

# Production and Consumption of Ceramics at Selinous: A Quantitative Approach

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## Introduction

This chapter presents new evidence from Selinous to shed light on the role of ceramic production in the economy of the Greek city-states in Classical times. At this Western Greek metropolis, we have found an efficiently organized system of mass production previously unknown in Greece. As I argue here, this is one of the few cases where we are on a more solid ground to calculate and compare production and consumption numbers of ceramic products.<sup>1</sup>

The term “ceramics” covers all products made of fired clay: (1) building materials, mainly roof tiles; (2) a wide range of objects of different sizes and functions: from the large (e.g., altars, louteria and sarcophagi), to the very small (loom-weights, lamps); (3) pots of various sizes, shapes and functions from large pithoi to cooking and table ware; and (4) figurines, mostly of small size and other decorative objects in terracotta.<sup>2</sup>

The main aim here is to provide a detailed account of ceramic production and consumption in Selinous. On the production side, how many workshops existed, and what was their annual output? How many workmen were involved in the ceramic industry? And on the consumption side, how many ceramics does a city require? How many households used how many ceramics? How many ceramic objects were used in sanctuaries? How many local ceramic products were given as grave goods in how many graves? How many ceramic products were used in other public spaces?

An examination of these issues allows us to draw some conclusions about the economic importance of the ceramic industry at Selinous, asking for example what percentage of the population earned its living from working in the ceramic industry. Can the numbers help us characterize the city’s economy in general: was it subsistence-based or export oriented?

While previous estimates of the production capacities of the Greek ceramic industry have been based largely on the output of painted Attic pottery, this is a particular case, significant mostly for Athens and not as relevant for the Greek polis economy in general as other ceramic products are.<sup>3</sup>

Many scholars, especially historians, doubt whether ceramics can be used at all for the reconstruction of ancient economies; as J.K. Davies recently stated: “And yet I have to be frank: from among the primary materials of all the specialist sub- disciplines of the *Altertumswissenschaften*, it is the ceramic material which I – and I suspect many others – find the hardest of all to use intelligently and constructively”.<sup>4</sup> Archaeologists, however, are mostly convinced of the opposite viewpoint, expressed as follows by G. Fülle: “If the field of ancient economy is a battlefield, arguments based on pottery research certainly belong with the best of the weapons.”<sup>5</sup> Even more skepticism exists –

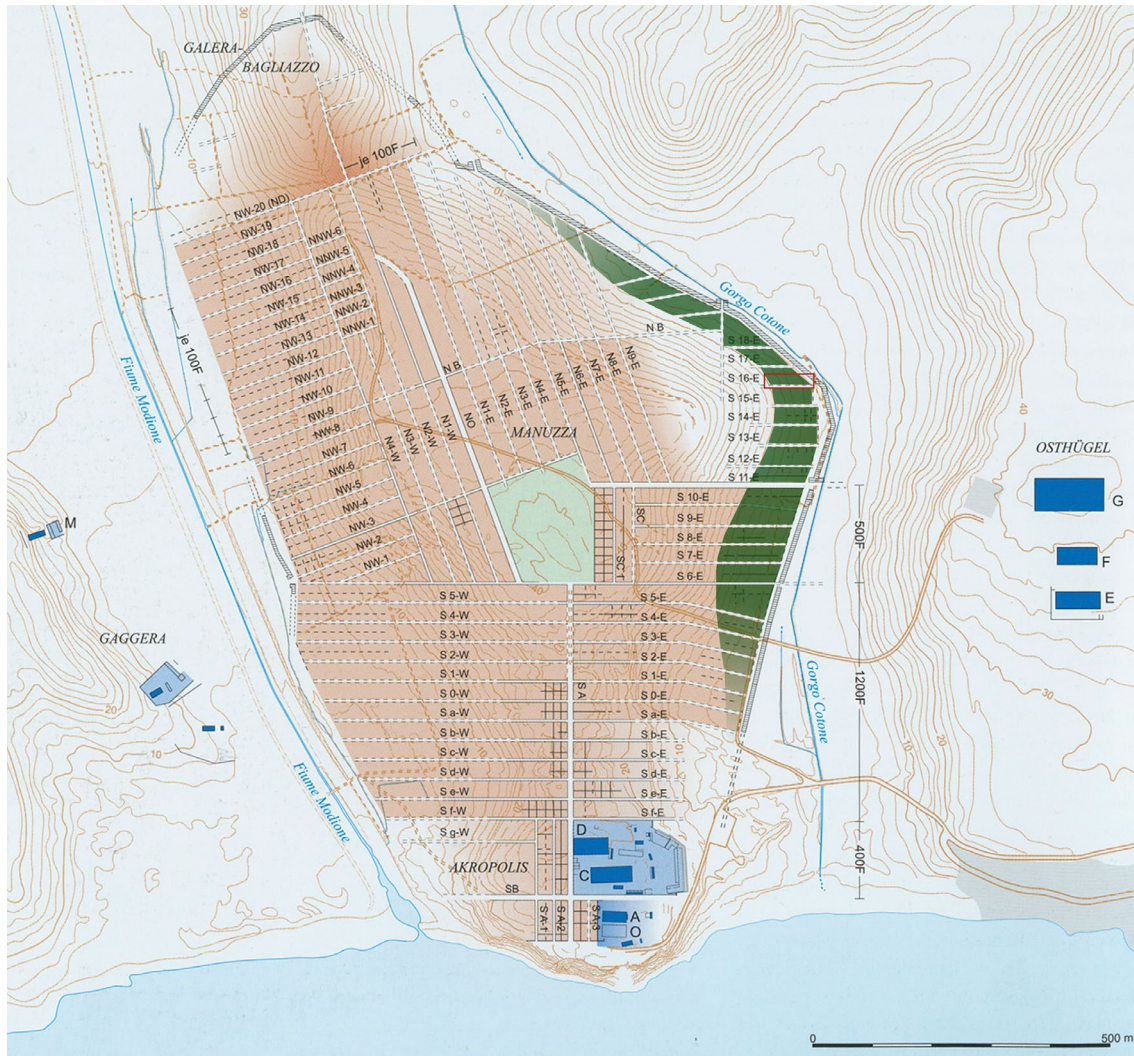


Fig. 1: Selinous with the potter's quarter (in green, to the right).

among archaeologists as well – concerning quantitative accounts: “to seek quantification is a pipe-dream”.<sup>6</sup> The numbers presented here can undoubtedly be criticized in many details and should not be taken as absolute. The general picture they outline, and the proportions they suggest, however, are founded on many observations in the field, not merely on assumptions.

### *Selinous*

Selinous was founded in 628 BC by its mother city, Megara Hyblaia and was destroyed by the Carthaginians in 409 BC. Thanks to geophysical prospection and studies by

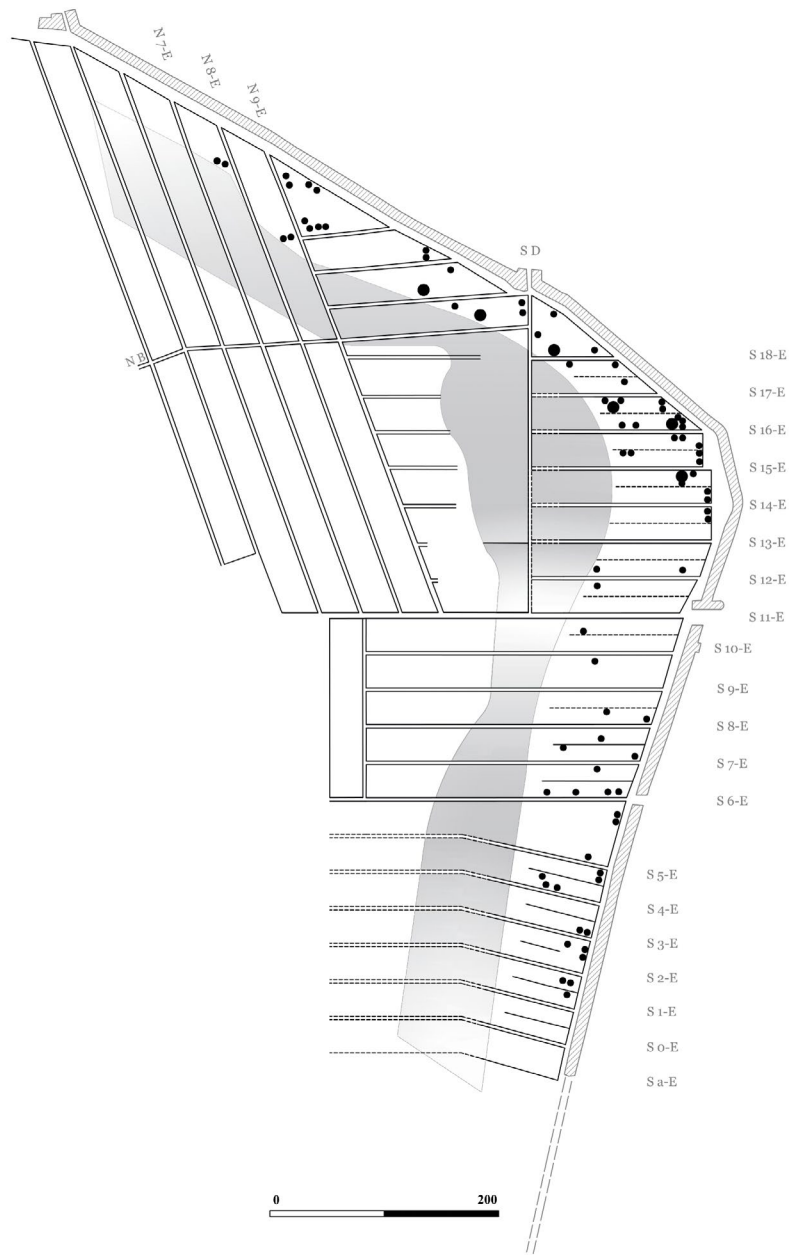


Fig. 2: Schematic plan of the potter's quarter.

Dieter Mertens,<sup>7</sup> we are able to reconstruct with a high degree of precision, the city map, including all streets, insulae, and houses (fig. 1).

Our understanding of the different functional parts of the town is well established: the sacred space with the central sanctuary on the acropolis with six temples; several extramural sanctuaries east and west of the city; the cemeteries bordering the town on the north and west; the agora, the political and economic city center; the residential areas; and

number of kilns	dimensions (diam.)	capacity single kiln	capacity all kilns
6	$\geq 5$ m	40 m <sup>3</sup>	240 m <sup>3</sup>
55	2–3 m	10 m <sup>3</sup>	550 m <sup>3</sup>
23	< 2 m	4 m <sup>3</sup>	92 m <sup>3</sup>
<b>84</b>			<b>882 m<sup>3</sup></b>

Fig. 3: Potter's quarter in Selinous, kilns and their capacities.

Ceramic-Types	Dimensions and Weights of Single Vases	no./m <sup>3</sup>	weight/m <sup>3</sup>
<b>Lekythoi, Aryballoi etc.</b>	diam. 5,5 × h 11 cm; 0,175 kg	1536	256 kg
<b>Bell krater</b>	diam. 30 × h 28 cm; 2,3 kg	36	128 kg
<b>Transport amphora</b>	diam. 35 × h 60 cm; 7,2 kg	12	86,4 kg
<b>Tile/stroter</b>	57 × 80 cm; 24 kg	50	1200 kg
<b>Tile/calyptr</b>	20 × 80 cm; 21 kg	100	2000 kg
<b>Pithos</b>	diam. 1,0 × h 90 cm	1	

Fig. 4: Dimensions and weights of different products.

the economic spaces, including the two ports located at the mouths of the two rivers and the potter's quarter in the east.

Geophysical prospection aided in the identification of an industrial zone or potter's quarter on the east edge of the city, inside the wall along the Cotone valley.<sup>8</sup> It is more than 1 km long and 84 kilns, clearly visible as black anomalies, can be identified, 55 of which are larger than 2 m in diameter. All of these kilns date to the 5<sup>th</sup> century, as kilns in Archaic levels would not be visible in the prospection,<sup>9</sup> and all went out of use when the city was destroyed in 409 BC. This potter's quarter is separated from the residential areas by a strip of undeveloped land. The schematic map reveals further details about its layout (fig. 2): the larger kilns (with a diameter of about 5 m) are located in the north, while the smaller ones are concentrated in the south, towards the port. There was obviously a purposeful topographic distribution of workshops for different products. Another striking aspect of the layout is the preference for pairs or clusters of kilns situated near each other; only rarely do we find single kilns.<sup>10</sup> This points to a high degree of efficiency in the production process, as these kilns were clearly used for continuous, cyclic firing; that is, when the first kiln was fired, the second was prepared and was fired when the first was emptied, and so on. Here we can recognize an optimized efficient division of labor with specialists handling each phase of the production process: a potter, for example, only working clay, and a kiln master only concerned with the firing.



annual consumption	Basis for calculation
<u>Houses:</u> – roof tiles etc. – equipment from big storage jars to lamps	– 2.500 houses in Selinous – parallels from Himera, Attica, Olynthos, Halieis
<u>Graves:</u> – grave goods – terracotta sarcophagi	ca. 5.000 graves from Tusa excavations 1963–1967, absolute no. of graves/year according to population
<u>Sanctuaries:</u> – buildings – votive offerings	e.g. Malophoros sanctuary with 7.000 terracottas, 4.850 lamps, 5.000 vases (18% local)
public buildings, infrastructure	

Fig. 5: Basis for the calculation of the consumption of ceramic products.

To illustrate the usefulness of the geophysics’ maps, we can compare observations based on the map against the results of excavations in one of the insulae where we found a workshop measuring about 1.200 m<sup>2</sup> built on four terraces.<sup>11</sup> The seven kilns, parts of which are well preserved, date to the 5<sup>th</sup> century. A wide range of products were made, or at least fired, here: the large circular kiln would have been used in the production of roof tiles, the rectangular kilns accommodated sarcophagi, pithoi, and louteria, while the smaller ones fired pots and table ware of different size and shape. This was a large workshop – one of the largest ever discovered – and it was designed for mass production: the big kiln alone (diam. 5.2 m) was able to fire up to 2.000 roof tiles at once. It is likely that about 18–20 men worked here (fig. 8).

In reality, the workshop was even more extensive, as the wall that limited the courtyard on the second level towards the north was pulled down in the early 5<sup>th</sup> century. This combined our workshop with the adjacent one creating a space of ca. 2.000 m<sup>2</sup> with a common central courtyard and at least six more kilns.<sup>12</sup>

### Calculation

#### Production

The evidence allows us to make some estimates relating to ceramic production and consumption at Selinous. We begin with the production numbers from the potter’s quarter. Altogether there are the 84 kilns of the 5<sup>th</sup> century: 6 with a diameter of at least 5 m, 55 of 2–3 m and 23 of 1–2 m. These should be viewed as minimum numbers as there may be smaller kilns that cannot be distinguished on the map from other structures. Given the diameter or length of the kilns it is possible to estimate their

	Pithoi	large (e.g., louteria, bathtubs)	medium (e.g., amphorae, bowls)	small (table- ware)	very small (e.g., loom-weights, lamps)	Terracotta figurines
<b>Dema</b>	5	2	29	53	6	1
<b>Vari</b>	2	27 (beehive)	40	81	2+x	
<b>Halieis 7</b>	1		56	202	11	
<b>Halieis A</b>	3		15	95	7	
<b>Halieis C</b>	3	1	27	101		
<b>Halieis D</b>	7		26	100		
<b>Halieis E</b>	?		27	87	16	x
<b>Olynthos, Many Colours</b>	4	2	19	75	150	19
<b>Olynthos, Bronzes</b>	3	3	4	>41	10	
<b>Olynthos, A iv 9</b>	2	5	6	32	112	5
<b>Olynthos, D v 6</b>	4	3	19	40	50	1
<b>Himera III, VI, 2</b>	3	9	11	59	34	35
<b>Himera III, IV, 1</b>	2	4	12	31	20	6
<b>Himera II, I, 2-3</b>	3	8	16	26	48	11
<i>range</i>	2-7	1-27	4-56	32-202	0-150	0-19
<i>average</i>	3	3	26	100	75	10
<b>Selinous, × 2.500</b>	<b>7.500</b>	<b>7.500</b>	<b>65.000</b>	<b>250.000</b>	<b>187.500</b>	<b>25.000</b>

Fig. 6: Ceramic products found in Classical houses.

volume/ capacity in cubic meters; exact numbers cannot be calculated, however, without knowing the height of the cupola, which differs according to kiln size (fig. 3).<sup>13</sup>

Fig. 4 lists products of varying sizes from small perfume vases or lamps up to large pithoi, and shows how many of them fit in a space of 1 m<sup>3</sup> and how much they weigh. These considerations become important for calculating consumption numbers.

I consider that a kiln was fired once per month (a firing cycle takes about two weeks and the pairs of kilns were used in the alternating manner discussed above).<sup>14</sup> I suppose that these specialized workshops operated year-round,<sup>15</sup> but due to variations in weather conditions production levels were probably not always consistent; therefore I assume an average number of nine months a year. These calculations yield a result of nearly 8.000 m<sup>3</sup>.

We must keep in mind that not all kilns detected by geophysics would have been in use at the same time. In our excavated workshop, for example, four of the seven 5<sup>th</sup>

	total no. all houses	per year	sanctuary	grave	total no.	m <sup>3</sup>	kg/ m <sup>3</sup>	fuel kg
<i>replacement rate</i>	+ 100%							
<b>pithoi</b>	15.000	164		2	164	150	100	4.065
<b>louteria etc.</b>	15.000	164	2		164	80	100	2.170
<i>replacement rate</i>	+ 800%							
<b>mid-size</b>	520.000	5.715			5.715	160	128	5.550
<b>small</b>	2.000.000	22.000	112	1.800	40.000	30	256	2.080
<b>very small</b>	1.550.000	16.500						
<b>terraccottas</b>	200.000	2.200	190	?	2.400			
<i>replacement rate</i>	+ 20%							
<b>tiles (stroter)</b>	1.000.000	11.000	?		11.000	220	1200	71.500
<b>tiles (calypter)</b>	1.000.000	11.000	?		11.000	110	2000	59.600
						<b>750</b>	<b>3.800</b>	<b>145.000</b>

Fig. 7: Consumption of ceramics in Selinous.

century kilns were used contemporaneously. So, to avoid inflation of the numbers, I divide the maximum capacity by two, arriving at 4.000 m<sup>3</sup> per year. This would represent about 2.000 tons of clay, if we take the average weight of all products per cubic meter.

**Consumption**

Calculations relating to consumption must take into account all parts of the city (fig. 5). First, we must consider all local products used in an average house, from roof tiles for the covered spaces,<sup>16</sup> to pithoi, amphorae, table ware, loom weights, and so on. This number can then be multiplied by the number of the existing houses (2.500). To reconstruct the number of ceramic objects found in houses, I compare the evidence from Selinous<sup>17</sup> to that from other Classical sites, including the well-published Himera on Sicily<sup>18</sup> and other better-excavated examples from Greece (fig. 6).<sup>19</sup> Houses used solely for residential purposes present a different picture from houses that were also dedicated to commercial activities. Still, the average result seems quite homogeneous: ca. 3 pithoi, 3 louteria, about 25 amphorae, and hundreds of small objects.

These numbers seem quite reliable, but there are other unknown factors, such as how often objects needed to be replaced. For example, how long would a roof tile last? Roofs were never entirely replaced; instead, individual damaged tiles were repaired as needed.<sup>20</sup> Wikander’s addition of 10% to account for repairs over a 100-year period<sup>21</sup> seems a bit low to me; accordingly, I have doubled this number, to 20%. For most other objects I figure on a substitution roughly every decade in the 5<sup>th</sup> century, which at Selinous lasted only until 409. Pithoi are only doubled whereas

human resources/ production steps	one big workshop (half insula)	whole potter's quarter (24 insulae)
clay extraction		25
clay transport		20
clay processing		25
fuel producing and transport		50
provision of other materials (e.g., colors)		20
potter	3	288
assistant	3	
painter	3	144
kiln master	3	288
assistant	3	
unskilled labor	3	144
organization/sale	2	96
	<b>20 (× 48 ?)</b>	<b>ca. 900–1.200</b>

Fig. 8: Human resources involved in the ceramic production.

mid-size vessels are multiplied by 8 in the 5<sup>th</sup> century. Finally, the total of products is divided by 91 to reach a yearly average (fig. 7).

We know the average numbers of grave contents very well as thousands of 5<sup>th</sup> century examples were excavated by Vincenzo Tusa in the 1960s. This number is not really relevant to questions about production, because only a few objects in the graves (one or two) were made of local clay.<sup>22</sup> There was, however, a limited production of terracotta sarcophagi at Selinous.<sup>23</sup>

In sanctuaries, mostly small objects, such as terracotta figurines or miniature vases, were deposited. The Malophoros sanctuary yielded thousands of objects, giving us some idea of the quantities involved.<sup>24</sup>

If we translate all of the numbers (fig. 7) from the different areas of the city into m<sup>3</sup>, in order to compare them with the kiln capacities, we reach a figure of 760 m<sup>3</sup> for the total consumption of ceramic goods.

The main conclusion to be drawn from these calculations is that annual ceramic production of the workshops (4.000 m<sup>3</sup>) would have resulted in a large surplus. At least five times more ceramics were produced than were consumed, meaning that a major part of the production was to be sold outside the city.

Another important aspect of the pottery industry's impact on the city's economy is the size of its workforce: the workers involved in the 40–50 workshops in the Kerameikos of



Selinous, plus the workmen engaged in extracting and delivering raw material and fuel, mostly wood. A workshop like ours may have employed 18–20 people; the ceramic business as a whole, about 900–1.200 (fig. 8).<sup>25</sup> If we consider only some these men as responsible for the support of a whole family we can estimate that the number of people living on ceramic production was between 2.500 and 4.000, a considerable segment (15%–25%) of the population of Selinous, which had between 14.000 and 19.000 inhabitants in the 5<sup>th</sup> century.<sup>26</sup> If we also take into account the building sector with its consumption of millions of mudbricks, the number of people living on clay products in general is much higher.

In conclusion, Selinous offers a unique opportunity to attempt to quantify both production and consumption of ceramics. The city's potter's quarter, an efficiently organized and specialized cluster of workshops with no residential features, was certainly dedicated to full-time production. Looking at the whole of products, it is possible to calculate production and consumption rates. Two or three workshops like the one we excavated would have been sufficient to meet the demands of the city alone, so it is clear that the annual production of all workshops resulted in a large surplus. The pottery industry with its required workforce, was an important part of the city's economy, supporting a significant part of its population. And while the demonstrable wealth of the city, which boasted a dozen temples, was more likely derived from agricultural products<sup>27</sup>, Selinous seems to have been a major ceramic production center, at least for Western Sicily. We cannot say whether Selinous, with its enormous surplus production and large workshops is a typical example or an exception. It is evident however, that the familiar concept of smaller, family-based workshops working mostly to satisfy local demand is not the only model for Classical ceramic production.<sup>28</sup>

### Notes

<sup>1</sup> This short paper focuses on production scale and does not provide a thorough description of the results of the excavations at Selinous. For a more detailed version, with more evidence and discussion of the implications on economic questions in general, see Bentz 2017, or the overview in Bentz 2018. All dates are BC.

<sup>2</sup> I exclude unfired clay products such as the millions of mudbricks used in the building sector.

<sup>3</sup> Cook 1959 was the first to attempt a detailed account; the most recent (and much more reliable) estimates can be found in Sapirstein 2013; Sapirstein 2014; and in this volume.

<sup>4</sup> Davies 2013, 11.

<sup>5</sup> Fülle 1997, 111.

<sup>6</sup> Davies 2013, 12. Cook (1959, 120) had already abandoned his quantitative considerations citing Beloch 1912, 88 who talks of houses of cards: "Er kann dabei sehr viel Scharfsinn und Gelehrsamkeit zeigen, aber was er baut, sind Kartenhäuser, die beim leisesten Hauch umfallen". Stissi 2002, 5–66, likewise remains very skeptical.

<sup>7</sup> Mertens 2003.

<sup>8</sup> Bentz et al. 2013; Bentz et al. 2016; Bentz 2017; Bentz 2018; the final publication of the results of the seven fieldwork seasons from 2010 to 2016 is in preparation.

<sup>9</sup>This is a result of our excavations; the measures of the excavated 5<sup>th</sup> century kilns correspond exactly to the geomagnetic plan where even the praefurnia of the bigger kiln can be seen.

<sup>10</sup>Bentz 2017, 21–24 with references and a detailed list in fig. 4.

<sup>11</sup>Space does not permit me to describe this space in greater detail; in addition to the references given in note 8, see panel 3.2 “Organization of space and work: potter’s workshops in the Greek World” in the congress proceedings.

<sup>12</sup>Bentz 2017, fig. 5.

<sup>13</sup>On the basis of iconographic evidence, better-preserved excavated examples and ethnographic parallels, it is generally assumed that the height of the cupola matches the diameter of the kiln. This rule, however, does not apply to larger kilns (2–5 m in diameter); a mudbrick cupola 5 m high, for example, cannot be realized. In these cases I assume a cupola height equal to one-half of the diameter. See Stissi 2002, 59–60; Cuomo di Caprio 2007, 510–512. 516–521; Manacorda – Pallecchi 2012, 287–292; Barra Bagnasco 1989, 30 with different approaches.

<sup>14</sup>There exists a consensus on this point: Cuomo di Caprio 1974; Barra Bagnasco 1989; Hasaki 2002, 271; Manacorda – Pallecchi 2012, 471–474.

<sup>15</sup>There are ethnographic parallels for this assumption: Hampe – Winter 1965, 199: “Die Töpfer und Ziegler Süditaliens müssen meist ganz von ihrem Handwerk, dem Töpfern und Ziegelmachen leben; sie arbeiten das ganze Jahr hindurch in ihrer Werkstatt, im Sommer pausenlos, im Winter gemächlicher, weil das Trocknen der Gefäße oder der Ziegel dann langsamer vonstattengeht. Oder, soweit Töpferei und Ziegelei in einer Werkstatt vereinigt sind, arbeiten sie in der warmen Jahreszeit vorwiegend als Töpfer, in der kalten hauptsächlich als Ziegler.” See also Manacorda – Pallecchi 2012, 472 f., who refer to the evidence of the monthly stamps from Scolacium with a break of only two months.

<sup>16</sup>The house plots measure 220 m<sup>2</sup> and we must consider that on average one-quarter was not roofed, there are overhangs etc., therefore, I count 330 stroters and calypters per house.

<sup>17</sup>To date, no inventory of a Classical house in Selinous has been completely published.

<sup>18</sup>Allegro 1976; Allegro 2008; Harms 2010.

<sup>19</sup>Attica, Dema House: Jones et al. 1962; Vari House: Jones et al. 1973; Halieis: Ault 2005; Olynthos: Cahill 2002.

<sup>20</sup>For example, one better-preserved workshop space in the Selinous workshop is roofed with 7 different types of stroters.

<sup>21</sup>Wikander 1993, 137–139.

<sup>22</sup>The Buffa necropolis contained more than 1.200 graves of the 5<sup>th</sup> century: Meola 1996, 14–16; Meola 1997, 520 pl. 5 with list of pottery; Meola 1998; Manicalunga-Timpone Nero-Necropolis: Leibundgut Wieland 1994, Leibundgut Wieland 1997; Manicalunga-Gaggera-Necropolis: Kustermann Graf 2002, 55–58. 260–271.

<sup>23</sup>Bonanno 1998, 40–41. 210–212 pls. 95–107 with the published examples.

<sup>24</sup>See Hinz 1989, 152 f. for an overview; Dewailly 1992, 33 lists 7.000 terracottas, 5.000 lamps and 1.250 local vases from the old excavations from 1888–1918; Dehl-von Kaenel 1995, 417, lists nearly 5.000 Archaic vases, 20% of which were locally produced. If you halve these numbers, to separate the 6<sup>th</sup> from the 5<sup>th</sup> century, and multiply the 5<sup>th</sup> century number by 10, to take into account the later excavations, the result is more than 500 statuettes and vases per year – which is irrelevant for the overall production.

<sup>25</sup> We do not know if these were mainly slaves or free citizens.

<sup>26</sup> Zuchtriegel 2011 with references, recently followed by De Angelis 2016, 197. These numbers depend on how many persons we consider to be part of a family and living in one house, the estimates range from 4,6 to 10 depending on how many slaves each family had.

<sup>27</sup> Bentz 2017, 36 with references.

<sup>28</sup> Acton 2014 and Acton 2016 on the “small-scale business” model which theoretically is the most efficient.

### Image Credits

Fig. 1: after Mertens 2006, 174 Abb. 303 with modifications by the author. – Fig. 2–8: by the author.

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