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NEW DOCUMENTATION ON DIGGING TECHNIQUES OF THE PREHISTORIC FUNERARY HYPOGEA OF THE WESTERN MEDITERRANEAN

Maria Grazia Melis*
Marie Elise Porqueddu**

ABSTRACT – *The digging of rock-cut tombs in Sardinia underwent an important development during the 4th millennium BC, in particular in the north-western part of the island. The subject is currently being re-examined by Maria Grazia Melis and her team through field research at S'Elighe Entosu. This necropolis is composed of eight hypogea, dug between the Final Neolithic and the Bronze Age. The study deals with various themes, including the positioning of the necropolis within the landscape, the architecture of the tombs and the diverse phases of related human activity. Recently the architectural data has been updated through the study of excavation techniques employed in creating the monuments. The new information has been fundamental in understanding the articulation of human frequentation of the site and the history of the various modifications made to the hypogea. The investigation was based on the analysis of excavation or tool marks present on the surfaces of the cuts and on the analysis of tools found in Tomb IV. Experimental archaeology played an important role in the proceedings. This research has led to the creation of a database of tool-marks, the study of picks and the experimental reproduction of this type of instrument.*

KEYWORDS – Rock-cut tombs, digging techniques, experimental archaeology, photogrammetry.

RASSUNTO – L'escavazione degli ipogei funerari raggiunte in Sardegna un importante sviluppo nel corso del IV millennio BC, in modo particolare nella parte nord-occidentale dell'isola. La tematica è stata riesaminata da Maria Grazia Melis e dal suo team in una ricerca sul campo in corso di elaborazione a S'Elighe Entosu. La necropoli è composta da otto ipogei, scavati tra il Neolitico finale e l'età del Bronzo. Lo studio analizza diversi aspetti, che comprendono il funzionamento della necropoli nell'ambiente naturale, l'architettura delle tombe e le diverse fasi d'uso in relazione alle attività dei gruppi umani che la frequentarono. Recentemente i dati architettonici sono stati integrati con lo studio delle tecniche di escavazione delle grotticelle artificiali. L'indagine è portata avanti attraverso l'analisi delle tracce di escavazione presenti nelle pareti degli ipogei e l'analisi degli strumenti da scavo rinvenuti nella tomba IV. L'archeologia sperimentale svolge un ruolo importante nello sviluppo della ricerca, che ha portato alla creazione di un data-base delle tracce di escavazione, allo studio dei picchi e alla loro riproduzione sperimentale.

PAROLE CHIAVE – *Ipogei funerari, tecniche di escavazione, fotogrammetria.*

INTRODUCTION

In the western basin of the Mediterranean the phenomenon of rock-cut tombs has its earliest manifestations in Sardinia in the first half of the 5th Millenni-

um cal. BC. The practise underwent an important development during the 4th millennium in the ambit of the Ozieri *facies*, and in particular in the north-western part of the island (Meloni 2007). The hypogea of this period are given the Sar-

dinian name of *domus de janas*; there are more than 3000 known examples, of which roughly 1350 are in the province of Sassari.

In 1994 a congress was held in Sardinia (Melis 2000), which represented an important opportunity for the international scientific community to meet and exchange ideas. Roughly twenty years later a project has been initiated that involves Italy, France and Spain, aimed at promoting the debate on the general themes of prehistoric hypogea of the western Mediterranean, with particular attention to insular contexts and to the ways in which they were initially created.

At the heart of the Italian participation in the project is the study of the necropolis of S'Elighe Entosu (Usini, Sassari), in north-western Sardinia (figs. 1-2). It was formed of nine hypogea, one of which was of uncertain identification, one was dug in the Middle Bronze Age and the remainder date to the Final Neolithic. It became part of a multi-year research programme, under the direction of the author (Melis 2010; Melis *et alii* 2011), aimed at a reconstruction of the relationship between the necropolis and the surrounding territory. Currently architectural characteristics and the various phases of excavation of the underground chambers are being examined in greater detail. This is done through morphological/technological analyses of the digging marks visible on the surfaces of the tombs and a technological and functional analysis of the tools used to dig the hypogea. Subsequently experimental activity is added to the research, providing important data to help verify technological considerations. The basis of the experimentation was provided by the technological and functional examination of the

picks discovered in tomb IV of S'Elighe Entosu. Almost all of these digging instruments were found in the Bronze Age occupation layers of the corridor of the tomb, reused as building material for a succession of cobbled floor surfaces.

The study of digging methods is particularly important because notwithstanding the large number of this type of tomb present on the island, the subject has only occasionally been examined (Tanda 1984; Melosu 2008); this is also the case in internationally, where discussion of the topic remains to a certain extent undeveloped.

The necropolis of S'Elighe Entosu constitutes an important archive because these monuments underwent diverse phases of architectonic adjustment; these modifications are very often most clearly seen through the various marks left on wall surfaces, the result of using different techniques and tools. Most recently attention has been focused in particular on tombs III and IV. *Domus* III still contained some traces of the most ancient phase of excavation on the walls of its entrance corridor; the antechamber underwent two phases of enlargement, both through the use of metal tools. Tomb IV is distinguished by its extremely long *dromos*, which due to its exceptional dimensions represents an extremely important element in the architecture of hypogea. The corridor, notwithstanding its poor state of conservation, still bears marks created during the initial digging of the tomb in part of the south-west wall.

In order to reliably date the marks it will be necessary to extend the research to those features with a well defined chronology; for example *domus* VII, which, unlike the others, was dug during the Middle Bronze Age, and the tombs from the

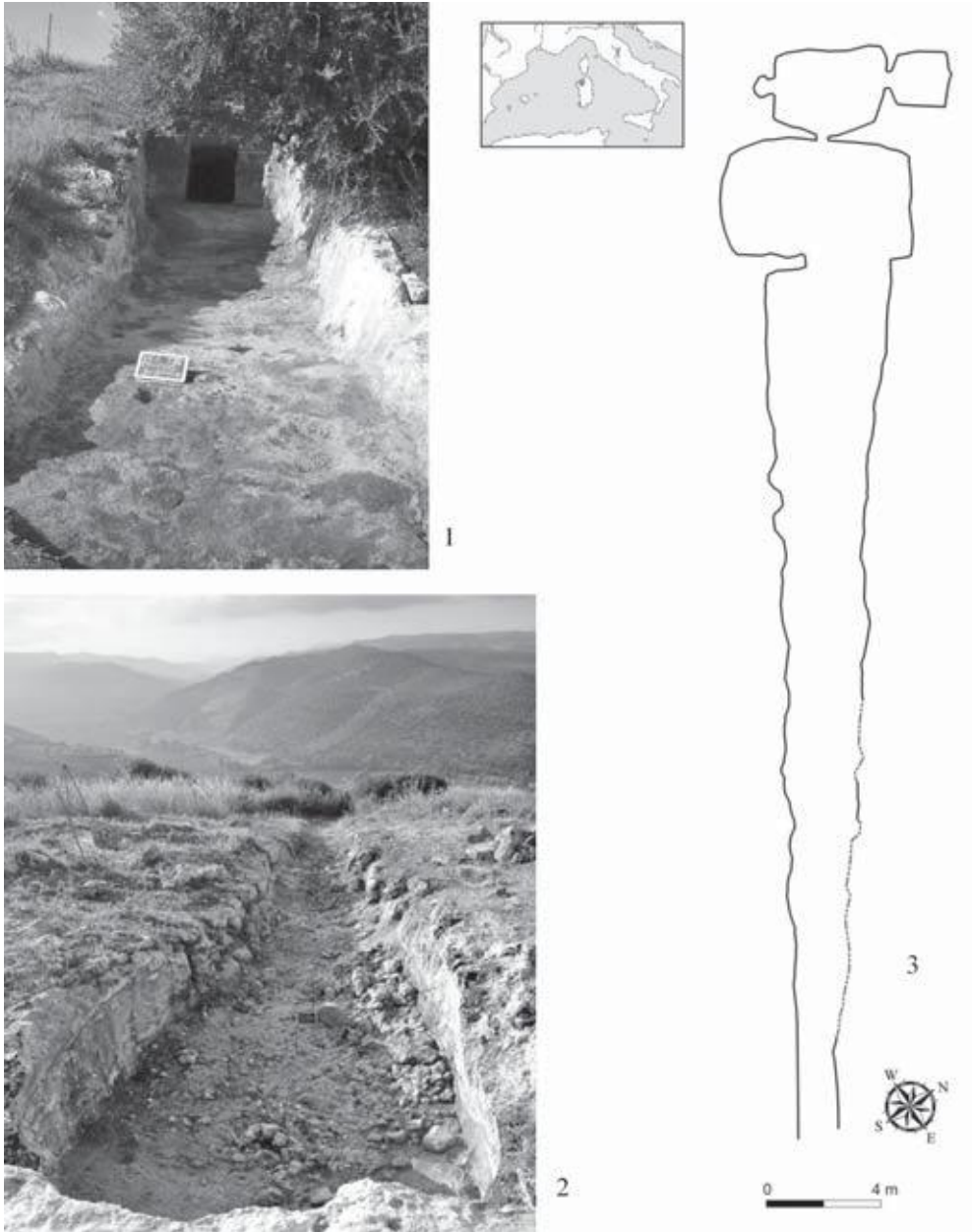


Fig. 1 – S’Elighe Entosu (Usini, Sassari). 1, tomb III; 2-3, tomb IV (1,3, by Melis 2010; 2, photo M. G. Melis).

nearby Roman necropolis and the adjacent post-Roman quarry.

The final objective is in fact to identi-

fy and compare the various marks corresponding to the different phases of excavation and use of the necropolis.

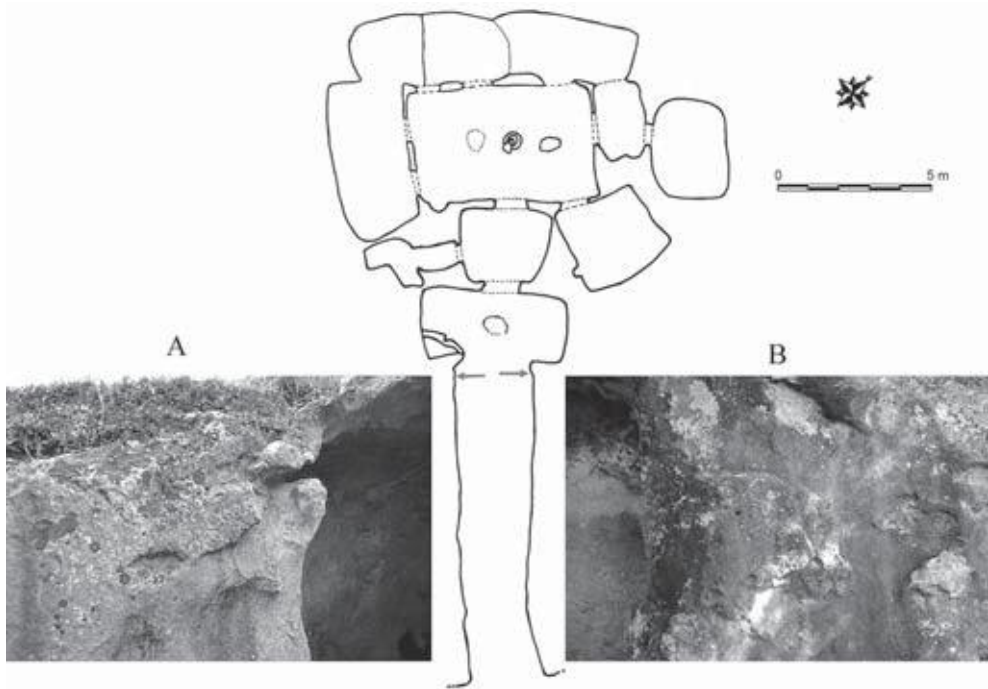


Fig. 2—S'Elighe Entosu (Usini, Sassari). Map of tomb III and localisation of surface documented through photogrammetry and laser scanning. (by Melis 2010; photos M. G. Melis).

The reading of these marks is often difficult and is sometimes complicated by both human activity over time (changes to the shape of the tomb, wilful damage etc), and by erosion and natural decay of the rock. It must also be remembered that the most ancient phases, corresponding to the digging of the hypogea during the Final Neolithic, are generally noted for the fine finishing of their surfaces; this procedure obviously obliterates marks made during the preceding passages of the *chaîne opératoire*, leaving only the final stage evident. This is mostly seen in the inner chambers, while in the various *dromos* it appears that this phase of finishing was not undertaken, as digging marks left by stone tools are still visible.

The study of digging techniques of the

hypogea was entrusted in 2012 to Marie Elise Porqueddu within the remit of the *mémoires de Master 1 and 2* at the Université de Bourgogne (Porqueddu 2011-2012; 2012-2013). Currently the subject is the basis of her doctorate thesis run concurrently with two universities (Aix-Marseille Université – Università di Sassari), in which the discussion is approached over a broader territorial scale; the study is in fact extended to include hypogea in France, and in particular those of Fontvieille in the Département of Bouches du Rhône (southern France).

The experimental activity was undertaken by LaPArS (*Laboratorio di Preistoria e Archeologia Sperimentale*), also utilising students from the Università di Sassari. Through this experimentation, a

new approach to the study of hypogea is possible, though it also provides new perspectives and insights into the organisation of the human groups at S'Elighe Entosu; among the results there should be information on the times, methods, technical knowhow and organisation of the people involved.

DOCUMENTATION OF EXCAVATION MARKS

The study of digging marks on the walls of funerary hypogea has raised the question of their documentation, which shares some of the aspects of recording rock art. The documentation methods in this field have evolved over time to provide results of ever greater definition, while using non-invasive methods to safeguard the surfaces under examination.

In the past the recording of rock art in Sardinia was documented through systems requiring physical contact (Tanda 1994: 14); more recently, in the same area of Usini, oblique light photography has been used, taken from a fixed point using illumination to highlight surfaces from various angles (Cassen, Robin 2010; Robin 2010). This method holds several advantages, among them the precision of the documentation and the reduction of time spent in the field. It also allows the creation of a unified image of an elaborate picture, permitting a general overview of a figurative composition. Nevertheless, the resulting product remains a two-dimensional document, and its usefulness is limited for the study of technological aspects, which require a three-dimensional image. Three-dimensional restitution is, in fact, indispensable for the study of the morphology of the incisions, for the

identification of the tools used and for the reconstruction of the methods employed by the engraver.

Similar limitations apply to Digital Image Enhancement software such as DStretch plug-in for ImageJ (Defrasne 2014), that nonetheless constitute a useful instrument for identifying and evidencing faint or difficult to see images.

The adoption of a specific method of documentation must necessarily depend on factors including the type of subject to be analysed, on the level of illumination, the state of conservation and of the objectives of the documentation. A useful solution is to combine both 2D and 3D techniques (Cassen *et alii* 2014; Domingo *et alii* 2013). Recently the integration of RTI (Reflectance Transformation Imaging) and 3D Laser Scanning has been used to study the steles of the Iberian Late Bronze Age, with the advantage of each compensating for the limitations of both methodological approaches (Diaz-Guardamino, Wheatley 2013). Other 3D recording techniques have been used in the documentation of rock art in the Alpine region, including SLS (Structured Light Scanning) and SfM (Structure from Motion) (Marretta 2014).

A two-dimensional document was initially made to record the excavation marks on the walls of the S'Elighe Entosu hypogea, using the oblique light method, which gave interesting early results. That was then later integrated with a 3D image. To this end we are currently testing the use of photogrammetry together with a 3D Laser Scanner, an approach also used to create aerial documentation of large outdoor areas, which in the context of the S'Elighe Entosu project has been used for the UAV (Unmanned Aerial Vehicle) survey of sever-

al archaeological sites (Melis *et alii* 2013; Melis with *Oben s.r.l.*, ongoing research).

Photogrammetry and 3D Laser Scanning, which have both been at the centre of a lengthy debate (see, for example, Baltasvias 1999; Böhler, Marbs, 2004; Ferreira *et alii* 2014; Grussenmeyer *et alii* 2008;

Koch, Kaehler 2009), are used in various fields, such as for monitoring landscape deterioration, the documentation of rock art and for monitoring incised or engraved surfaces (Doehne, Price 2010; García Moreno, Garate 2012.), the survey of archaeological areas and monuments as well as the doc-

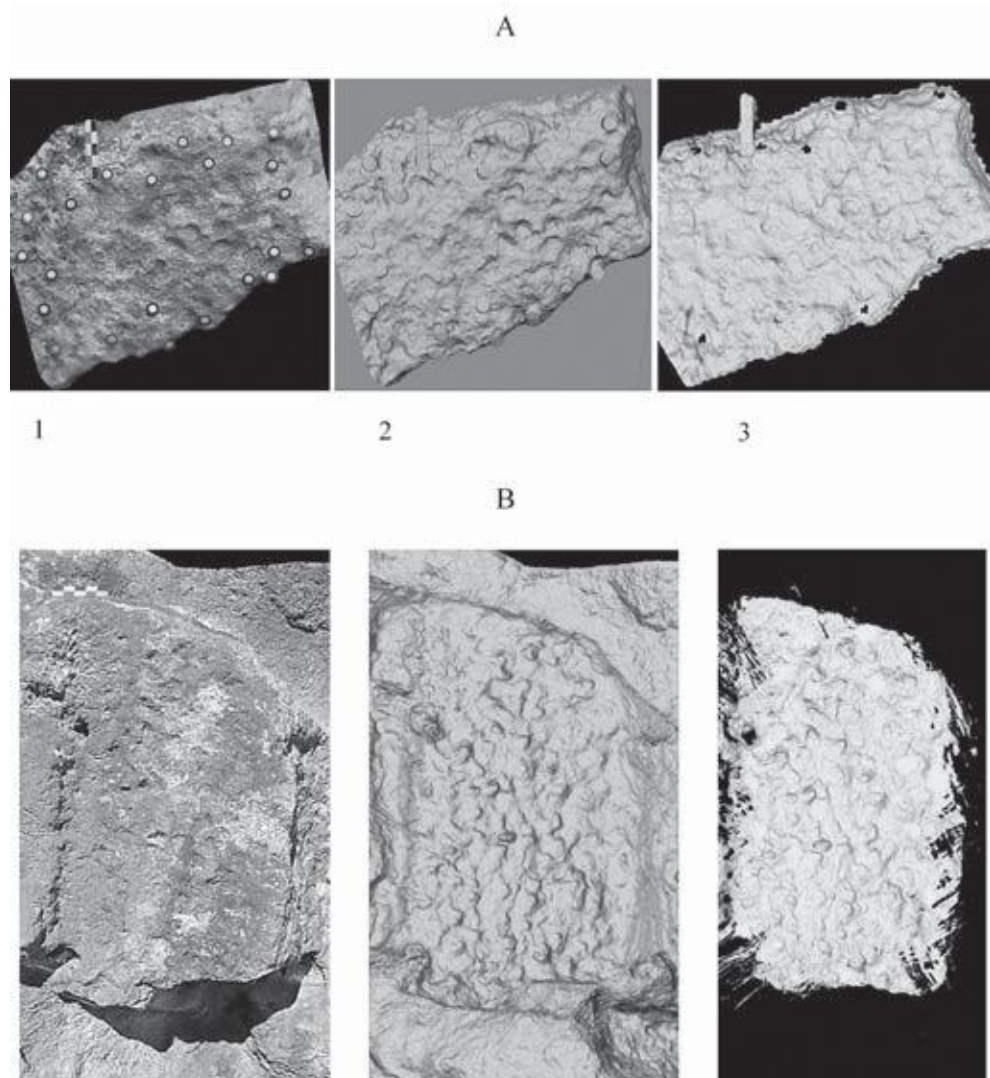


Fig. 3 – S’Elighe Entosu (Usini, Sassari). Documented surface of south-west (A) and north-east (B) corridor walls: 3D model obtained by photogrammetry, represented as texture (1) and mesh illuminated by oblique light (2); 3D model obtained by laser scanning, represented as mesh illuminated by oblique light (3) (elab. C. Caradonna, M. G. Melis and P. Fallavollita).

umentation of archaeological excavations (Girardi *et alii* 2007; Fiorini 2012).

At S'Elighe Entosu the first tests were carried out on the north-east and south-west walls of the corridor of tomb III (figs. 2-3), in which part of the original cut remained together with the initial digging marks. The photogrammetry was carried out with a photographic record later processed through Agisoft Photoscan software. The 3D record was realised with a laser scanner Creaform REVscan™, with a resolution of 0,2 mm.

One of the advantages of laser scanning is the possibility of recording poorly illuminated or unlit surfaces, as well as the immediate acquisition of a three-dimensional document; the disadvantages include the high cost of the technology and the complexity of the field equipment; this includes the laser scanner itself, its power source, a computer and a work surface. The advantages of photogrammetry include lower costs, faster acquisition of data in the field and the relative simplicity of the equipment: a camera and a tripod, sometimes augmented by artificial lighting. However, good illumination of the surfaces to be documented is a necessity, and the data collected in the field must be subsequently processed in order to map the points that will be used to create the three-dimensional model. Neither method is particularly adapted for the documentation of large areas, due to the enormous quantity of data created. Furthermore they can give disappointing results for the documentation of poorly defined marks. Therefore, depending on requirements and objectives it is often necessary to work with a combination of various methodologies (Bueno Ramirez *et alii* 2014).

m.g.m.

A NEW METHODOLOGY FOR STUDYING THE DIGGING PROCESS

In order to find answers to the problem facing us, a new methodology was drawn up which integrates different techniques and other issues. It was studied and elaborated during a Master thesis. There are three lines of reflection, from the technological and functional analysis of the macro-tools to the study of the marks made by the digging process which are present on the walls of the monuments. Both are connected with the experimental approach which is the final aspect. These main lines of research are complementary and inseparable for the pursuance of the study. The idea of this methodology was born from a consideration ensuing from the poor level of conservation of the necropolis at S'Elighe Entosu.

Indeed, we only have partial data and it is necessary to look at each and every issue in order to reconstruct the operational sequence of the first digging phase of the hypogea.

The first part of the project is the study of the tools. It is based on a technological and functional study directly inspired by and modified from the methodology "Lecture d'un objet lithique taillé" (Inizan *et alii* 1995).

Due to the nature of the artefacts, the methodology involved needs to be modified on specific points such as a separate phase for the digging marks, for instance. The objective was to reconstruct the complete operational sequence, which includes activity and the use of tools, implicated in the making of the macro-tools. From these analyses, it is also possible to gather data about how they were used, and what techniques were employed in the digging and what order they were used in.

The second objective is the study of the tool marks. Most of them can be easily seen and documented in the tombs of the S'Elighe Entosu necropolis. They are evidence of the use of the tools and techniques on rock. It was particularly difficult to create a methodology to examine these traces because they were not perfectly preserved. The techniques chosen for the study do not require direct contact with the stone surfaces but at the same time they need to guarantee the most faithful reproduction of the marks, in order for the study to be valid. Techniques related to photography and new technology are being applied at S'Elighe Entosu to resolve this problem. Other objectives include the chronological reconstruction of the different phases of digging.

Experimentation is the third aspect of our research and it is used to connect the two other facets of the methodology. The use of experimental archaeology is very important because it made it possible to fill in the blanks left by the other analysis. It helps in understanding the relationship between the tools and the marks. More importantly, the use of experimentation helps in answering anthropological questions regarding the prehistoric human group. It helped in understanding the necessary skills, how the rock-cut tombs were dug and how the process was organised. The experimentation is structured over two phases from the making of tools followed by their use.

DIFFERENT TYPES OF TRACES RELATING TO THE DIGGING PROCESS AT S'ELIGHE ENTOSU

Different kinds of marks are present in the tombs at S'Elighe Entosu. The use of

oblique light photography made it possible to highlight them. The different types defined different digging periods. Tombs III and IV are the most relevant examples. The photographic method employed was inspired by the system created and used by Guillaume Robin (Cassen, Robin 2010; Robin 2010).

The three different types of marks are present in tomb III. Most of them are located in the antechamber and in the corridor leading to the principal chamber. They demonstrate two phases of digging. The first one is the lower part of the antechamber which is interpreted as a phase of floor preparation. There are linear and regular marks, possibly made by a metal tool. That phase is also distinguished by the creation of a separate space in one corner. The second type corresponds to marks mainly present on the roof and the higher section of the antechamber and the corridor. There are many marks made by a rectangular metal tool, and they are more recent. In the corridor, the contrast between the higher and lower part of the area is important. Initially, the area was rectangular with straight walls and clearly defined angles. These two types of marks support the results of finds analysis from this tomb and prove that it was reused in different periods (fig. 4). No experimental study related to these marks was carried out.

Tombs III and IV each possess a very long corridor that gives access to the antechamber. These corridors display the third type of mark. Circular in form, they are very different from the others. They are typical of the use of a tool similar to a pick. The marks from tomb III were documented by photogrammetry and 3D laser-scanning (figs. 2-3). We obtained a more faithful virtual model of digging-

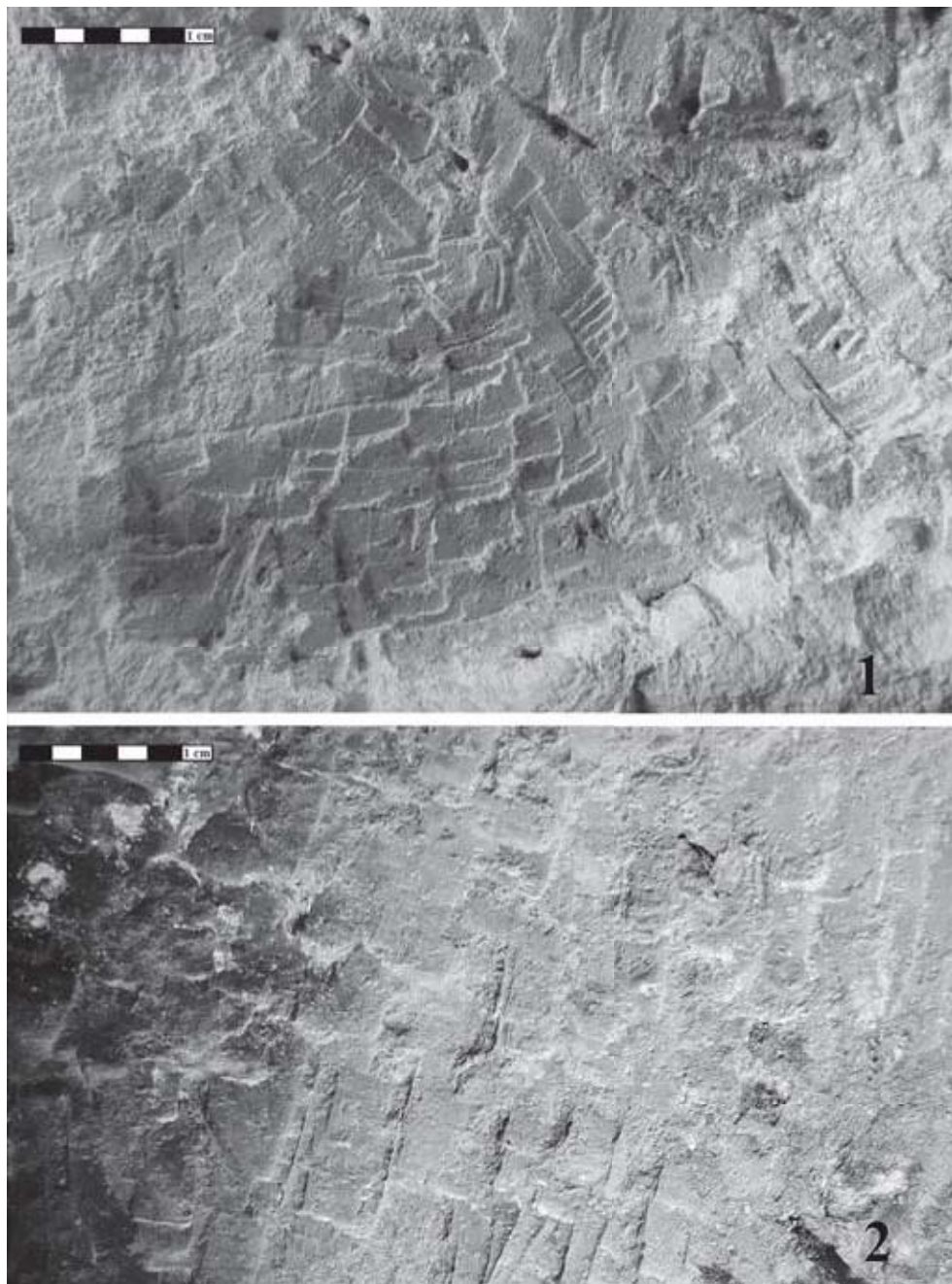


Fig. 4–S’Elighe Entosu (Usini, Sassari). Modern digging marks created with a metal tool. 1: marks from tomb III, access corridor of the principal chamber; 2: marks from tomb III, lower part of the antechamber (photos and processing M. E. Porqueddu).

marks in order to better study them. This is particularly important because the traces were not well preserved due to their position in the corridor. Indeed, the marks in the corridor are exposed to the weather and to light.

Similar traces are present in the corridor of tomb IV. They are particularly evident at the end of the passage where the conditions are favourable for their conservation. They are present on both the floor and the walls and made it possible to identify the end of this long corridor.

Based on the observation of this last group, the fact that it is really different from the other two and the discovery of tools in tomb IV, we started to hypothesise that those traces were due to the impact of that particular tool. It means that this type of mark is related to the first phase of the digging of the tombs during the Neolithic.

This preliminary study of the marks gave the first information about them and furthered better understanding of the different phases of the monuments. It provided important chronological data regarding how, after the Neolithic period, these tombs were reused during Roman, Medieval and post-Medieval times. This different approach to the structures made it possible to further the analysis and to look at problems of conservation.

THE DIGGING TOOLS: DIFFERENT MORPHOLOGY FOR DIFFERENT FUNCTIONS?

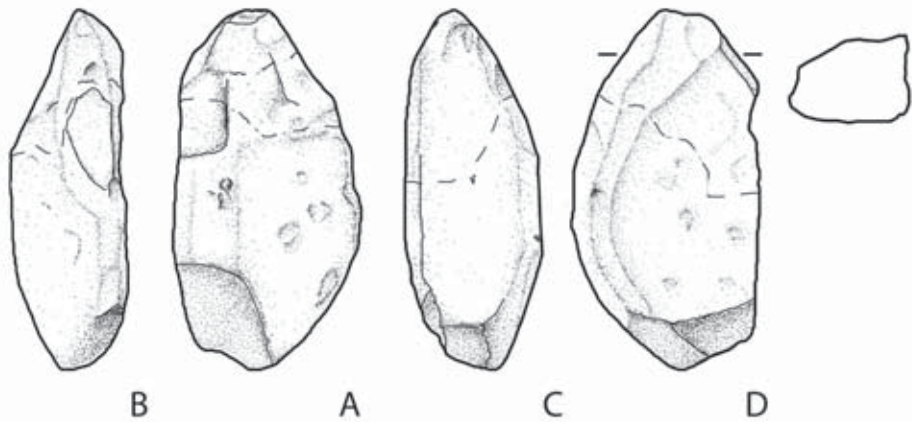
Seven tools were found at S'Elighe Entosu. They were discovered during different excavations, coming from tomb IV and its surroundings. All of the tools are picks. There were examined through a

technological and functional analysis as part of a Masters thesis. The objective is now to continue the study through experimentation and comparison with other types of material, for example the tools from another necropolis, at Santu Pedru, also located in northeast Sardinia. The PhD project included the study of the French necropolis at Fontvieille where the same methodology is applied.

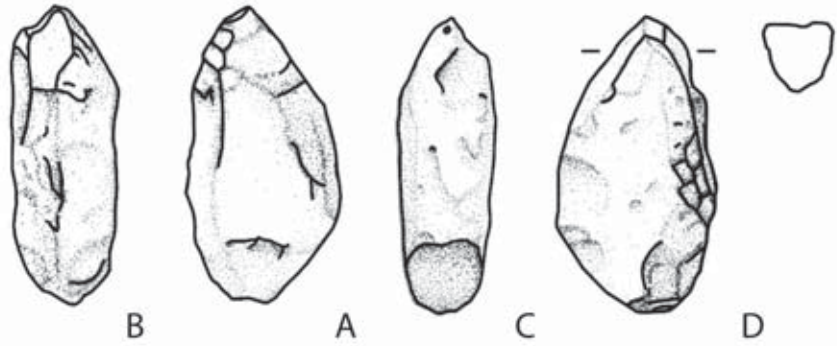
The first result of the analysis was to divide the tools into three groups. These groups were based on criteria such as shape but also on the presence of use-wear use-wear traces and stigmata created during manufacture and the type of raw material used. The first group is composed of three instruments, tools number 2, 4 and 7 (figs. 5-6).

These tools are of a similar shape, roughly the same size and made from the same raw material. Indeed, there are made from andesite, although which specific type is still to be defined. They possess a sub-quadrangular middle section and two straight faces, A and D. The other faces, B and C, underwent a good deal of work, implying the need to create a regular surface and forming the convex outer edge. Some of the marks observed on this part, face E, are evidence of the use of these tools. All seven tools were at some point employed. In this group the tools are of modest dimensions, i.e. between 12 and 14 centimetres long, 6 and 8 centimetres wide. Tools number 4 and 7 are also the lightest weighing 716 and 630 grams.

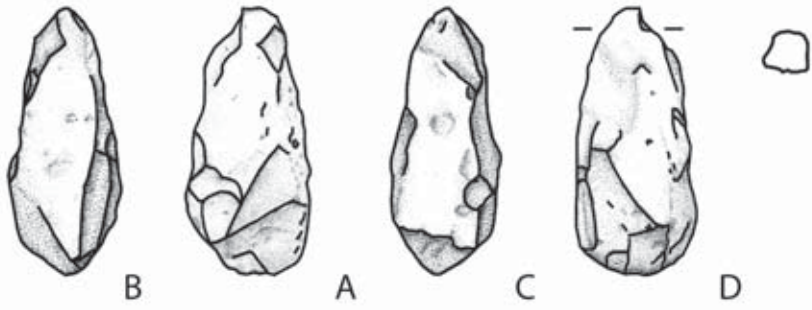
Tools number 1 and 6 are of larger dimensions and form a second group (figs. 7-8). They are longer than those of the other groups. In fact tool number 1 is the longest of the group with a length of 22,5 centimetres, a width of 7,7 cen-



n. 2



n. 4



n. 7

Fig. 5 – S'Elighe Entosu (Usini, Sassari). Digging tools n. 2, 4 and 7: faces A, B, C, D and section (drawings and processing M. E. Porqueddu).

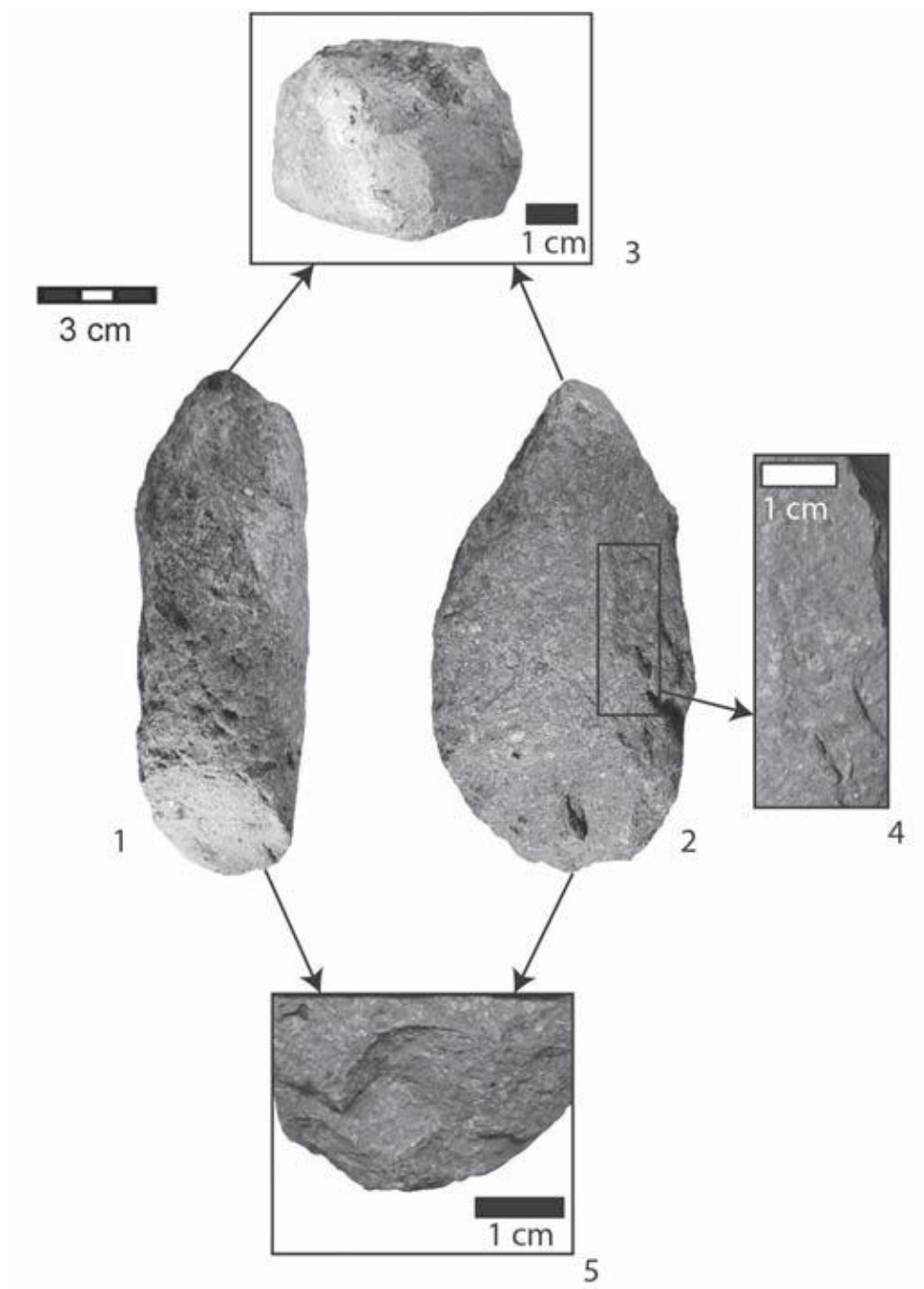


Fig. 6 – S'Elighe Entosu (Usini, Sassari). Digging tool n. 4. 1: face C; 2: face A; 3: face E; 4-5: marks from face A (photos and processing M. E. Porqueddu).

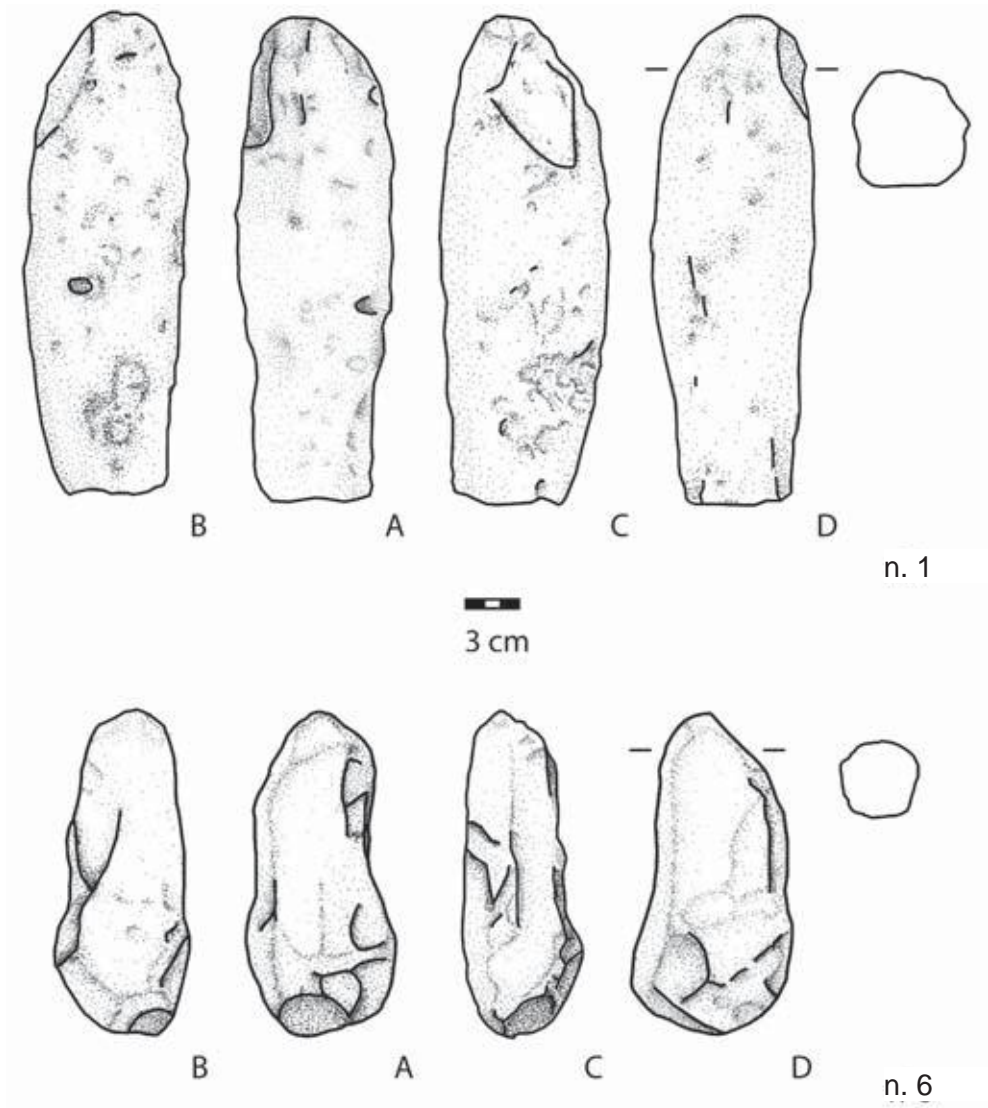


Fig. 7 – S’Elighe Entosu (Usini, Sassari). Digging tools n. 1 and 6: faces A, B, C, D and section (drawings and processing M. E. Porqueddu).

timetres and a weight of almost two pounds. It is better conserved and has better surface finishing than the other. Faces B and C were realised through a hammering technique (fig. 8). Some areas have been prepared for the attachment of

handles, using the same technique. Those areas, together with the presence on face D of a fracture with a tongue-shaped chip, are significant and show the possibility of a haft for this tool. The same hypothesis is put forward for tool 6 but it lacks the

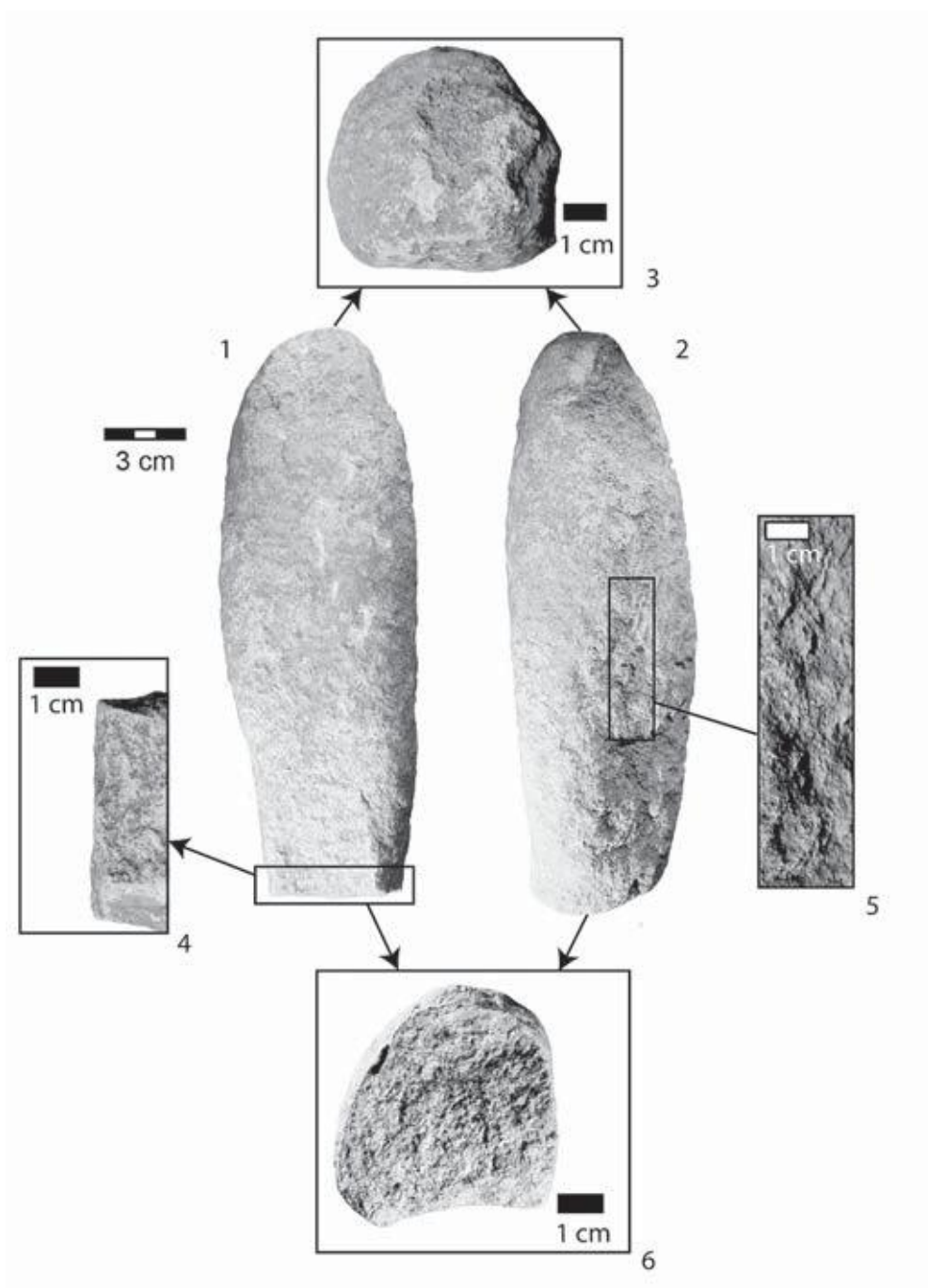


Fig. 8 – S'Elighe Entosu (Usini, Sassari). Digging tool n. 1. 1: face D; 2: face C; 3: face E; 4: detail from face D; 5: areas prepared for the attachment of handles with hammering technique from face C; 6: face F (photos and processing M. E. Porqueddu).

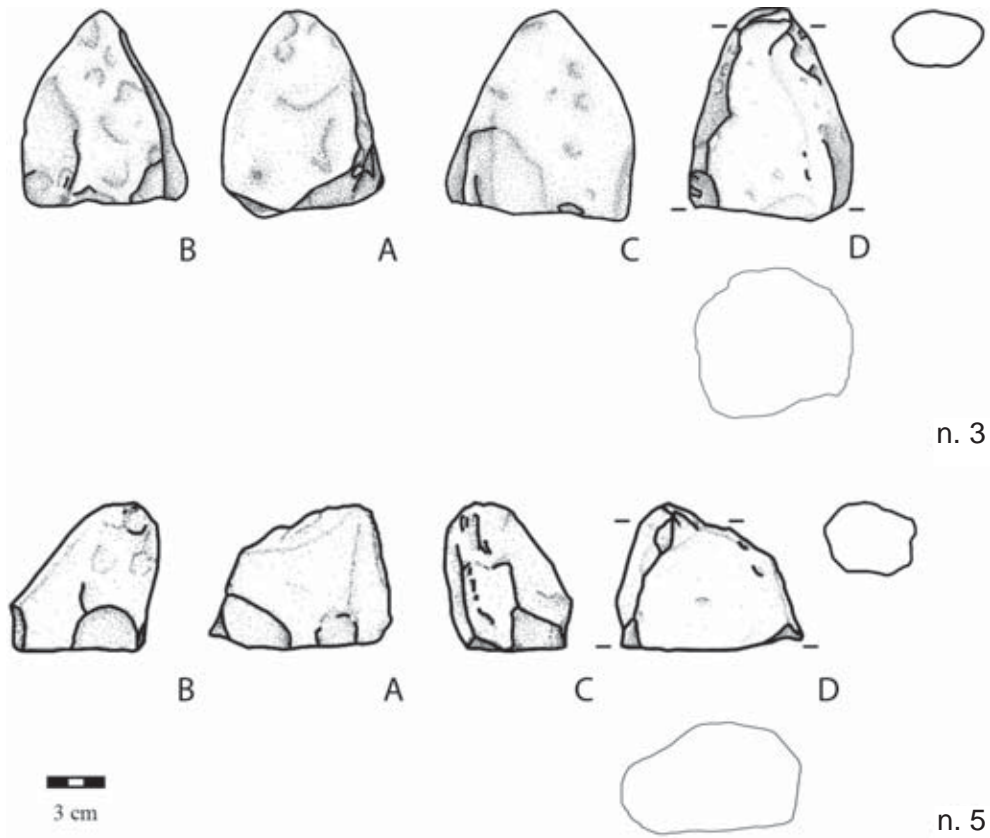


Fig. 9 – S’Elighe Entosu (Usini, Sassari). Digging tools n. 3 and 5: faces A, B, C, D and section (drawings and processing M. E. Porqueddu).

same marks due to its poor conservation. Tool 1 was made from limestone while tool 6 was made of andesite.

The last group is composed of instruments number 3 and 5 (figs. 9-10). They were not found intact, with only the functional part surviving. They are distinguished by the presence of a peak and a straight fracture on face F. There are different theories for why this is so. The first of these is based on the premise that in other contexts in Prehistory, materials were found broken in order to remove their significance and render them useless before

being abandoned. It is a theory related to the importance of these tools and may hold some ritual significance. There are other similar contexts in Sardinia such as Anghelu Rujù and Iloi Ispiluncas (Caprai, Melis 2008). As far as S’Elighe Entosu is concerned, this possibility remains uncertain for the moment as we cannot be sure that the picks were found in a primary deposit. This consideration leads us to the second hypothesis which is related to the stratigraphic position of the tools. Indeed, they were found in a context dated to Middle Bronze Age,

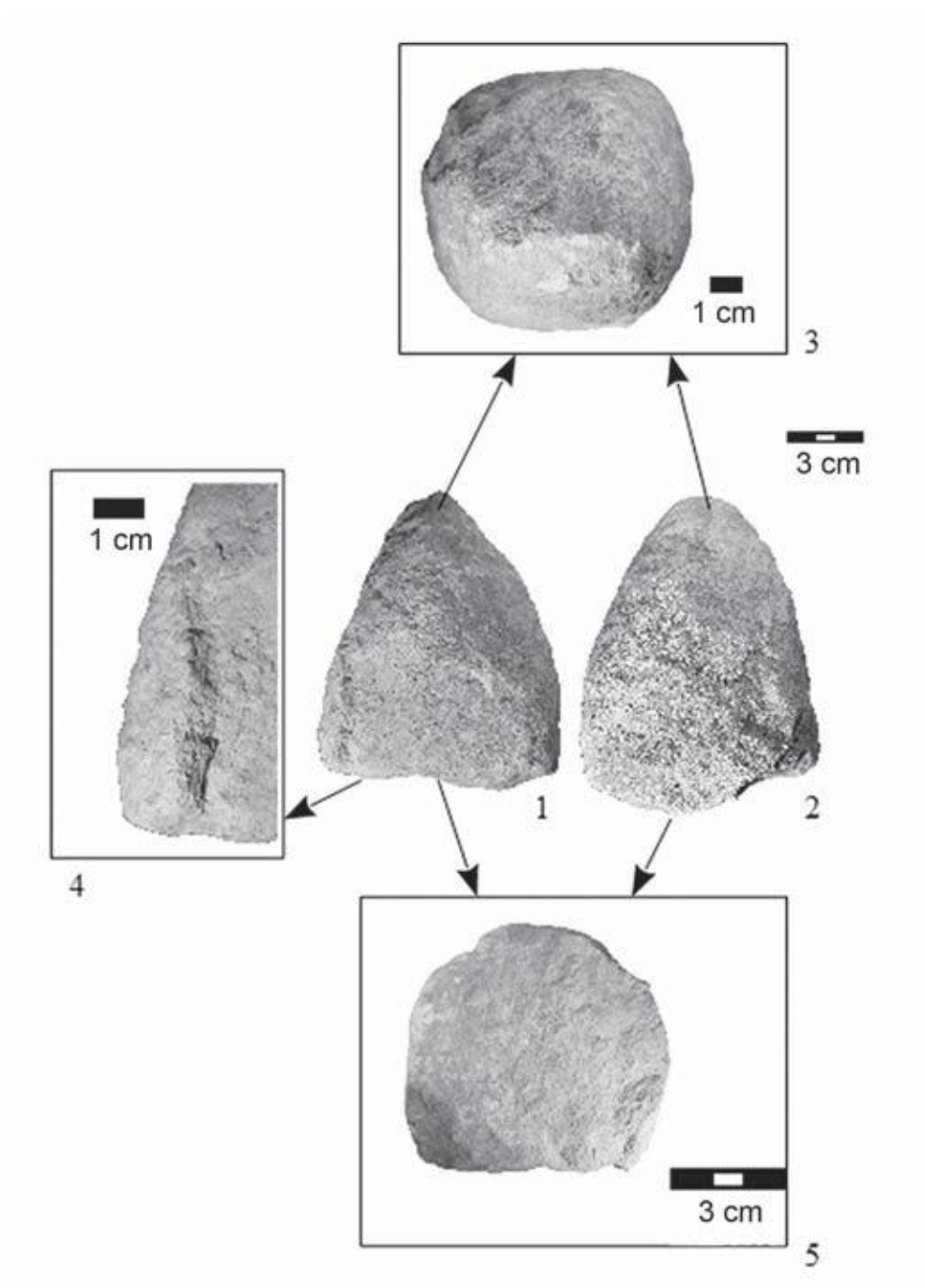


Fig. 10 – S'Elighe Entosu (Usini, Sassari). Digging tool n. 3. 1: face C; 2: face A; 3: face E; 4: detail from face C; 5: face F (photos and processing M. E. Porqueddu).

adding another phase to the use of tomb IV. This context was formed of a bed of calcareous stones creating a floor surface. It is probably due to this that the tools were broken before being included in the layer. Difficulties surrounding the conservation of the stratigraphy makes it harder to be certain of this and therefore support the hypothesis. It is to be hoped that comparison with finds from other sites will help shed light on this.

The poor state of conservation of the tools and of the context are a limit to the technological analysis but the preliminary data made it possible to identify some similarities and differences between the tools. From this data it is possible to begin to hypothesise about the various phases of the operational sequence.

Indeed, the choice of raw materials used for the tools and the lack of finesse in their making makes one think that the work sequence was opportunistic. This was evident from the lack of technical investment, the skill and the time taken during the operational sequence to make the tools. The raw materials used are to be found near the necropolis, in the bed of the river Riu Mannu. They are probably river pebbles. Concerning the shaping step in the sequence, two phases were recognised, one for the creation of the pre-form and one for the specifics of the finished object. For some tools, it is also possible that there was only one phase of the sequence. The choice of the stone is probably based on the form of the raw material and on its quality which make the creation of the instrument quicker. The same technique is used for the second step, consisting of a hammering technique characterised by a direct blow using a hard hammer. This is a basic and simple technique and it is clearly visible on tool number 1 (fig. 6, details 2 and 6).

These results should lead to further considerations, mostly concerning shafts or handles. The work is still to be developed on this aspect but also on the fact that we have different groups of tools. Are they used in the same way and during the same phase of work? We need to work on their function more precisely.

A PROTOCOL FOR EXPERIMENTATION: FROM TOOLS TO DIGGING MARKS

We can begin to answer the questions facing us through experimentation. The experimental protocol is divided into two parts; production of the tools themselves and the subsequent use of them on stone in order to create experimental marks. The first stage was realised during the Masters course in 2013, at the LaPArS, at Sassari University. It was performed by a group of students of the University as a didactic activity.

The students participated in activities searching for the raw materials that could be used to make these tools. This was concentrated in the area surrounding the necropolis and in the bed of the Riu Mannu river in the search for calcareous stones and river pebbles. The process also involved the use of geological maps to identify areas where andesite could be found. Two sites were identified, both between 12 and 15 kilometres from the necropolis. One of them is directly connected with the Riu Mannu and the research also included a survey of that area. This confirmed theories about the use of river pebbles for making picks. Different types of stone were collected, one type for the tools and another for use as hammers. These were in trachyte, andesite and basalt. We did not find andesite river peb-

bles with the pre-form that we required for the tools. Because of this, it was decided to exclusively employ limestone.

The next stage was the realisation of the tools. Different techniques were tested for the shaping of the instruments but the foremost was direct and indirect blows with a hammer (fig. 11). The protocol involved the use of different hammers of various weight and form. This choice depended on the rock to be worked on and on the phase of the operational sequence. All the experimental work was carried out on a stone floor. Many attempts were necessary to obtain useful results, the use of six tools was attempted but only two examples were satisfactory. Indeed, a few problems arose during the experimentation. Being the first time that we attempted to make experimental tools for digging some errors were made. The first mistake appeared at the beginning of the operational sequence. An error was made during the choice of the raw materials for the picks. They didn't all have the necessary quality to withstand the different techniques. On top of that, during the test other mistakes were made that did not provide solutions. These mistakes helped in the improved understanding of the operational sequence and the techniques employed, greatly adding to our knowledge.

This first step of the experimental protocol showed that the tools were created with simple technique and demonstrated that it was not necessary to have specialist knowhow. The principal technique was the use of direct blows, which is a simple method and included the variation of hammering styles. This technique was used for preparing part of the object in order to make a handle for the tools (fig. 12). We noticed that the knowledge re-



Fig. 11 – Techniques used during the experimentation. 1: direct percussion; 2: indirect percussion (photos and processing M. E. Porqueddu).

quired for the choice of the raw materials to be used in making the tools was more important than the level of skill for the techniques employed. This choice may well be the most important part of the operational sequence. The successful manufacturing of tools depends on it because a better initial choice limited potential mistakes and lowered the time involved during the following operations of the sequence.

The second step of our experimental protocol is planned for 2016, once again with the participation of a group of students. The program included the use of 15 to 20 tools with different weights and dimensions and different types of haft. The goal is to use as many tools as possible in order to avoid any mistakes or misunderstandings during the work but

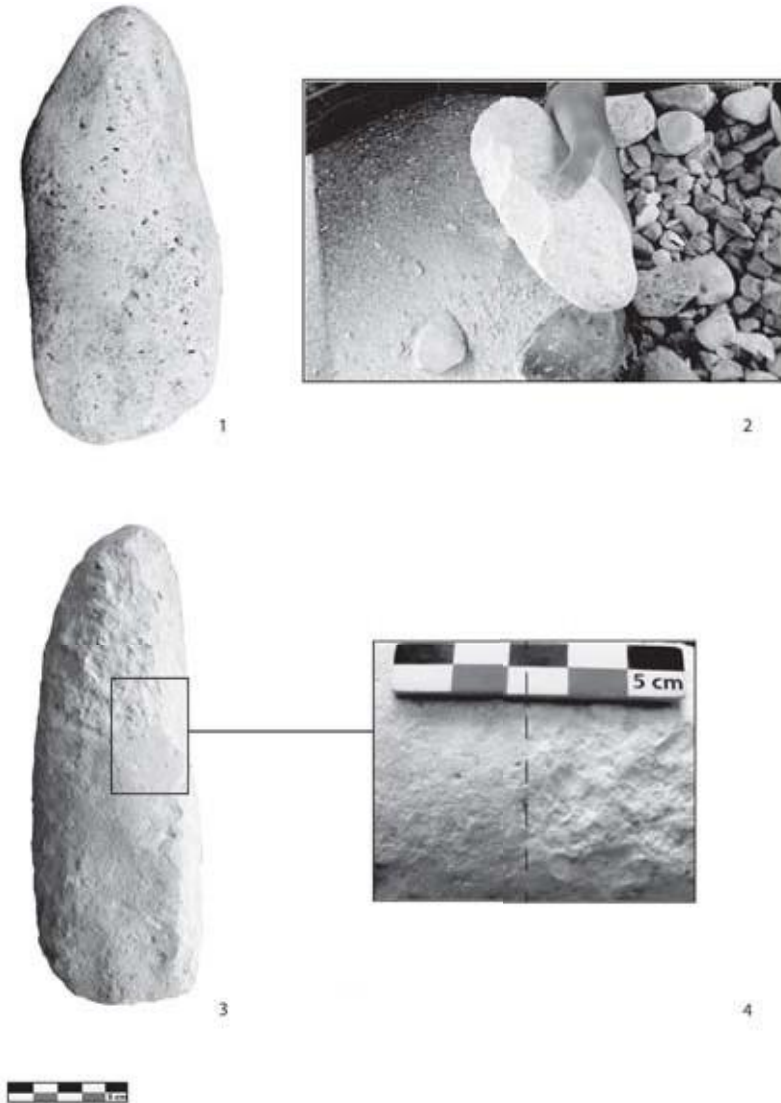


Fig. 12 – Experimental digging tool n. 1. 1: Raw material; 2: phase of *façonnage*; 3: final experimental digging tool; 4: hammering marks and part of the “cortex” of the experimental digging tool (photos and processing M. E. Porqueddu).

more importantly to answer our questions. In this next stage, we will test the variability of tools with different dimensions and see in which ways they can be used. The variability of techniques can also show how each of the tools can be used, what

technique is the most effective and in which circumstances they can be used. The principal objective is still to connect tools and marks. Performing the second stage experimental marks will appear. The objective is to study them and make com-

parisons with the archaeological evidence.

The realisation of this experimental programme is of real interest even though it is of limited size, confronting various problems. It helps in the comprehension of the operational sequence regarding the picks and answers many of our questions.

m.e.p.

FINAL CONSIDERATIONS AND OUTLOOK FOR FUTURE RESEARCH

In recent years the study of digging methods of rock cut tombs has undergone an important development with the introduction of a methodology that integrates morphological-technological analysis with experimental archaeology. This approach was applied to the *domus de janas* of S'Elighe Entosu, that contain evidence of diverse phases of excavation, identified through the examination of digging marks on the walls.

The research has shown that the areas best suited to the study of these marks were the corridors, in which there was no final phase of finishing and the traces of excavation, where they survived, were easily visible. The inner rooms show various periods in which modifications were made to the earliest phase of excavation, which were identifiable through marks of a different type, made by differing tools.

The study was organised in four main phases; a morphological-technological study of the digging marks, a technological and functional study of the picks discovered in the necropolis, experimental reproduction of tools and the experimental reproduction of digging marks.

With regard to the fourth phase and the tools themselves a new experimental protocol will be introduced, which will look

at studying various forms of handles. Through this protocol a *corpus* of experimental marks will be created, which will become a databank to be used as reference for comparison with other contents.

At the same time the documentation of excavation marks will continue with the development of 2D and 3D integrated systems of recording.

The elaborated data will necessarily have to be compared to other evidence of marks and the use of tools on a wider scale in Sardinia.

The application of the same methodologies to the context in Fontvieille, France, will represent an important opportunity for comparison of the phenomenon in the Mediterranean area.

Lastly, from the point of view of methodology and the technical means employed, the application of new approaches, underused or so far untried in Sardinia, such as experimental archaeology and integrated 2D-3D documentation of digging marks, will make a considerable contribution to the study of funerary hypogea.

The research is still ongoing, as are both the study and the excavation of the necropolis and the investigation of settlement contexts. In particular the settlements, identified through the presence of surface material, are being examined using an infrared thermal imaging camera, which may provide useful information for an estimate of the demographics of the communities that used the hypogea.

Beyond the chronological distinctions of the various excavation phases of the hypogea, this study, and especially the experimental process, should provide indications as to how the members of the human group were involved in the excavation of the hypogea, on the number of people employed, on the necessary workload

and the time required, and therefore on the ramifications that this activity would have exerted on the social and economic organisation of the community. The impact of these results will be of considerable interest beyond the specific case of S'Elighe Entosu, considering the importance of the phenomenon of funerary hypogea in Sardinia and further afield.

m.g.n., m.e.p.

* *Università di Sassari, Dipartimento di Storia, Scienze dell'Uomo e della Formazione, LaPArS (Laboratorio di Preistoria e Archeologia Sperimentale, Sassari (Italy))*
mgmelis@uniss.it

** *Aix-Marseille Université, Laboratoire Méditerranéen de Préhistoire Europe Afrique LAMPEA UMR 7269 Aix-en-Provence (France)*
porqueddu.marieelise@gmail.com

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