipment requires the collaboration of two people: one to handle the PC and one to handle the pantograph. The person handling the PC governs Autocad and through Autocad the orders that are transmitted to the ARCHEOGRAF. The person handling the pantograph just reads or moves the pointer along a trajectory so Autocad can execute the polylines or continuous lines.

The drawing thus obtained at real scale can be scaled, wireframed, con-

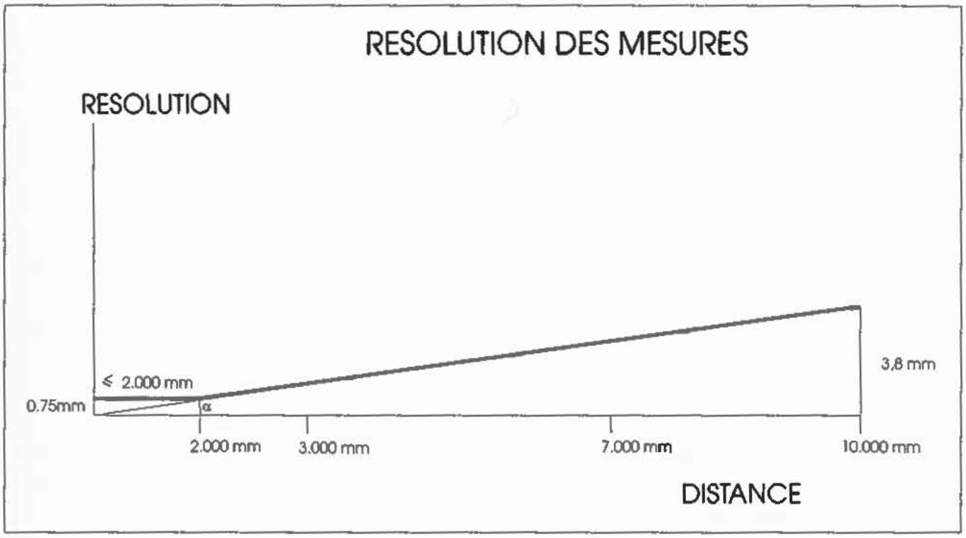

RESOLUTION DES MESURES
RESOLUTION
≤ 2.000 mm
0.75mm
α
3,8 mm
2.000 mm
3.000 mm
7.000 mm
10.000 mm
DISTANCE

Fig. 5

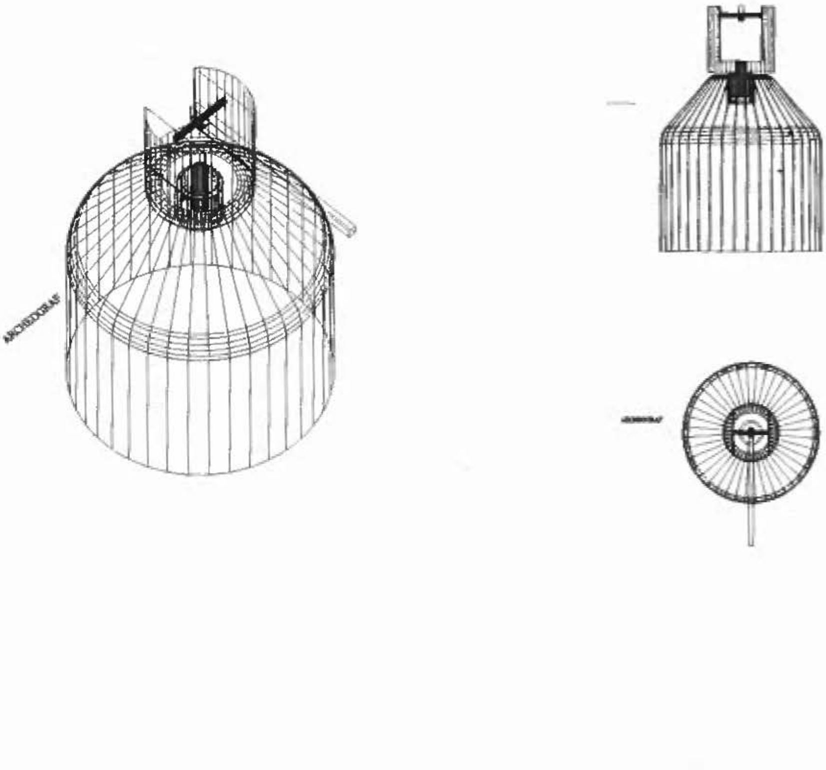


Fig. 6

verted to solid, presented in different positions in space, broken down and viewed according to the researcher's needs as well as totally or partially printed out if a printer is available on site.

6. Conclusions

Our ARCHEOGRAF work is not the only undertaking in this direction; others have developed their machines and still others will, too. Neither is the aim of our work just to reduce one of the cost factors of digging: time; our main concern lies in contributing to a deontological aspect of our profession. We can assume, and in fact it is consubstantial with field procedures, the total or partial destruction of the deposits as long as we document the destroyed sequence with total accuracy. The raw data must be preserved exactly as they were found with no selection under pressure of the cost of that documentation and without interpretation of that data. We aim to streamline that documentation but we are aware that in so doing we use a series of "fragile" utensils and supports. Who has never been betrayed by a diskette, a CD or a hard drive? One accident and all can be lost. But that is not the only problem. The speed at which we are being bombarded with new software and hardware and the quantity of tools designed by private individuals for these jobs and that are rigid in their communication systems and of doubtful future adequacy are another part of the problem when it comes to storing data. On balance there is a factor of insecurity about whether, in the mid and long term future, the computerised data will be available to us to help in reviewing the research or new projects.

It is generally accepted that our obligation as liaison between a buried past and a future with more and better knowledge is based on accuracy, the ample scope of the documentation and the permanence in time of the data that we gather. Consequently, if anyone were to ask me what would be the theme of the IV International Colloquium on Archaeology and Computerisation, I should propose: «The conservation and permanence of archaeological data and the evolution of computerised systems. Long term guarantees.» Once, in an old digging diary from the beginning of the century, I read, «...the tomb was located about two meters from where the foreman was». Where is the foreman today? Nowadays we have more methodology and more resources; our data are so important for research in the future that we cannot fail to be concerned with improving the quality and the quantity of what is collected and conserved for tomorrow.

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ABSTRACT

In archaeology, when data is gathered directly at the digging, we face a long series of steps that slow down and complicate this process. In general, they are inconveniences assumed by the archaeologist with no further ado; they are a drawback associated with or inherent in field work. But these circumstances may or may not be acceptable; they may or may not influence the quality of the interpretation, enable short term review or have unintentionally manipulated it by selecting what and how we document at the digging. When we work with serious time restrictions, with a limited budget and in poor conditions and at the same time want to get the best documentation to safeguard for the future and to be able to use during the development and study process, our attitude changes and we would wish to have an option that streamlines those vexatiously slow moments. That is when we ponder the options for automating as many processes as possible in the field.

Since 1985, we have been working on a digging, the uniqueness of which makes us wish to document each step with total accuracy. The information arises, sometimes, after many square meters of opened surface. Therefore we cannot fail to document anything. Add to this the fact that the digging itself and the interpretation of the place gave rise to a flood of controversy. Therefore there exists a double need to document the site completely. The work involved in drawing the charts and profiles soon became vexatiously slow. The very numerous elements of interest that we wanted and the succession of layers of information were a "bottleneck" where the economic budget vaporised. It was at the beginning of the work when we thought about "streamlining" through selective gathering of data. But we did not do so; we looked for alternatives, we tried them out and we substantially improved the performance.

In the final analysis, we had only improved the results in the field. We still had two steps left in the laboratory and, at the end, we would have only one rigid and modifiable chart at a very high cost. We all know how economic fluctuations effect budgets for digging. We needed to reduce our drawing costs in the field as well as in the laboratory in order to be able to destine that time and money to other segments of the research.

Since 1993, an interdisciplinary team has been working on the ARCHEOGRAF project. Right from the start we focused on obtaining a tool that would assist drawing for diggings and that would reduce cost and time within a framework of four basic requirements: 1) be as universal as possible, 2) be totally computerised, 3) be easy and accurate and 4) be accessible for archaeologists. Today this tool is a reality meeting all the requirements that we had set out and opening new expectations for more advanced versions.