Research Article

Alice Vassanelli*, Cristiana Petrinelli Pannocchia, Elisabetta Starnini

The *Chaîne Opératoire* Approach for Interpreting Personal Ornament Production: Marble Beads in Copper Age Tuscany (Italy)

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Abstract: This article discusses the *chaîne opératoire* concept in prehistoric archaeology, traditionally employed for the study of lithic industries and ceramic production, and focuses on personal ornament manufacture. This category of non-functional objects has been analysed with the operational sequence approach in the framework of a research project aimed at the techno-functional study of prehistoric marble artefacts. Throughout an experimental approach, the study presents the actions and choices made by the artisans to produce marble beads and tries to understand the role and social-cultural meaning that these items had for the Copper Age communities in Tuscany. Finally, our study proved that the beginning of the use of the Apuan marble can be traced back to the sixth millennium BC, and it was connected with the production of personal ornaments, reaching its peak during the Copper Age.

Keywords: *chaîne opératoire*, marble beads, Copper Age, Tuscany, experimental archaeology

1 Introduction

In recent years, multiple studies are aimed at reconstructing the so-called "*chaîne opératoire*," now considered a fundamental approach for understanding and interpreting ancient artefacts or productions, not exclusively referable to the prehistoric periods (Benton, 2020; Georgel-Debedde, 2022; Pelegrin & Yamanaka, 2016; Roux, 2016). Today, the literature often emphasizes the historical evolution and the origin of this approach (Audouze & Karlin, 2017; Delage, 2017; Martinón-Torres, 2002; Soressi & Geneste, 2011; Tostevin, 2011). Although the term *chaîne* first appears in the works of M. Mauss and M. Maget during the forties and fifties, years marked by post-war industrial reconstructions, the first use of this term is attributed to Leroi-Gourhan (1952, 1964), an ethnologist student of M. Mauss. In *Le Geste et la Parole*, the author posed the theoretical concept behind of *chaîne opératoire*. According to the author, as in an operational sequence: "*La technique est à la fois geste et outil, organisée en chaîne par une véritable syntaxe qui donne aux séries opératoires à la fois leur fixité et leur souplesse. La syntaxe opératoire est proposée par la mémoire et naît entre le cerveau et le milieu naturel*" (Leroi-Gourhan, 1964, p. 164). As F. Audouze points out, the author's main purpose was to investigate continuity and interactions between the biological and social realms through the mediation of technique (Audouze, 2002). During those years, important prehistoric discoveries gave an innovative impetus to the research on

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*** Corresponding author: Alice Vassanelli,** Dipartimento di Civiltà e Forme del Sapere, Università di Pisa, Pisa, Italy, e-mail: alice.vassanelli@phd.unipi.it
Cristiana Petrinelli Pannocchia, Elisabetta Starnini: Dipartimento di Civiltà e Forme del Sapere, Università di Pisa, Pisa, Italy

prehistoric societies. A group of Prehistoric Ethnologists formed around the figure of Leroi-Gourhan. They applied systematically innovative methods to the studies of the lithic complexes recovered (refitting and spatial distribution). However, the application of the *chaîne opératoire* concept does not seem yet recognizable in their works (Karlin, 1972; Leroi-Gourhan & Brézillon, 1966). Over the years, the former students of Leroi-Gourhan gave new impulses to the development of the original concept of *chaîne opératoire* underlining its social dimension due to the strict connection between technical processes and social nets (Cresswell, 1976; Haudricourt, 1964).

During those years, moreover, the studies of prehistoric lithic industries were enriched with new interpretative tools, in particular employing raw material analyses (Demars, 1982), systematic typology (Laplace, 1966), experimental archaeology, and technological approach (Boëda & Pelegrin, 1979; Tixier, 1976; Tixier, Inizan, & Roche, 1980, 1984) as well as use-wear analyses (Anderson-Gerfaud, 1981; Semenov, 1964; Tringham, Cooper, Odell, Voytek, & Whitman, 1974) and quantitative methods for data analysis. In many publications of those years appear expressions like "*chaîne des actions de fabrication*" (Tixier, 1978) or reconstituted "*la chaîne des operations*" (Cahen, 1978), to underline the importance of understanding the single phases or steps composing the production process. According to J. Tixier, the attention of these scholars should not be limited to the techniques used or to the single product of the technological method, but it has the aim also to "*percer les intentions*" of those who have played the actions (Tixier, 1967, p. 773). This statement has therefore underlined the strict interaction between actions and the actor of those actions.

During the last 20 years, the debate on the concept of *chaîne opératoire* seamlessly animated academic studies, growing in complexities and significance (Pelegrin, 2005; Soressi & Geneste, 2011). Today, we can consider the *chaîne opératoire* as an integrated approach, not only useful to observe the sequence of the stages necessary to achieve an objective but also above all a skilful instrument to understand the concatenation of ideas and planning that drove the actions and the choice made to achieve the final objective. Moreover, in this approach, this product is conceived as having a biography that starts from its conceptualization and ends with its final use and re-use (Inizan, Reduron, Roche, & Tixier, 1995; Pelegrin, 1990; Sellet, 1993; Sillar & Tite, 2000).

The conceptualization of the operational chain as an integrated approach allows multiple levels of interpretation. At the first level, we can observe and achieve information on the chronological succession of the actions performed by an individual (simple/complex production chains, high/basic technological applications, selections of particular raw materials, etc.). At a second level, we can investigate natural and social factors that may have affected the choice carried out by the "artisan" (presence/absence of raw materials, technical skills, cultural traditions). At the third and higher levels, an attempt is made to understand the economic and social dynamics involved in carrying out production processes within a given society/human group (control of particular supply areas, the existence of a specialized production organization, the symbolic meaning of the productions, etc.).

With these premises, the present article focuses on the application of the *chaîne opératoire* approach for studying non-utilitarian artefacts. The study of non-utilitarian items whose production requires time, labour, and particular skills can be useful to understand the importance of craft production in the communities and reconstruct the social and economic relations involved. In the last few years, many authors have dealt with the study of personal ornaments considering these items, as well as any other artisanal product, as embedding both material (technical-cognitive abilities) and immaterial aspects (values, knowledge, expertise, and memories) (Bar-Yosef Mayer, 2015; Hodder, 2011; Kuhn & Stiner, 2007). The Copper Age marble beads production in Tuscany (Italy) is used as a case study to exemplify this methodological approach. The current knowledge suggests that ornamental objects have played an important role in the life of past human groups, who spent time and energy to produce these non-utilitarian artefacts, to materialize their social and ideological beliefs (Bains, 2012; Baysal, 2019). Data that can be obtained from the analysis of personal ornaments allow us to reconstruct the actions and choices made by the producers, as well as the social and economic dynamics and the cultural aspects within which these objects have been conceived, produced, and used.

In Italy, before our research, there were many gaps in the knowledge about this production and the prehistoric use of marble (Micheli, 2020). The beginning of the use of this lithic resource in Italy during the prehistoric period was generally unknown. Only beads were mentioned as made of marble, but always this identification was never supported by any archaeometrical investigation. Information about production processes was totally absent. There were no specific, large-scale studies analysing this manufacturing tradition and its role in the Copper Age society. Therefore, our research was aimed at performing a techno-functional study to define the actions and choices made to produce marble beads and to understand the role and social-cultural meaning that these items had for the Copper Age communities in Tuscany.

2 Chrono-Cultural Context

In most parts of Europe, the period from the fourth to the third millennium BC was characterized by changes in settlement structures, subsistence strategies, cultural assemblages, and mortuary practices that altered the techno-economic and social organization of the human groups (De Angelis et al., 2021; Dolfini, 2019). Data show that in the Italian peninsula, the Neolithic/Copper Age transition was a process that took place gradually. Despite the continuous revision of the published data and the study of new records (Anzidei & Carboni, 2020; Baioni, Longhi, & Mangani, 2017; Chiarenza, 2013; Dolfini, Angelini, & Artioli, 2020; Perucchetti, Bray, Dolfini, & Pollard, 2015), there are still many aspects needing clarification to define the Copper Age cultural groups, their cultural connotations, and their geographical distribution.

In Tuscany, the Copper Age is documented almost exclusively by burials. Settlements are less known. However, along the Arno valley, a few rather large sites testify to a long human occupation from the middle Neolithic to the end of the Copper Age, that is characterized by the presence of Bell Beaker pottery (De Marinis & Pedrotti, 1997; Leonini & Sarti, 2008; Nicolis, 2001; Sarti, 2012). The study of the various aspects of this long period allowed various authors to highlight the links between Tuscany and the other cultural areas of the Italian peninsula, from the Alps to the southern regions. These connections are to be put in close correlation with the first metal ore mining and metallurgy activities which must have had remarkable importance in the development of the Tuscan cultures during this time span (Bagolini, 1989).

As mentioned before, the archaeological collections from Copper Age sites in Tuscany show a remarkable presence of marble ornaments. The first attempt to discuss this category of artefacts was done by D. Cocchi Genick (Cocchi Genick & Grifoni Cremonesi, 1989). In her work, the author established a possible typological classification of the beads recovered in Tuscany discussing their geographic distribution. However, no observations were made on the morpho-dimensional attributes of the beads and their technological aspects.

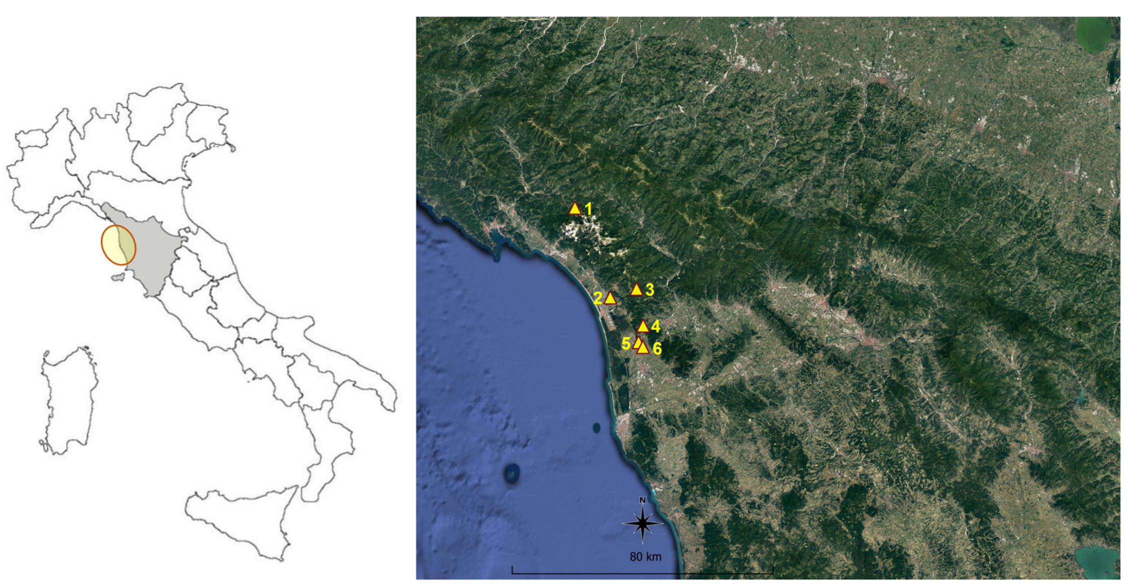

Figure 1: Map of central Italy with the location of the Copper Age sites mentioned in the text: (1) Tecchia di Equi, Casola in Lunigiana; (2) Buca di Fondineto, Massarosa; (3) Buca del Corno, Lucese; (4) Spacco dell'Assassina di Balbano; (5) Grotta del Castello, Vecchiano; and (6) Grotta dell'Inferno, Vecchiano. Map created using the Free and Open Source QGIS.

Available data show that marble beads have been found almost exclusively in burial contexts. The sites that yielded these items are mainly distributed in north-western Tuscany (Figure 1), along the slopes of the Apuan Alps. Beads have been found inside small natural cavities used as grave places during the Copper Age. The beads, together with other artefacts such as pottery, stone, and bone tools, were part of the grave goods placed for the deceased. This connection probably underlines the strict symbolic connotation of these products.

3 Materials and Methods

The studied beads have been found in several sites mainly excavated in the last century, among which are: the Tecchia di Equi, Casola in Lunigiana (Massa-Carrara province, De Stefani, 1916); Buca di Fondineto, Massarosa (Lucca province, Fornaciari, 1977); Buca del Corno, Lucese (Lucca province, Campetti, 1993); Spacco dell'Assassina di Balbano (Lucca province, Cocchi Genick, 1985); Grotta del Castello, Vecchiano (Pisa province, Grifoni, 1962); Grotta dell'Inferno, Vecchiano (Pisa province, Cocchi Genick, Ceccanti, & Fornaciari, 1982). The number of beads recovered from the sites varies and most probably depends on the recovery techniques used during the excavations. Wet sieving with small-sized mesh has been employed very rarely in the past.

A total of 93 prehistoric and protohistoric sites that yielded stone objects identifiable as ornamental items have been surveyed in the Museum collections in Tuscany and analysed during our project MARMO/MARBLE (Methodologies for the Analysis and Research of prehistoric marBLE). These artefacts have been often only mentioned in the literature as made of marble but never analysed before with scientific methods. Starting from this survey in museums and collections, it was possible to recover and register a total of 343 stone beads.

In total, 89 marble beads (Figure 2) were identified in the Museum collections and analysed during our project. Unfortunately, no by-products or lithic tools related to bead production have been recovered in the examined collections. These items have also been observed under a petrographic microscope (Laica DMLP) to better define the possible supply areas (Lezzerini, Pagnotta, Legnaioli, & Palleschi, 2019).

The beads were first grouped according to their typology based on their morphology and shape (Table 1) (Baysal, 2014) to proceed subsequently with the technological analysis. Four different types have been distinguished: cylindrical, discoidal, biconical, and globular beads.

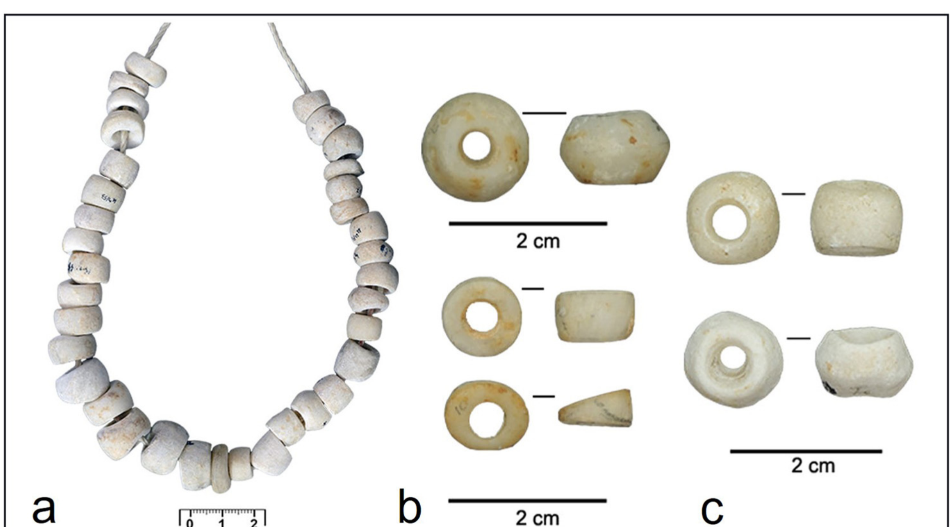

Figure 2: Selection of the archaeological marble beads analysed: (a) Grotta del Castello di Vecchiano; (b) Grotta dell'Inferno; and (c) Tecchia di Equi. Photographs by A. Vassanelli.

Most of these beads have a simple shape. The cylindric beads are predominant, and they are both short and long. Less numerous are the biconical beads. Six discoidal beads and a globular bead occur. Cylindrical and discoidal beads show both straight and convex profiles.

All the beads are centrally perforated, and the outline of the perforation is usually regular, with a diameter rarely exceeding 6 mm. The longer beads usually have a biconical/bidirectional perforation, although there are examples of conical/unidirectional ones.

The length, width, thickness, and diameter of perforation of all the studied beads have been measured with a calliper. In addition, we recorded the weight too. The bead surfaces have been observed with an optical microscope (OM) (LEICA MZ125, from 10× to 55× magnifications), a petrographic microscope (LEICA DMLP, up to 100× magnification), and an electronic microscope (SEM-FEI Quanta 450 FEG) to detect manufacturing traces and use marks. Beads have been photographed in several projections with a Nikon Coolpix and with a FLEXCAMC1 associated with the microscope. Multifocus reconstructions of the images have been made with the help of LAS X software.

The beads have been analysed with a handheld pXRF (Bruker Tracer III-SD) and a handheld Raman (BRAVO) to determine the raw materials used for their production and the nature of the residues present on some surfaces. Archaeometric analyses have been performed at the Department of Earth Science of the University of Pisa and at ICCOM-CNR of Pisa.

A special experimental program has been conducted, in the *Laboratorio di Archeologia Preistorica e Sperimentale* of Pisa University, to determine the different technical procedures utilized in re-producing the prehistoric specimens.

4 Raw Material: Petroarchaeometrical Analyses

The petroarchaeometrical study carried out on the beads revealed that the raw material for their production has been selected with non-homogenous criteria. The chemical analyses performed by Raman spectroscopy on various bead samples have revealed that the main constituent is calcite.

The petrographic analyses suggest the use of local white marble to create the beads, but two different main provenance sources have been recognized: the Apuan Alps (i.e. the Carrara basin) (150 µm < Maximum Grain Size [MGS] < 2 mm) and Monte Pisano (Lezzerini et al., 2019), at the southern part of the Tuscan Apennine, between the cities of Pisa e Lucca (MGS <150 µm).

The most used is the medium-fine-grained marble from the Apuan Alps. The other lithotype, the Monte Pisano Marble, is a fine-grained marble, with a colour ranging from white grey to ivory and grey and sometimes with thin yellowish veins.

Table 1: Typology of the analysed marble beads from Copper Age burials in Tuscany

Site	Type of Bead					
	Cylinder-short	**Biconic**	**Cylinder-long**	**Disc**	**Globular**	**TOT**
Buca di Fondineto di Massarosa	6	3	/	/	/	9
Buca del Corno di Lucese	23	2	4	/	1	30
Grotta del Castello di Vecchiano	24	7	2	2	/	35
Grotta dell'Inferno di Vecchiano	4	3	/	4	/	11
Spacco dell'Assassina di Balbano	1	/	/	/	/	1
Tecchia di Equi, Casola in Lunigiana	1	2	/	/	/	3
TOT	59	17	6	6	1	89

In both cases, the raw material could be easily collected either in primary outcrops, i.e. directly from the bedrock or dispersed as clasts in the surrounding area, or as pebbles/cobbles in a secondary position, in alluvial deposits along riverbeds or beaches.

5 Traceological Analysis

The 89 beads from the various Museum collections have been first observed under a binocular, petrographic, and electronic microscope with different magnifications to record and identify the possible manufacture/use wear traces present on their surfaces.

Some of the beads show alteration of the surfaces and are partially covered by calcareous concretions, perforation striations are poorly preserved due to the same factors.

Only a few archaeological beads show surfaces affected by longitudinal or transversal bundles of thin striations related to the manufacturing processes (Figure 3a and c). In some cases, the perforation striations are preserved on the walls of the perforation (Figure 3b). The perforation traces observed on our samples seem to be linked to the use of a stone point, an interpretation supported by our experimentation. However, our research on this issue is still in progress.

6 The Manufacturing Processes: Technological *Chaîne Opératoire* and Experimental Archaeology

The recovery of these beads mainly within burial contexts authorizes attributing a particular meaning to these items embedding a symbolic value connected to the funerary sphere.

As the other items selected to be part of the grave goods, these artefacts have been separated from their daily life and economic context. Indeed, in funerary contexts, information regarding the manufacturing process, such as the presence of by-products, wastes, or tools used for artefact production, is usually missing.

Thus, to understand the *chaîne opératoire* to produce marble beads it is necessary, as already mentioned, to analyse every single stage of the manufacturing process throughout the experimental approach: from the procurement of raw materials to the actions, techniques, and instruments used to create these items. As Soressi and Geneste (2011, p. 337) argue: “The efficacy of the ‘chaîne opératoire tool’ is augmented by physical experiments performed by archaeologists using the raw materials employed by prehistoric groups to produce their stone tools, as well as by the growing number of analyses of archaeological assemblages using this methodology.”

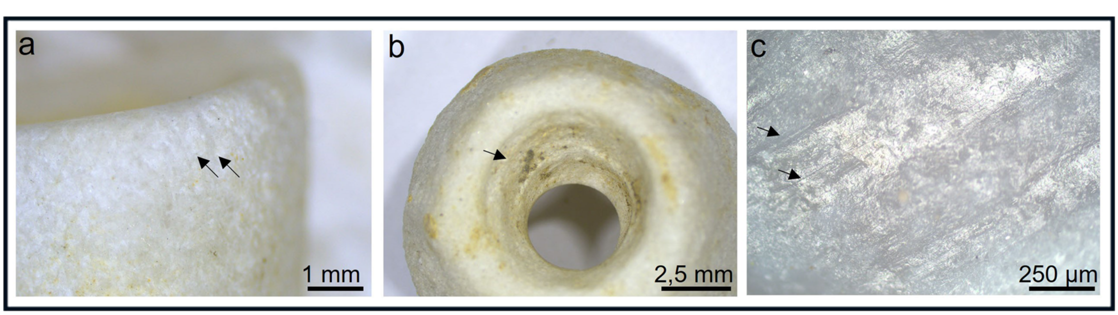

Figure 3: OM images of the manufacturing traces observed: (a) Buca del Corno, longitudinal striations (binocular microscope, magnification: 20×); (b) Tecchia di Equi, rotary striations on the walls of the perforation (binocular microscope, magnification: 10×); and (c) Grotta dell’Inferno, longitudinal striations (metallographic microscope, magnification: 100×). Photographs by A. Vassanelli.

Our experimental protocol has been designed according to the aforementioned principles. The aim was to investigate the technical aspects of marble bead manufacture and to address some questions including:

– How much time is required to produce marble beads?
– How do the texture and hardness of the raw material affect the choice of the manufacturing technique and the morphology of the beads?
– Were different technical operational chains employed?
– What kind of technique was employed to drill effectively marble beads?

Data obtained from typological, raw material analyses, and a first observation of the bead surfaces with a binocular microscope were used to plan the experimental protocol.

Suitable raw material pieces have been collected during surveys in various marble outcrops of the Apuan Alps, with the same characteristics as those used by ancient craftsmen. The second step was the selection of suitable pieces of raw material based on the morphology and the size of the final product. The large pebbles have been divided into smaller parts testing different techniques: cutting, direct, indirect percussion, as well as on anvil.

Marble roughouts were obtained by abrasion on flat grinding stones with different granulometry and using different techniques: dry abrasion or with additives (water or water and sand), testing both horizontal and vertical movements. Abrasion with additives has proved to be the most efficient and rapid technique for shaping. More specifically, adding sand or a compound of marble dust and water increases the abrasive power of the sandstone.

The appearance of production stigmata on the surfaces of the experimental specimens varies according to the raw material worked. In the case of fine-grained marble, the processing traces are much more visible, with deep and narrow striations.

The perforation phase has been tested at different stages of the manufacturing process.

Two different perforation techniques have been performed using experimental flint drill bits: moved by hand and by a pump drill. With the former technique, three different types of perforation movements were experimented (Figure 4): the axial rotation of the perforator (Figure 4a); the simultaneous rotation (with opposite directions) of the perforator and the bead blank (Figure 4b); and a movement combining perforator rotation and digging (Figure 4c). The tested techniques created regular circular perforations, regardless of the thickness of the piece. For thicker items, drilling using the pump drill was particularly effective, as it greatly

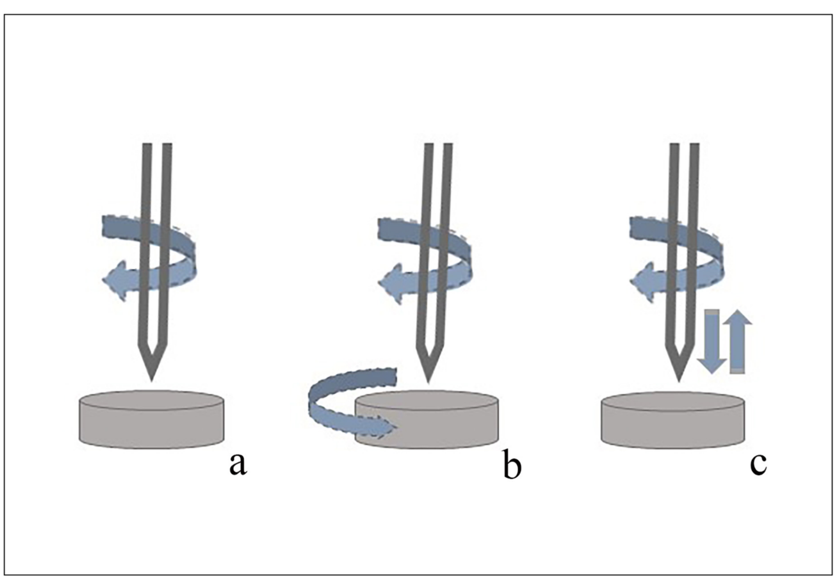

Figure 4: Schematic representation of the different perforating actions performed: (a) axial rotation of the perforator; (b) simultaneous rotation (with opposite directions) of the perforator and the bead blank; and (c) combined actions of the perforator: rotation and digging.

reduced the action time. All the perforations show pronounced rotational striations. In the case of the holes done with the pump drill, the striations follow a regular and circular pattern.

The diverse drilling techniques employed produced conical or biconical perforations. Some of them have been subsequently enlarged to acquire a cylindrical shape, using a thicker perforator.

The experimental replica of the marble bead manufacture has been documented registering the time and modifications occurring at the various stages of the process both with workflow sheets, and micro and macro photographs.

The results obtained from the experimental protocol and the comparative traceological analysis of both the experimental and archaeological artefacts enabled us to hypothesize the existence of at least three different technical and operational sequences (Figure 5).

6.1 Chain 1

This technological process is aimed at the production of bead blanks by direct abrasion of small pieces of marble on a flat grinding stone (Table 2, Figure 5).

6.2 Chain 2

With this procedure, it is possible to obtain a marble slab by abrasion, which is then cut and abraded on the lateral surfaces to obtain a blank bead with the desired shape and dimensions (Table 3, Figure 5).

6.3 Chain 3

This third chain is more complex and allows the production of multiple blanks. From a selected piece of raw material, cylindrical marble roughouts have been produced by abrasion. These roughouts will be successively cut into multiple blank beads of standardized dimensions (Table 4, Figure 5).

7 The Use-Wear Traces

Few archaeological beads observed under the OM revealed the outline of the perforation affected by use-wear. The perforation is slightly enlarged in a small area due to the abrasion of the suspension rope (Falci, Cuisin, Delpuech, Van Gijn, & Hofman, 2019; Figure 6a). In other cases, the continuous friction of a thread has left bands of transverse striae and polishing on the edge of the holes (Figure 6c and d). In some beads (*n*. 34), the faces show an irregular profile, partly convex, due to the continuous friction with other items while they were worn (Figure 6b).

8 Discussion and Final Considerations

The application of the operative chain approach, considered an integrated approach of different analytical methods, provided important data for the reconstruction of the Copper Age marble beads' production in Tuscany.

The outcomes of the experimental activities combined with the traceological analysis have allowed the identification of three possible operative chains for the ornament's production.

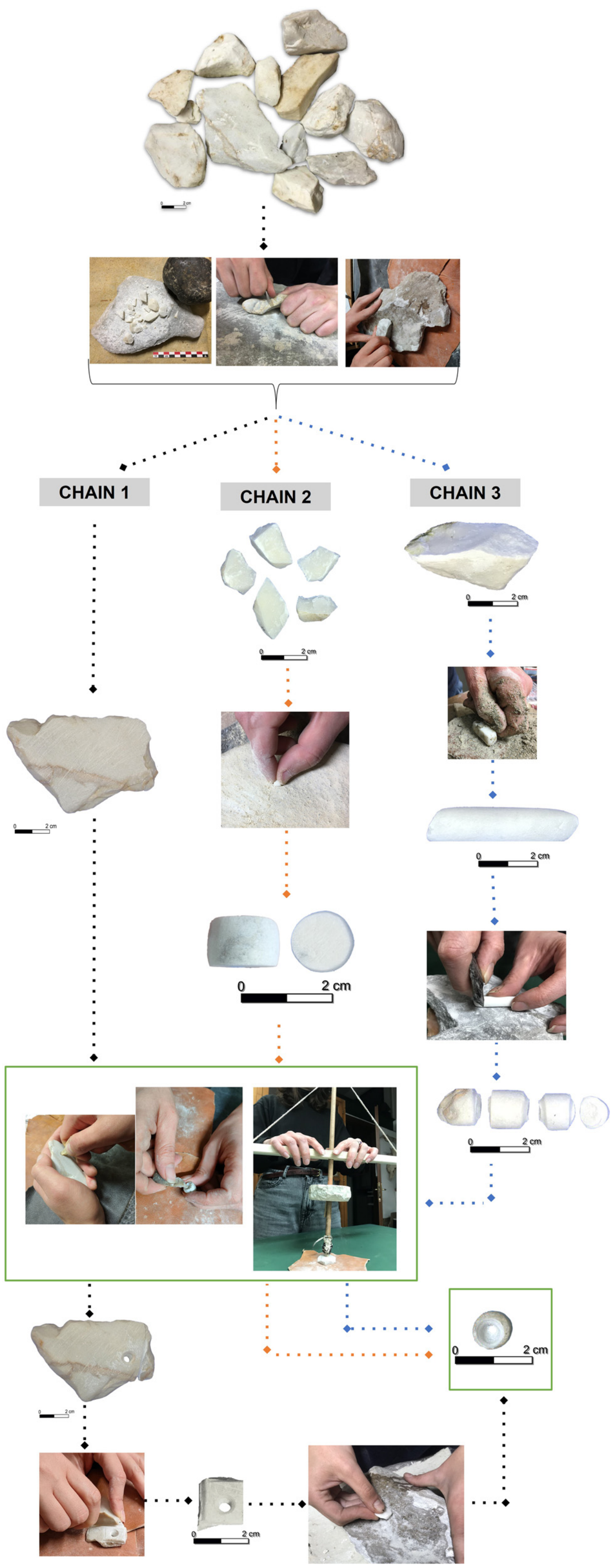

Figure 5: The experimental workflow of the three operative chains for marble beads' production. Elaboration by A. Vassanelli.

Table 2: Chain 1, summary of the experimental data

ID	S. High (mm)	S. Wid. (mm)	S. Max. Th. (mm)	Tech.	Add.	Min. Fin. Th. (mm)	Max. Fin. Th. (mm)	Fin. Diam. (mm)	Time (min)
B1	35	30	23	ABR	D	32	20	26	120
B2	42	38	25	ABR	D	12	13	20	200
B3	30	25	15	ABR	D	10	14	19	72
B4	22	18	12	ABR	D	8	8	12	69
B5	30	22	18	ABR	D	8	8	10	140
B6	14	11	8	ABR	D	4	6	9	38
B7	9	7	7	ABR	D	4	6	5	22
B8	11	10	8	ABR	D	4	4	7	10
B9	25	23	11	ABR	W	5	5	6	62
B10	21	19	17	ABR	W + S	8	9	12	46
B11	27	23	22	ABR	W + S	11	10	18	54
B12	12	9	8	ABR	W + S	10	9	8	10

Key: ID = identification number; S. High = starting hight; S. Wid. = starting width; Min. Th. = minimum starting thickness; S. Max. Th. = maximum starting thickness; Tech. = technique; Add. = additives; Min. Fin. Th. = minimum final thickness; Max. Fin. Th. = maximum final thickness; Fin. Diam. = final diameter; Time = time occurring for the entire procedure.

Table 3: Chain 2, summary of the experimental data

ID	S. High (mm)	S. Wid. (mm)	S. Max. Th. (mm)	Tech.	Add.	Fin. High (mm)	Fin. Wid. (mm)	Min. Fin. Th. (mm)	Max. Fin. Th. (mm)	Time (min)
S1	55	50	22	ABR	D	54	50	19	19	51
S2	49	43	16	ABR	W + S	48	43	8	8	31
S3	81	59	19	ABR	W + S	80	59	10	10	22
S4	42	37	18	ABR	W + S	40	34	7	7	101
S5	58	29	24	ABR	W	57	28	8	8	35
S6	63	32	25	ABR	W	63	32	51	51	45

Key: ID = identification number; S. High = starting hight; S. Wid. = starting width; Min. Th. = minimum starting thickness; S. Max. Th. = maximum starting thickness; Tech. = technique; Add. = additives; Fin High = final high; Fin Wid = final width; Min. Fin .Th. = minimum final thickness; Max. Fin. Th. = maximum final thickness; Time = time occurring for the entire procedure.

Table 4: Chain 3, summary of the experimental data

ID	S. High. (mm)	S. Wid. (mm)	S. Max. Th. (mm)	Tech.	Add.	Fin. High. (mm)	Fin. Diam. (mm)	Time (min)
C1	36	25	14	ABR	W + S	9	8	319
C2	58	27	19	ABR	W	55	14	168
C3	40	27	21	ABR	W	39	8	100
C4	59	35	29	ABR	W + S	35	11	100
C5	49	23	20	ABR	W	46	12	45
C6	51	23	23	ABR	D	44	11	170
C7	53	37	17	ABR	D	36	8	135
C8	61	33	29	ABR	W + S	61	21	190
C9	60	50	16	ABR	W	35	7	86
C10	44	20	23	ABR	W + S	40	6	60

Key: ID = identification number; S. High = starting hight; S. Wid. = starting width; Min. Th. = minimum starting thickness; S. Max. Th. = maximum starting thickness; Tech. = technique; Add. = additives; Fin High = final high; Fin. Diam. = final diameter; Time = time occurring for the entire procedure.

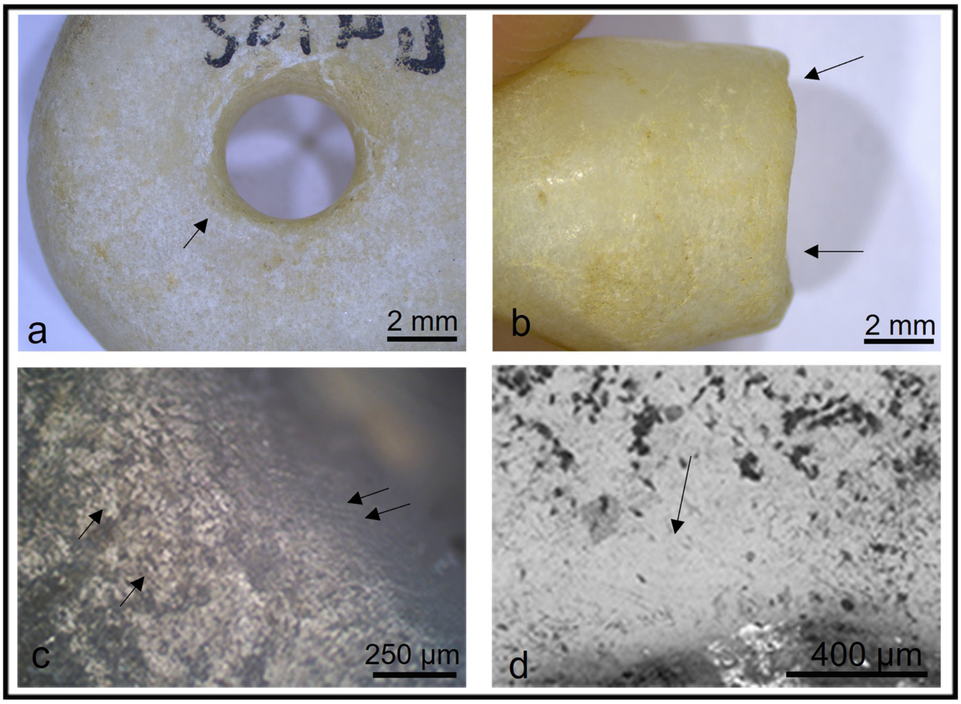

Figure 6: Use-ware traces on archaeological marble beads: (a) Grotta del Castello, deformation of the rim of the perforation (binocular microscope, magnification: 10×); (b) Buca del Corno, irregular profile of the edge of the bead face (binocular microscope, magnification: 10×); and (c) Grotta dell'Inferno di Vecchiano, transverse striations on the bead surface due to the friction with other items (sx) and longitudinal fine striation on the rim of the hole due to the friction of a wire (dx, petrographic microscope, magnification: 100×); and (d) Grotta dell'Inferno di Vecchiano, a polished area close to the rim of the hole due to the friction of a wire (electronic microscope, magnification: 300×). Photographs by A. Vassanelli.

Our experimentation of the technological sequences confirmed that the manufacturing processes involved different stages of shaping, grinding, perforating, and polishing that are influenced by the raw material characteristics. The hardness of marble, in the Mohs scale, is between 3 and 4. It affected the choice of the dimension of the final products. The archaeological artefacts recovered are often larger than 8 mm in diameter. Minor dimensions require more time and special ability.

Generally, the recovered Copper Age beads display high skill and labour investment, considering the hardness of raw materials and technological choices made. However, some artefacts show different morphologies and dimensions. The technological observation suggests a more simple, domestic manufacture for these specimens. Some of the beads from Castello Cave, near Pisa, show larger dimensions suggesting their individual production (Chains 1 and 2).

As mentioned before, the lack of by-products is due to the particularity of the studied assemblages, which are composed of objects deposed in burials as part of grave goods. Unfortunately, this factor does not allow us to make a clear distinction between the use of Chains 1 and 2. The final products of these two chains do not show particular differences in morphology or in the distribution of technological marks on their surfaces. It is possible, however, to hypothesize the attribution of the biconical beads to production Chain 1. Through a direct abrasion of selected pieces of raw material, it is easier to produce the biconical shape, the longitudinal section of which, however, often does not show a perfect lateral symmetry.

The preferential choice of a standardized, serial bead production, probably attributable to expert craftsmanship (Chain 3) is testified by another group of finds. Differently from Chains 1 and 2, the beads produced through Chain 3 have a reduced and standardized dimension and in some cases show a progressive shrunk of the diameter of one of the ends, caused by the action of the cut made for segmenting the cylindrical preform (Figure 7).

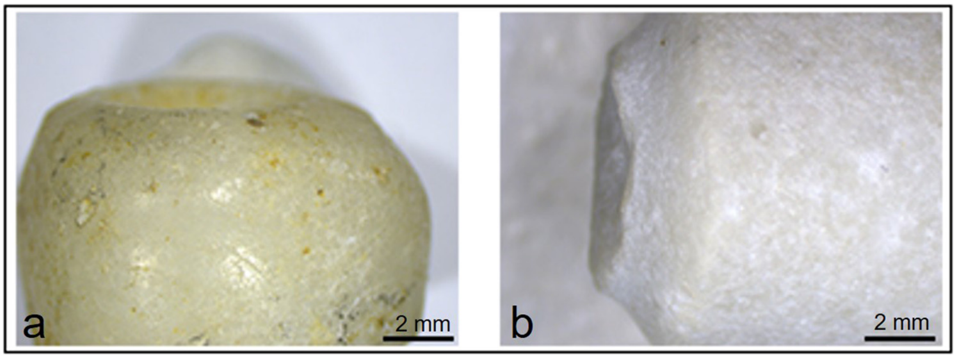

Figure 7: Compared OM images of archaeological bead from Buca del Corno (a, binocular microscope, magnification: 20×) and experimental bead (b, binocular microscope, magnification: 10×), cut from a cylinder. Photographs by A. Vassanelli.

In addition to the reconstruction of the technical processes for their production, it was possible to shed light on the intangible aspects of these productions, such as their social value and meaning within the society that produced them. Our research enlightened a significant diffusion of marble beads during the III millennium BC, revealing the emergence of new styles of products and manufacturing techniques. The intensive use of marble signed a change in ornament productions. This raw material, hard, and therefore durable characterized by a pure white colour was preferred over limestone or steatite, similarly available in the sites surrounding area and widely used in the previous periods (Micheli, 2014; Micheli, Ferrari, & Mazzieri, 2014; Petrinelli Pannocchia & Vassanelli, 2021). However, steatite was not completely abandoned and was used to produce ornaments with more complex morphologies, such as the buttons found at the Tana di Maggiano (Cocchi Genick & Grifoni Cremonesi, 1989).

Unfortunately, the scarcity of radiocarbon dates available for the region under study prevents understanding the timeline of these productions.

The unique radiocarbon date at our disposal comes from Buca del Corno (Camaiore, Lucca: LTL3846A: 4699 ± 30 uncal BP, M. Bonato, personal communication). This is the northernmost site of the studied area, testifying to the presence of a standardised stone bead production (Chain 3) since the earliest phase of the Copper Age.

Furthermore, the three different production procedures should not be interpreted either as the result of an improvement or subsequent chronological evolution but as three "ways of doing" probably used simultaneously.

This hypothesis is confirmed in some sites by the associated presence of different types of marble beads obtained through distinct operative chains.

The presence of different items at the same collective burial sites could be explained in different ways. The beads could belong to different ornamental kits (bracelets or necklaces) but also to different individuals. However, we cannot rule out that the beads could be part of the same ornament belonging to an individual, who progressively added different items over time.

Although these beads are known to date in burial contexts, a few occurrences from settlements suggest that these beads cannot be considered exclusively grave goods productions. Rather, beads may be interpreted as ornaments produced to be worn during daily life as social media or perhaps worn during specific social occasions or ceremonies but not as items exclusively linked to the funeral sphere.

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