Typologies of pottery kilns of the Iron Age. A critical review

Elena Paralovo

ABSTRACT

Approaching the pottery firing structures of the Iron Age[1] involves dealing with a large and diverse amount of data that is difficult to disentangle. One of the most challenging aspects of studying pyro-technological evidence is the absence of a unified and valid typology and of a common vocabulary. In the late 1970s and early 1980s, various scholars, such as Duhamel, Swan, and Cuomo di Caprio, proposed typologies for pottery kilns based on different criteria. While their work is undoubtedly valuable, it does have limitations that need to be addressed, such as a neglect of the protohistoric/pre-Roman periods, and an excessive focus on the shapes of features rather than their actual functioning.

Following their steps, many scholars attempted to expand and further explore issues related to ancient kilns, eventually including protohistoric evidence as well. Recent proposals have emerged (e.g. by Thér or Amicone *et al.*), and a significant revolutionary aspect is the development of a 'functional' typology that goes beyond traditional approaches primarily based on morphological features. Building upon new insights, this paper will present a discussion of the key features of the pottery kilns, trying to propose a unified terminology and a critical comparison of all the European typologies.

KEYWORDS

Pottery kilns; typology; Iron Age; pyro-technology; methodology.

INTRODUCTION

This paper originated as part of the research work for my doctoral thesis, which focuses on the pottery kilns of northeastern Italy in the Iron Age (specifically from the 9th to the 4th century[2]). One of the main problems concerning my research is dealing with the confusing terminology with which the kilns (and their constituent parts) have been described. In fact, it turned out to be impossible to compare data from different publications, even those focussing on the same site. To complicate the situation, since the early 1980s, authoritative authors in the field have proposed typologies of pottery kilns, mainly ascribed to the Hellenistic/Roman period, each following their own criteria. There has never been, until more recent years,[3] an attempt to unify or at least compare the various types. A further factor that prompted the writing of this thesis, and of this text, is that even today, in most publications dealing with pottery kilns at Iron Age sites, the structures are described according to the traditional bibliography, which, however, originates (as will be seen below) for kilns from later periods and intentionally excludes the

1 Defining the European Iron Age is, for many and obvious reasons, an insidious task. Here, the term Iron Age is used to refer to the first millennium BCE. For a complete debate regarding the chronology, see Bartoli – Delpino 2005.

2 The choice of this specific time segment is due to the emergence not only of the first pottery kilns in the area under consideration, but also and above all to the blossoming of organised workshops that allow considerations about the development of the first urban centres and their socio-economic dynamics. See Zamboni 2021.

3 Revision made by Mangel – Thér 2018, for Central Europe.

pre-Roman (or Protohistoric) times. Iron Age furnaces are thus assigned to typologies of little relevance, and which do not consider the functioning, let alone socio-cultural factors that led to the adoption of certain solutions. So, in the wake of recent revisions made specifically for Central Europe (Mangel – Thér 2018), the intention is to apply the same considerations to shed light on the Italian Iron Age as well, in the hope that this work can be consolidated and become a valid tool for approaching all pottery kilns in general.

THE FIRST AUTHORS

Pottery kilns in archaeology are not an obscure matter. It has been centuries since archaeologists began to consider the pyro-technological structures, by collecting archaeological evidence and facing the issues concerning the methodology of this study (Corder 1957; Grimes 1930; Pitt Rivers 1892; Smith 1846). Although the number of publications on pottery kilns in Europe is consistent, here will be presented those, which elucidated the problems that arise when approaching the pottery kilns and eventually proposed methodological reflections. Moreover, they operated solutions that apply to different contexts. The exhaustivity of their work ended up in typologies that, even though based on regional and chronological confined evidence, can be reliable for the study of kilns in general. Nonetheless, these studies present criticalities, as the various authors have never worked towards a unification of the terms used to describe the objects of the research. For these reasons, it seemed appropriate to make a critical synthesis of the bibliography, also in light of recent proposals involving the use of different methodologies, such as experimental archaeology and archaeometry. The aim of the current research is to propose a unified terminology based on the collection of the terms found in literature and compare existing typologies, where it is possible, to provide a tool that will hopefully be useful for future investigations concerning firing technology and pottery production.

In the paragraphs below, the main scholars who made a significant contribution to the critical study of pyro-technology will be presented. Some of them remained faithful to a more standard, chrono-typological approach, while others have broadened the methodological scope to include technological, social, and economic considerations.

Between 1973 and 1974, **Pascal Duhamel** reported on 2000 Gallo-Roman kilns scattered all over France (Duhamel 1974). By presenting his work, the scholar highlighted the difficulties of navigating the several methodological approaches that one may use to study pottery kilns. Important, in fact, are not only the morphological features of the structure but mostly the firing processes and the kiln functioning. A few years later, in 1979, Duhamel published a key study in which he presented the main shapes and features of kilns (Duhamel 1979). He precociously faced the set of issues that a study on the firing structures brings within itself. First of all, he recognized that a mere morphological approach can be limiting; although important, it cannot be the final goal of a kilns study that aims to be thorough and complete. Secondly, he stated that the firing structures must be considered both vertically, through a historical and evolutionary approach, and horizontally, by encompassing the effects caused by the local context, and the technological and economic environment. Duhamel openly raises important questions, such as how to approach the study of the kilns, and how to correctly investigate the complexity of archaeological evidence, especially when what remains of firing devices is nothing but holes with burnt soil (Duhamel 1979, 49). He identified two main sets of criteria to analyse the kilns. The first set is made by what he called ‘objective criteria’: the find context, the kilns’ shapes, the dimensions, and the techniques and materials through which the kilns were built. The secondary criteria also labelled as ‘interpretative criteria’ are the dating of the device and the kind of production it was made for (Duhamel 1979, 52). A typical kiln is constituted of three main structural elements, the cooking chamber, the lower chamber where the combustion happens, and the corridor for the air draft. There are three main shapes of pottery kilns: circular (the most common), quadrangular (usually associated with the production of bricks, even though there is no strict evidence), and elongated. The morphology of the lower chamber is related to a specific technological request, such as the stability, the solidity, and the right circulation of air. Functionality is central in Duhamel's discourse; it is necessary, for a well-functioning kiln, to avoid voids, which dissipate the heat. For this reason, Duhamel supposed that the circular shape is the most suitable, by avoiding the corners and by allowing a better circulation of the air. Alongside the morphological description of the kiln and its main elements, Duhamel considered it fundamental to present a structural-functional typology, based on the number of spaces (volumes), kilns can be one or two-chambered, the air draft, and the number of mouths (holes for the air and for the loading) present on the walls of the kiln (that can have different degrees of insulation and refractoriness).

Regarding the perforated floor, Duhamel posited that this technological feature, situated between the two chambers and upheld by various structural configurations (such as tongues, pillars, columns, and arches), was introduced in France towards the close of the Bronze Age, coinciding with the emergence of the Iron Age. During this period, a surge in kiln construction, primarily two-chambered, is evidenced (Duhamel 1979, 58–59). A subsequent substantial increase in pottery kilns took place throughout the La Tène phase, driven by the proliferation of the land management system associated with oppida. Duhamel emphasized how shifts in economic structures also influenced pottery production methods. Despite this evolution, the dominant kiln shape during this era remained two-chambered, indicating a delayed adoption of alternative forms even in later chronological periods. Many of these kilns bear a resemblance to those found in Central European regions such as Slovakia, Hungary, Austria, and the Czech Republic (Duhamel 1979, 60–63). Additionally, Duhamel observed that kilns were often not standalone; rather, they were clustered within 'ateliers' – workshops dedicated to pottery production, where other features like clay pits or postholes were also evident. The simultaneous use of these features can be hypothesized.

As the La Tène period concluded and the Gallic colonies experienced the potent influence of Roman culture and economics, new technologies emerged, accompanied by fresh production demands such as *terra sigillata* (Duhamel 1979, 63–64). Duhamel's narrative described an economic evolution that unfolded linearly, commencing with a tribal, household-based system. Through the Iron Age, this system underwent a profound transformation with the introduction of specialization, culminating in the Roman period's serial and industrial production, which has endured to the present day.

In a section of his 1979 publication, Duhamel briefly traversed the entirety of pottery firing history, ranging from 'primitive methods' to the refined Roman kilns (Duhamel 1979, 53, fig. 4). Despite his groundbreaking work on firing structures, which introduced the concept of functionality for the first time, his perspective retains a classicistic tone, emblematic of the era. This view characterizes the Roman period as the pinnacle of technological evolution. In conclusion, his work aimed for immediate comprehension and a logical description of firing structures.

Renowned for the manual she published in 1987, **Ninina Cuomo di Caprio** made her appearance in the debate with a first presentation in 1972 (Cuomo di Caprio 1972), where she threw a set of criteria further developed into a morphological typology of Italian firing devices (Cuomo di Caprio 1987). She defined kilns as fixed firing structures, enclosed or delimitated, with a clear separation between the fuel and the pots. Whatever was used to fire the pots which

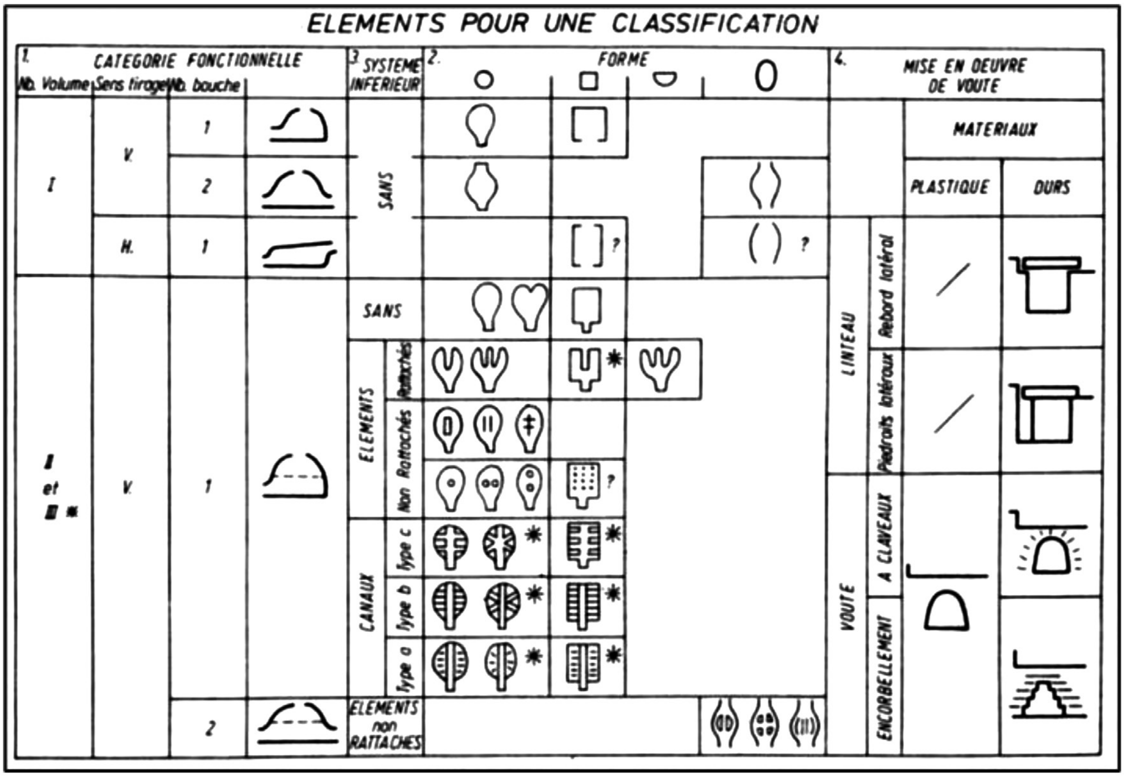

Fig. 1: Elements for a possible classification of kilns. Duhamel 1979, 73, fig. 43.

cannot conform to a kiln, was considered a primitive solution and therefore overlooked. Kilns, on the contrary, can be seen as the peak of the evolution of firing technology and therefore as a symbol of a growing economic system that ended up in industrialization and in serial production. In her book, she did not focus on one specific geographic area or chronological period, but she drew a typology based on the publications of Italian archaeological contexts. She divided the kilns into two main categories, determined by the flow of the air draft: vertical kilns (updraft) and horizontal kilns, in which the air follows a circular and horizontal movement (Cuomo di Caprio 2007, 508–509, 545–546; Cuomo di Caprio 2017, 346–347). She made a further distinction between direct and indirect flames. The direct flames characterize every kiln in which the heat is transmitted from the burning fuel to the pots through heat circulation; in an indirect flames kiln, the heat is irradiated through adjunctive features, mainly tubes, that are piled all over the chamber or run just in some part of it, like the ceiling of the dome. This specific type of kiln is late and most widespread in Roman Gaul (Cuomo di Caprio 2007, 519; Cuomo di Caprio 2017, 360; Dufay 1996; Duhamel 1979, 63–71; Duhamel 1973 and for tiles see Le Ny 1988). The main components of kilns for Cuomo di Caprio were the combustion chamber, the corridor for the air passage (stoking channel), and the cooking chamber, where the firing of the pots takes place (Cuomo di Caprio 2007, 512; Cuomo di Caprio 2017, 353–358). She added to these structural elements also the perforated floor and its support, which can be a pillar, a pot, or a system of columns and arches. Cuomo di Caprio exposed also other important parameters, even though secondary, that may be considered in kiln studies: the position, shape, and dimensions of the kiln, the presence or absence of the perimeter walls, the dimensions of the mouth and the corridor (Cuomo di Caprio 2007, 512–516; Cuomo di Caprio 2017, 349–351). The most problematic element to define is – for obvious reasons – the dome, which can be stable or removable. The removable dome is temporary, and it is removed after the end of each firing. This solution entails negative side effects, such as lower thermal efficiency, heat loss, and increased risk of cracking. On the contrary, the stable dome ensures higher insulation, preventing the dissipation of heat (Cuomo di Caprio 2007, 516–521; Cuomo di Caprio 2017, 357–358).

The work of Cuomo di Caprio was received and largely used by the majority of Italian archaeologists and even abroad. The strength of her research lies in the typology she proposed, which is primarily based on the perforated floor. This overemphasized consideration given to a technological feature appears to be critical, due to an excessive focus on form rather than actual function.

The approach of Cuomo di Caprio suffered from a classicistic perspective; she, in fact, assumed that there is an evolutionary progress, from a primitive form of production to an industrialized Roman society. Her approach suffers from a dichotomic tendency, in which pyro-technology can be split between primitivism versus technological sophistication (Iaia 2009, 55–56). In addition to that, even though the intention was to present a complete analysis of the Italian kilns, the typology did not give enough space and a proper approach to the evidence from the pre-Roman periods, even though there are many and diversified firing solutions, each of which requires a detailed analysis rather than a trivialization justified by the difficulty in reading the archaeological evidence.

While Cuomo di Caprio was working on the typology, in England, **Vivien Swan** was publishing her work on Romano British kilns. In her groundbreaking 1984 publication, preceded by pioneering studies conducted by authors such as Pitt-Rivers (Swan 1984, 1), Grimes (1930), and Corder (1957) Swan compiled a trove of information on pottery kilns and workshop sites scattered across England, Scotland, and Wales. She posited that kilns bear inherent significance, shedding light on diverse facets of the economy, social structures, and technological history of ancient societies.

Swan's seminal contribution lies in her keen focus on the physical attributes of the environment. She regarded comprehension of natural resources as fundamental for analysing kilns. The position of a workshop, and by extension, a kiln, was influenced by specific prerequisites that must be met. Clay and water sources play a pivotal role in determining the kiln and workshop locations (Swan 1984, 3–6). Furthermore, the availability of fuel, particularly significant in damp regions like Great Britain, dictated that wood had to be completely dried and processed before use (Swan 1984, 6–7). The energy expended in managing fuel, economic considerations, and even the socio-political realm – marked by markets, which necessitated roads and trade routes – must all be factored in (Swan 1984, 8). This point sparks intriguing reflections about the changes brought by the Roman conquest of the island. The Roman army was the primary consumer of pottery, resulting in a sudden surge in demand for such products post the year 43 CE. This led to the establishment of pottery workshops in areas easily accessible to both local markets and the military. These workshops were situated at crossroads, serving as pivotal points in the complex web of interactions between local communities and the Romans.

Swan identified nine fundamental components of kilns (Swan 1984, 29–32). The stoke hole or stoke pit, is a cavity dug into the ground for fuel feeding. The distinction lies in the depth of the cavity; the stoke hole is excavated at ground level and is broader than it is deep. The second major component is the fuel (or fire) tunnel, a corridor connecting the stoke hole to the cooking chamber. This component, alongside the raised oven floor, is the most fragile and is typically reconstructed after each firing. The combustion chamber, where firing occurs, allows hot air to ascend, thus endowing the kiln with an 'updraft' quality. The support, whether temporary or permanent, protrudes to sustain the raised oven floor, which can be either perforated or ledge-shaped. This element comprises removable, portable components and is crucial for hot air circulation in the oven chamber where pots are stacked. The oven chamber is enclosed by a superstructure – usually a freestanding dome – that might be permanent or temporary. This dome features vent holes and a capping or topping, often a provisional cover facilitating pot loading and extraction. Kilns can either be built above the ground (surface-built kilns) or dug into it (sunken kilns) (Swan 1984, 30–31). In her exposition of these constitutive parts, Swan underscored several vital considerations. The paucity of evidence poses challenges in comprehending kilns, necessitating a reliance on reconstruction hypotheses. When dissecting kiln design, Swan delved beyond mere morphological delineation to unravel the functional significance underlying diverse shapes and factors that influence them. Elements such as local traditions, practices adopted by Roman soldiers, technological needs for specific vessel types, and fuel type all impact the selection of particular kiln shapes (Swan 1984, 35–36). According to Swan, squeezing the structures into a rigid typology is unwise (Swan 1984, 32); instead, she advocated describing them by understanding their functionality within the environmental context. To this end, she categorized kilns based on construction techniques and operational series. Particularly important is the distinction between surface-built and sunken kilns. Furthermore, she detailed the primary support types for oven floors, ranging from single free-standing pedestals to intricate support systems like cross-walls. Swan also classified oven floors as bars or perforated plaques (Swan 1984, 30–32). Swan's work did not conclude with a typological classification; she proceeded to explore kilns in their locations, region by region. She also described the array of tools typically associated with pyro-technological activities, such as pot spacers, tools for clay extraction, and querns (Swan 1984, 49–50). Swan's work remains one of the most captivating and holistic. She scrutinized kilns through a wide lens, encompassing socio-political factors and integrating them within a comprehensive landscape approach.

SAME PROBLEMS, DIFFERENT SOLUTIONS

In the last 40 years, many other influential voices have taken part in the discussion. Some scholars insisted on a typology, by creating new models or adjusting and recodifying the existing ones. Generally, what clearly emerged from the manuals proposing the topic of pyro-technology is that there is a plain repetition of the same knowledge, by proposing information that has never been verified through experimental activities (Vidale 2007). By looking at the previous body of studies, Cristiano Iaia recognized two main trends among the first scholars. The first tendency is 'optimistic' (Iaia 2009, 55), meaning that the archaeological traces of firing activities are categorized in typologies without deeply questioning the quality of the data (see also Nijboer 1998). In this regard, it is easy to describe the evidence provided by the kilns in a superficial and generalizing way. The other tendency, which is at the opposite pole, is defined as sceptical, due to the constant doubting perspective while approaching archaeological evidence. More specifically scholars, for example Cuomo di Caprio, categorized firing evidence that does not exactly conform to the definition of a kiln as primitive solutions of pottery firing and therefore not worthy of thorough consideration. Consequently, many scholars followed this trend, without critically reflecting on what they were effectively proposing. However, there are scholars who focused more on the technological issues, by correctly individuating the core problems related to the technology of firing (Gosselain – Livingstone Smith 2005; Livingstone Smith 2001; Gosselain 1992; Rice 1987). Some of the later works that followed reset the problems and find solutions (Roux 2019; Iaia 2009), through the application of archaeometric analyses and social theories. These fresh approaches, enriched by data coming from experimental archaeology, allow a new number of archaeologists to observe the firing structures from another perspective. Inspired by the necessity to say more regarding the firing activities, these new authors revisited the concept of kiln and typology, taking the study a step forward.

A young voice in the Italian panorama is that of **Agostino Sotgia** (Sotgia 2019a; 2019b). His study developed around the collection of all firing devices of Italy, dating between the Bronze Age and the Iron Age,[4] by conducting a systematic survey of kiln structures, with an emphasis on craft areas. The background of his work must be seen in the attempt to tidy up the evidence on Italian kilns made by Cristiano Iaia a few years earlier (Iaia 2009). Sotgia highlighted the common features, similarities and dissimilarities that characterize production sites of the peninsula. His work is not just a collection of data, since he reconsidered the issues related to firing and faced the problems of old typological approaches. According to Sotgia's perspective, the more complex a firing device is, the more specialized the production can be. This idea, nonetheless, is presented only through technological reference, free from any evolutionistic vision, such as those of Cuomo di Caprio and Duhamel. In this regard, the ethnographical and experimental experience that the author conducted in Southern Italy, at Trebisacce (prov. Cosenza, Calabria), is a big help. The archaeological evidence can be divided into three groups: according to the presence/absence of structures; according to the relationship between fuel and pots inside the kiln; and lastly according to the kilns' morphology. In his typology (after Iaia 2009; Negroni Catacchio 1995; Jones *et al.* 2014; Roux 2019) Sotgia distinguished the kilns on a structural basis and also included the first firing strategies, such as the open firings. He identified five types, which can present an array of variations. He premised that this division needs to be a guiding line, an instrument to approach the study of kilns and not a limitation. As for the kilns, Sotgia underlined also for the production areas how impossible and even unwise it is to classify them with strictness. It is more useful to describe each situation and context since there are many differences that characterize a pottery production site or a workshop. The main attributes that indicate the activity of pottery making are not just kilns, but also basins, tanks for clay decantation, channels for the water management, and pole holes for coverage. However, it is almost impossible to find all of them at once, at least in the Italian scenario of the prehistoric and proto-historic archaeological excavations. In conclusion, Sotgia reckons that the oldest ways of firing clay, such as open firings, are not doomed to disappear as the evolutionary perspective would claim (Sotgia 2019b, 314–315; Sotgia 2019a, 62–63). In fact, although some solutions are more favourable in terms of effort and outputs, it is common to find open firings alongside more complex and recent solutions (Sillar 2000), by confirming the idea that technology cannot be perceived just as a determined set of progresses, but more like a continuous rethinking of choices.

After making her initial appearance into the kiln-related studies in the early 2000s (Hasaki 2002), **Elena Hasaki** recently authored a book that centres on the pinakes of Penteskouphia, a prominent production area in Corinth (Hasaki 2021). This region is recognized as one of the scarce iconographic sources portraying ancient pottery kilns at our disposal. Her work extends beyond a mere catalogue of the *pinakes*. She provided a thorough overview of the pottery workshops in ancient Corinth, gathering information from different methodological approaches, such as iconography, archaeology, ethnography, and archaeological experiments.[5] Iconography is particularly helpful for the reconstruction of the kilns, especially regarding the upper part (dome), almost never found in the archaeological records. Hasaki proposed

4 He defines the Bronze Age as the time span between the 2200 BCE and 950 BCE, and he considers the Iron Age according to the traditional Italian chronology, which encompasses the Iron Age between the 950 BCE and the arrival of the first Greek colonizers (ca. 750 BCE) and then it continues into the orientalising and archaic period (725–500 BCE). Although the declared chronological horizon, the study sees a preference for the Bronze Age sites at the expense of the Iron Age ones.

5 She refers mostly to the Tucson Greek kiln project. See https://aiatucson.arizona.edu/greek-kiln-project.

a typology based on the combustion chamber shapes and the type of supports of the perforated floor, following Cuomo di Caprio and adding more types. She distinguished two main groups of kilns based on the shape that can be circular and rectangular, subsequently divided according to the type of support for the perforated floor. Most of the ancient Greek kilns are two-chambered, and of the up-draft and direct flame kind (Hasaki 2021, 247–249).

Describing the kilns, she identified seven major structural elements (listed from the bottom upwards): The stoking channel is the first feature we encounter, also known in the literature as the firebox[6] (Livingstone Smith 2001, 993; Gosselain 1992, 245, tab. 1; Rice 1987, 166–167). The stoking channel is a protruded part in which the fuel is loaded (Hasaki 2021, 252). It fulfils moreover the function of air corridor. It is strategic for the air draft. The stoking channel is generally made of clay, mortar, and stones. Its length varies between a few centimetres and one meter (Matson 1972, 218) and it influences the air draft. In some cases, the large Roman rectangular kilns can present even two stoking channels (Hasaki 2021, 254). It is also common to find, in the archaeological contexts, a sort of hollow in front of the entrance of the stoking channel, where the ashes were collected, called a stoking pit (Hasaki 2021, 254). In some cases, it can serve two different kilns at the same time (Hasaki 2021, 254; Despoini 1982).[7] In my opinion, this is just the evidence left by the burning of the fuel and it is difficult to distinguish from the entrance of the stoking channel. Thus, the stoking pit may be just an overcomplication of an already clear feature. At the end of the stoking channel stands the combustion chamber (Hasaki 2021, 255), which is the most often preserved part of the kilns in archaeological contexts. The shape is mostly circular, with many variations such as elliptical or ovoidal, and even some rectangular examples. In most cases, the chamber is dug into the ground. If not dug, the combustion chamber is built on the ground level; in this case it is frequent to find different constructions in the surroundings, such as a podium or a stone fence. These built-around structures both support and increase the insulation of the kiln. Usually, the combustion chamber is slightly smaller than the pot-firing chamber, which is installed above it, their size ratio being generally calculated at 1:1.5 (Voyatzoglou 1974). Between the two chambers, it is common to find the perforated floor and its support. Regarding this last element, it is usually made of clay, stones or mortar and it can have different shapes and be built in many ways, which partially determined the typological subdivision (Hasaki 2021, 256). Even for Hasaki, the intermediate perforated floor[8] is presented as the most crucial part of a kiln. If in the shape of a clay disk, the thickness of this feature is around 10 to 20 cm, and the holes can have a diameter between 3–10 cm. The total number of the holes is around 30–50, covering about 30–50 % of the surface. The first examples of this crucial feature trace back to the Middle and Late Bronze Age, both for the mainland and Crete (Hadjimichael-Skorda 1989, 205–206; Catling 1980, 153–157; Touchais 1981, 794; Keramopoulos 1909, 61; Davaras 1973a, 80; Davaras 1980, 124; Hadji-Vallianou 1997, 497). On the perforated floor lies the pottery, ready to be cooked in the pot-firing chamber (Hasaki 2021, 260). The shape of this upper chamber (like that of the lower one) can be either circular or rectangular. The chamber itself is closed by a dome that usually has a chimney on the top (or other vent holes) to increase the power of the draft. The dome can be temporary or permanent, as the ethnographic evidence also confirms (Hasaki

6 Roux (2019, 116) is referring to it as an area for loading the fuel, and she labels the combustion chamber as 'firebox'. Once again, the confusion and the arbitrary use of the terminology is obvious.

7 Hasaki 2019, 254, footnote 83. The note presents some critical points. Regarding the examples of stoke pits outside of Greece, she mentioned the case of Marzabotto, by referring to the publication of Nijboer 1998, where there is no specific mention of a stoke pit.

8 Called here by the Greek term *ἐσΧάρ*, which originally refers to the grill used on the altar during the sacrifices (Hasaki 2021, 256; Ekroth 2002, 23–59; Ekroth 2001).

2021, 261; Hampe – Winter 1962, pl. 18 and 45; Blitzer 1990, 695–698; Giannopoulou 2010, 93–94, 138–140; London 1989a, 225, 227; London 2000, 107). In the first case the dome needs to be rebuilt after each firing and in most of the cases it is constructed after the loading of pottery; this method allows one to adjust the dimensions of the dome to the size of the pots (London 2000, 107). If the dome is permanent, it is frequent to have a loading door, beside the upper vent hole. The door can be paired with a smaller opening called a spy hole (testified by iconography) that lets the potter inspect the pot-firing chamber to check the firing. The advantages of this solution are a more insulated chamber and the possibility to reach higher temperatures. Concerning the chimney, cylindrical vases are frequently used for this purpose.

Besides a renewed and simplified typology that integrated the work of Cuomo di Caprio with the vocabulary of Swan, the upside of this work is the collection of all the iconographical data discussed in light of ethno-archaeological observations and bibliographical comparisons. The most fascinating aspect lies in the knowledge acquired through the iconographical studies. If on the one hand we must be careful when trying to find an iconographical match with the archaeological evidence, on the other hand it is fascinating to see for its representation of both the technology and its 'technician'. The depictions on the *pinakes* show not just the kilns, but also tools, such as harpoons and ladders used by the potters to master the firing. In fact, these images offer us the possibility to consider aspects related not only to a technological device, but also and especially to a technology 'in action'.

From the beginning of the 2000s, in the wake of archaeometry and experimental archaeology, **Richard Thér** has proposed a different approach to study the firing technologies. In his works (Thér 2014; 2004) and in cooperation with Miloš Gregor and Tomáš Mangel (Thér – Mangel – Gregor 2014; 2015; Mangel – Thér 2018; Thèr – Mangel 2011; 2014) the interest regarding the function of firing structures prevailed over the classic and outdated

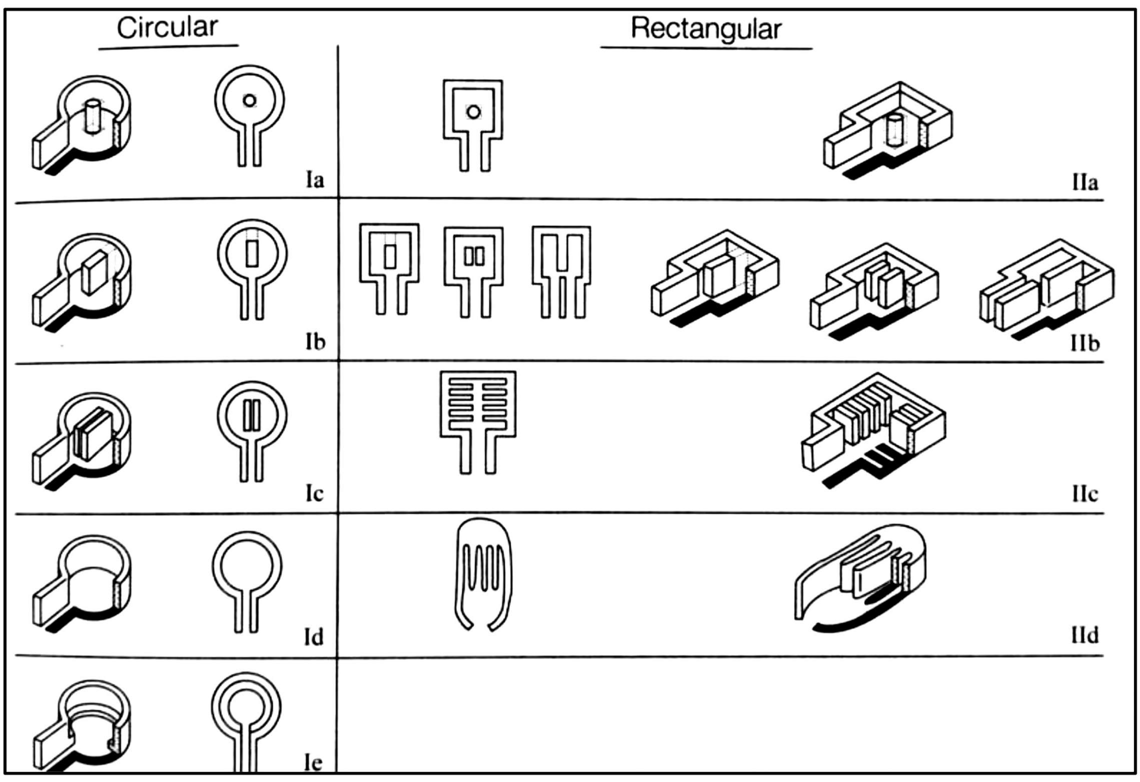

Fig. 2: Typology of kilns. Hasaki 2019, 247, fig. 6.19 (after Cuomo di Caprio 2007).

idea of shapes as the only feature that can give us information. The interpretation of firing procedures is never easy, especially because simple types of firing structures do not survive in archaeological contexts. It is likely work with evidence left by the fixed or semi-fixed structures, although it is not enough to understand the firing procedures. To overcome this issue, a possible solution is to analyse the pottery attributes through the traces left by the firing (Rasmussen *et al.* 2012; Tite 2008; Livingstone Smith 2001; Gosselain 1992). Thus, the merit of Thér's approach is to draw attention to the product itself: it is the thermal profile of pots that helps us understand the firing technology that was implemented. There are five parameters through which the thermal profile is studied: the maximum temperature, the soaking time, the heating rate, the duration of the fire, and the thermal homogeneity. These are the premises for Thér's experiments (Thér 2014, 83–90; Thér 2004). Only equipped with the data coming from the experimental phase, Thér proceeded to make a basic classification of the firing devices. His first typology proposal was published in 2004 (Thér 2004) where he distinguished the criteria according to which it is possible to read firing devices (Thér 2004, 36–41). In his following work, he condensed the various criteria to the essential trait, to build a typology on the degree of insulation and the number of spaces, namely the separation between the fuels and the pots (Thér 2014, 80).[9] In one space structures there is direct contact between fuel and pots and in two spaces there is a separation, obtained through different solutions, among which the perforated floor is just one. In between these two structure types, there are several transitional forms, mainly single-chamber kilns with an open-top superstructure. Regarding the terminology, he refers to Duhamel (1979, 52) and Swan (1984, 29), trying to choose non-interpretative terms, that are as descriptive as possible. So far, there are five main types of firing solutions, and all of them can be related to finds from Central Europe (Czech Republic and Slovakia mainly). The first type is represented by bonfires, comprehending all possible variations. The variety is dictated by the degree of insulation that goes from none, light, temporary to permanent. The second category is made by the clamp firings. A clamp kiln is a temporary structure, and it is very difficult to recognize and distinguish it from the traces left in the archaeological record (Thèr 2004, 45). The single-chamber kilns with open-top superstructures represent the third group and they could have been used also as ovens (updraft or downdraft) or as updraft kilns without a combustion chamber (Thèr 2014, 80). The fourth and fifth groups are made by the two-chamber kilns. These structures are all updraft, in which all the three stages of firing happen: preheating, heating, and cooling (Thér 2014, 80). They are distinguished, and therefore divided, according to the absence (group 4) or presence (group 5) of the perforated floor. What comes up from the experimental analysis of all the categories is that there is not always a clear correlation between the thermal characteristics of the pottery and specific firing procedures (Thér 2014, 79; Livingstone Smith 2001). Nonetheless, there is fruitful information such as the fuel consumption of the two-space kilns, which is significant, and it can go from 110–140 kg in small two-chamber kilns to about 170–200 kg for bigger ones (Thér 2014, 88). Moreover, the comparisons between thermal profiles proved that maximum temperatures are not enough to identify the type of structure,[10] in contrast to what other authors proposed (Cuomo di Caprio 2007, 507). The temperatures, even in the kilns, depend on the ability of the potters and their intentions. In addition, the maximum temperatures can be influenced, in open firings and in kilns, by the type and quality of the fuel and the fuel/

9 Already in Rye 1981, 96; Rice 1987, 153–162; Sinopoli 1991, 31–33; Orton *et al.* 1993, 127; Gosselain – Livingstone Smith 1995, 153–155; Kingery 1997; Livingstone Smith 2001, 993.

10 This is valid up to a temperature of 1050 °C, which implies the presence of a two-space kiln. Thèr 2004, 90.

pottery ratio (Mangel – Thér – Gregor 2015, fig. 16). What is true is that during a bonfire the possibilities to control the maximum temperatures are limited. The heating rate is the parameter that can indicate more clearly the kind of structures in use, differentiating between structures with a high and low degree of insulation (Thér 2014, 91–92). The structures which present a high variability are the single-chamber kiln, since the firings are like the ones in kilns but with a heating rate value comparable to the ones in bonfires (Thér 2014, 92). The soaking time data presents differences between open firings and heavy insulated procedures

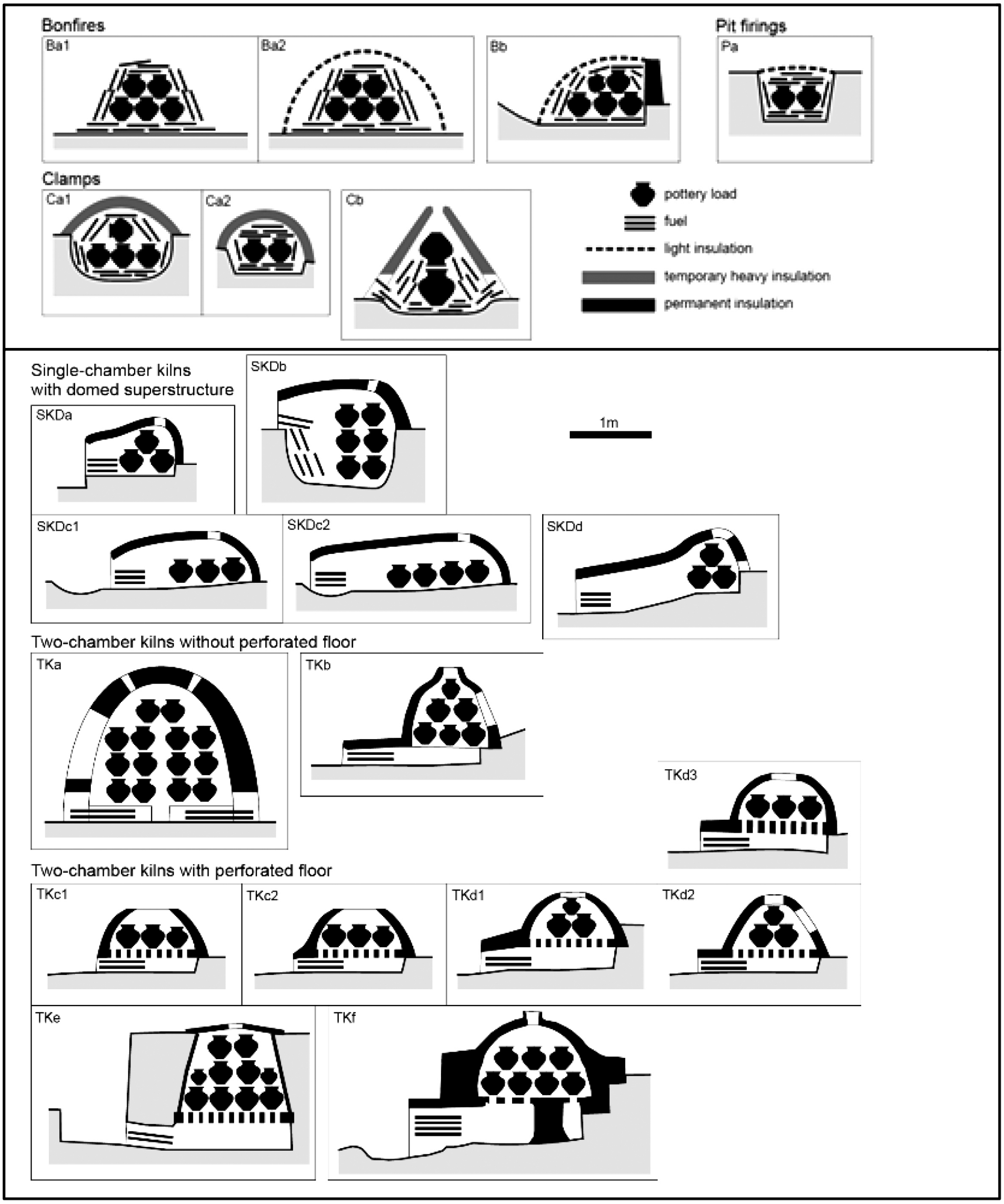

Fig. 3: Kilns typology. Thér 2014, 81.

(clamps and kilns). This parameter can reflect, in fact, the last phase of the firing, whether it was abruptly interrupted or not (Thèr 2014, 92, fig. 5). In conclusion, what is clear is that some kinds of firing are more flexible than others, thus some types of structures have only a few firing procedures compared to other ones. In this regard, structures such as bonfires and clamps allow a wider range of firing procedures compared to two-chamber kilns with a perforated floor, where the potter is limited in their choices.

DISCUSSION AND CONCLUSIONS

So far, the main trends in methodology can be summarized in the classical approach, interpreted by Cuomo di Caprio and Hasaki in contrast to a more analytical one represented by the works of Sotgia and Thèr. In between can be placed the works of Duhamel and Swan, which had an opening towards issues such as the functionality and the landscape approach. However, it is evident that the description of the firing structures is characterized by an overabundance of terms that refer to the same structural elements. Every author uses a specific and variegated vocabulary, by creating – on many occasions – confusion and misleading interpretations. The same goes for the typologies. Despite the different positions held by the scholars, from now on the kilns are going to be defined as follows. The main features to identify a kiln are the separation between the fuel and the pots, a good degree of insulation, and the existence of an air draft. Then, they may present variations regarding the type of dome, the number of chimneys and the building material of which they are made. Moreover, kilns could be furnished with movable/portable material (Hasaki 2011). The most common is the perforated floor. Early examples of this feature were found scattered all over Europe, tracing back to the Middle--Late Bronze Age.[11] It was largely adopted during the Iron Age, where its implementation grew significantly throughout all Europe. Nevertheless, it is not a mandatory feature of the kilns, for it is not the only solution to obtain a separation between the pots and the fuel.[12] The traces of perforated floors in the archaeological record may suggest the presence of a kiln, but they are not enough to be a sure marker of a production site. In fact, these objects, if found alone, can rather suggest the presence of a cooking oven or a simple kitchen feature, such as a grate (Poole 2002; Gascó 2002). Unsurprisingly, it seems that the origin of this feature can be seen precisely in the cooking technology, to be only later adapted by the pottery firing structures. There are many solutions to put up the perforated floor, in fact, alongside it, it is common to find supports, mainly vessels, pillars or more complex sustain systems. In many cases, the support is built as a structural part of the kiln itself, in the shape of a tongue or a fork (Hasaki 2019, 256; Cuomo di Caprio 2007, 524; Duhamel 1979, 73). In some others, the perforated floor can simply rest on an inner step created by the excavation of the combustion chamber (type Ie in Hasaki 2019; Thér 2014, 81), other solutions include arches and corridors. Among the movable objects of the kilns, are the spacers. This class of materials has been recently considered by many scholars, who created apposite typologies, sometimes increasing confusion about the terminology and function of these objects. Spacers are clay-made objects used to pile the pots in the cooking chamber, preventing them from sticking one to another. In this way, the heat could homogeneously circulate into the chamber, and the capacity of the volume of the

11 In Greece (islands and mainland) it is attested quite early (Hasaki 2019) as well as in Italy (Iaia 2009). In France first evidence starts from the Late Bronze Age; the perforated floor became diffused at the beginning of the Iron Age (Duhamel 1979).

12 This is why an approach that prefers the perforated floor sustain morphology is rather limited.

chamber itself could be fully exploited. These objects are widespread all over the Mediterranean and Europe (Hasaki 2021, 263–264; Fusi 2017; Zamboni – Buoite 2017; Zamboni 2016; Cuomo di Caprio 2007, 527–532; Cracolici 2003; Papadopoulos 1992; Patitucci Uggeri 1988; Swan 1984, 38–41) and they can present different shapes, dimensions and manufacture.

It is indispensable to provide a clarification of the terminology.[13] Here below, there is a proposition of unified terms corresponding to the many different terms commonly found in the literature.[14] Every term aims not to raise ambiguities. It has been decided to use terms coming from different authors, so long as they are clear and auto descriptive at the most. The table is accompanied by a drawing showing what the terms refer to.

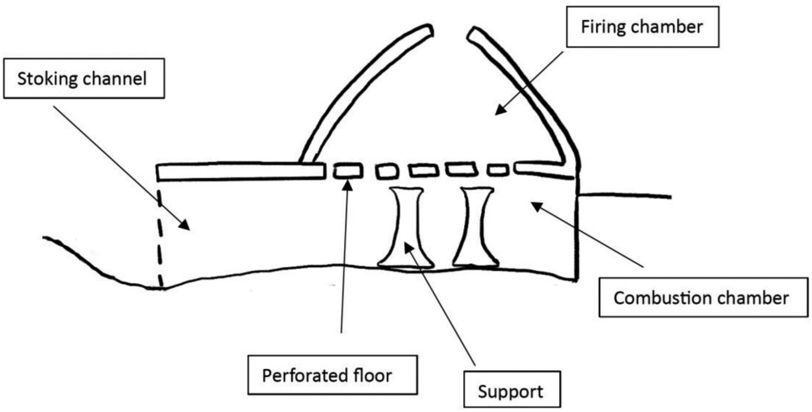

Fig. 4: A kiln section (by the author)

Tab. 1: Terms of the constitutive parts of a kiln.

Actual term	*Description*	*Other terms in literature*
stoking channel (Hasaki 2021)	It is a corridor, or a series of corridors, of various lengths (from a few centimetres up to 1 meter) fundamental to creating the air draft. The fuel is usually put at the entrance of the corridor. The fuel can be pushed forward in the channel as well as the ashes can be accumulated in a small cavity dug at the mouth of the channel itself. In some cases, it may coincide with the combustion chamber itself.	-**flue** (Swan 1984) -**firing tunnel** (Swan 1984) -**exterior conduct** (Duhamel 1979) -**firebox** (Thér 2014; Livingstone Smith 2001; Gosselain 1992; Rice 1987) -**mouth** (Rice 1987) -**praefurnio** (Cuomo di Caprio 1985; 2007)
firebox	Term covering the combination of stoking channel and combustion chamber.	
combustion chamber (Roux 2019; Swan 1984)	It is the space into which heat flows and increases the firing dynamics. It can be also in single chamber kilns	-**lower chamber** (Duhamel 1979) -**furnace chamber** (Swan 1984) -**firebox** (Thér 2014; Rice 1987)
firing chamber (after Roux 2019)	It is the space where the pots are placed (piled or tidily disposed) and in which, through the heat, they are cooked. It is covered by a dome or an open topped superstructure.	-**oven** (Swan 1984) -**ware chamber** (Rice 1987) -**upper chamber** (Duhamel 1979) -**cooking chamber** (Cuomo di Caprio 2007) -**pot-firing chamber** (Hasaki 2021)

13 An important work in this regard has already been carried out by Mangel and Thér (2018, 46).
14 The literature is vast, and it may be possible to find other terminologies. Here are listed only the terms found in the primary bibliography, mainly the most organic works regarding the kilns.

Tab. 2: Terms of the mobile features of a kiln.

Actual term	*Description*	*Other terms in literature*
perforated floor (Hasaki 2019; Thér 2019)	It is a clay-made plaque, pierced by holes (the number can vary as well as the dimension and the thickness). The shape can be rectangular or circular. It can also be made by radial bars (Swan 1984, 31)	-**raised oven floor** (Swan 1984) -**intermediate clay floor** (Hasaki 2016) -**diaphragm** (Sotgia 2019; Iaia 2009) -**mid-height partition** (Roux 2019)
support (Hasaki 2019)	It is the element on which the perforated floor leans, and it may be obtained through different solutions. The support can be a cylindrical vase, a pillar, a more complicated net of arms and sustains, like inner walls or a net of arches.	-**sustain** (Cuomo di Caprio 2007)
spacers (Fusi 2017)	Clay-made objects, with different shapes and dimensions, used to correctly pile the pots into the cooking chamber, preventing stacking.	-**supports** (Papadopuoulos 1992; Hasaki 2019) -**distant pads** (Swan 1984) -**stilts** (Swan 1984)

Regarding the kilns, there are two main schools of thought among scholars: the recent approach of Thér and Sotgia that consider the transitional forms interesting and equally valid solutions that can also be defined as kilns. On the opposite front, there are more traditional studies (i.e. Hasaki 2021; Cuomo di Caprio 1985; 2007) according to which, the kilns are exclusively elaborated solutions, two-chambered and with perforated floors. The diversity of approach is reflected in the typologies they made. What appears clear from the literature review is that the morphology alone is insufficient. It is a handy tool, and it also reflects the formal characteristics that immediately stand out. On the other hand, dismissing the attention to shape in studying technology as a cultural phenomenon would be a mistake. The way things look is a visible expression that doesn't follow strict techno-economic rules. It provides useful insights into how ceramic producers communicate socially. So, examining both the functional and non-functional aspects together can give us a fuller understanding of how technology evolved.[15] Looking at the evidence and at the typologies, there are two main shapes of a kiln. This variation can be explained in different ways. Traditionally, the shape is related to the type of production (Cuomo di Caprio 1985; 2007) but many examples prove that not to be the case (i.e., Da Vela 2022). The shape can represent some sort of building technique output, since a kiln needs to provide a certain degree of insulation (Thér 2014; 2004; Swan 1984); it may also be a response to a specific fuel (Swan 1984, 7). To have fewer angles means less heat dispersion, and that can motivate the predominance of the circular or oval shape over the rectangular one. Therefore, overall, we can say that the circular shape prevails with a certain long life due to its technological advantages, such as a good degree of insulation and less heat dispersion, an easiness to be built and to be maintained. A rectangular shape, on the other hand, may be a building output of a necessity for a bigger chamber, in combination with the heat flow. Some of the other determining aspects for the shape of the features of a kiln are therefore the dimension of the production, the available workforce, and the initial investment (Mannoni – Giannichedda 2003). But pottery production is not the only subject that involves these discussions. The same kind of approach was taken further by Pelet, already

15 For a thorough discussion about the functional aspects of the main components of kilns see Mangel – Thér 2018, chapter 5.

Tab. 3: Typological correspondences (light grey: open firings; middle grey: transitional solutions; dark grey: kilns. After Thér 2014).

Description	Thér 2014, 81	Hasaki 2021, 247	Sotgia 2019, 306–311	Cuomo di Caprio 2007, 524	Swan 1984, 30	Duhamel 1979, 73
Pots are placed on a layer of fuel and covered with it. The fire is lit in a flat place, and it gets ignited on the lower parts of the heap.	**Ba**	**/**	**Tipo 1**	**Focolare all'aperto**	Surface clamp or **bonfire (i)**	**Cuisson en meule**
It is a semi-sunken solution, in which pots lie on the fuel and are covered with it, but on one side of the heap, there is permanent insulation.	**Bb**	**/**	**/**	**/**	**/**	**/**
Pots are placed on the bottom of a pit dug into the ground. They lie on a layer of fuel, and they are covered with it, also laterally. There is a light insulation.	**Pa**	**/**	**/**	**Pit kiln**	**/**	Cuisson en fosse
Pots are placed on a layer of fuel in a hollow dug into the ground. They are covered with the fuel, also laterally. There is temporary heavy insulation.	**Ca**	/	**/**	**Cottura a catasta**	Surface clamp or bonfire **(i)**	**Four simple à une chambre**
The hollow in the ground is less deep. The pots are piled on a layer of fuel, covered with it, by forming a sort of pyramid. There is a temporary insulation.	**Cb**	**/**	**Tipo 1**	/	**(i)**	**/**
It is a semi-sunken solution, in which the pots are placed on a layer of fuel and covered with it. Two sides of the cover, built above the level of the ground provide permanent insulation while the top provides light insulation.	**SKOa**	**/**	**Tipo2**	**/**	**/**	**Four simple à une chambre**
It recalls a pit-firing solution, since it is a cavity in the ground, but two sides, built above the level of the ground provide permanent insulation.	**SKOb**	**/**	**2**	**/**	**/**	**/**

Description	**Thér 2014, 81**	**Hasaki 2021, 247**	**Sotgia 2019, 306–311**	**Cuomo di Caprio 2007, 524**	**Swan 1984, 30**	**Duhamel 1979, 73**
The pots are placed adjacent to the fuel. The dimension is small.	**SKDa**	**/**	**/**	**/**	Single-chambered sunken kiln **(ii)**	**IV.1 sans**
The pots are piled in a cavity dug into the ground.	**SKDb**	**/**	**/**	**/**	**/**	**IV.1 sans**
It is similar to SKD but built completely above the ground level.	**SKDc**	**/**	**/**	**/**	**ii**	**IV.1/ IH.1 sans**
The stoking channel is longer, and the structure is built on a slope (natural or artificial).	**SKDd**	**/**	**/**	**/**	**ii**	**IV.2 sans**
The pots are piled on a step that separates them from the fuel. It is fully built upon the ground.	**tKa**	/	**/**	/	**/**	**IV.1. sans**
The stoking channel and the combustion chamber are built sunken. The pots are placed on a step.	**TKb**	**Id**	**Tipo 3.1**	**/**	**/**	**IV.1. sans**
There is no stoking channel, and the combustion chamber is built sunken.	**TKc**	**Ie**	**Tipo 3.2**	**/**	Sunken kiln with permanent/ temporary superstructure **(iv-v)**	**IV.1 rattachés**
It has a longer stoking channel, and the cooking chamber is partially built under the ground level. It is slightly bigger, and the pots are piled.	**TKd1**	**Ie**	**3.2**	**/**	**iv-v**	**IV.1 rattachés**
Completely built in the ground. Pots are piled.	**tKe**	**/**	**Tipo 4**	**/**	**/**	**IV.1 rattachés**
Built using a slope, it has great insulation and big dimensions, and the perforated floor is sustained by a prop (usually a pillar). Pots are piled.	**TKf**	**Ia**	**3.2**	**Ia**	**/**	**IV.1 non rattachés**

in 1980, concerning the metallurgical furnaces (Pelet 1980). If attention was paid to the study of other forms of craftsmanship in antiquity, observing the mode of analysis of other specialists, we might have realised sooner that not only do we share the same underlying problems, but that many of these questions find effective solutions in the field of metallurgy, for example. In the case of furnaces for iron ore reduction, the shape is an indicator of technological and functional aspects (Mannoni – Giannichedda 2003, 178–180).

As previously stated, there are many typologies we may refer to in our studies of pottery kilns, therefore it seemed appropriate to present them in a synoptic table. Thér's set of variants was chosen as a main reference, since it is the most complete and most accurate and it includes also other firing solutions such as open firings and transitional structures. Moreover, Thér's work has been accompanied by a rich experimental activity, by acquiring a verifiable understanding of the kilns' functioning. For this reason, the description of each solution/kiln is made based on what emerged from Thér's study (Thér 2014). It has been chosen to present not all the experimented variants, but only the main types. Nevertheless, his typology is challenging due to its limited emphasis on shapes. For this reason, it is impossible to find comparisons for Cuomo di Caprio's types II, the rectangular-shaped kilns (Cuomo di Caprio 2017; 2007; 1985; Hasaki 2021). A similar limitation pertains to Swan's kiln type III, where both the dome and the perforated floor are classified as temporary. Additionally, comparing Sotgia's typology yields some difficulties as well. Despite concerted efforts, drawing parallels with Sotgia's type 5, described as a fixed kiln with built walls, remains elusive. This category could potentially be encompassed within the TKf type. In the case of Duhamel, his typology appears more akin to a combined table, acting as a precursor to the later, more streamlined work developed by Thér.

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Elena Paralovo
Institute of Classical Archaeology
Charles University, Faculty of arts
Celetná 20, CZ-11642, Praha 1
elena.paralovo01@gmail.com