POTTERY SMOOTHERS FROM COLLE SANTO STEFANO (ORTUCCHIO, L'AQUILA)

Lucia Angeli[1], Cristina Fabbri[2], Marcella Parisi[1] and Alice Bertini[1]

[1] *Cultures and Forms of Knowledge Department - University of Pisa*
[2] *Independent researcher, email: cristina.fabbri@virgilio.it*
Corresponding author, email: lucia.angeli@for.unipi.it

Introduction

While investigating an excavated area of about 200 square m (70-100 cm deep) archaeologists identified eight pottery smoothers: potsherds used as tools (Fabbri 2006; Angeli and Fabbri 2011). It seems interesting to highlight their presence at the site of Colle Santo Stefano di Ortucchio (Radi 1991; Radi *et al.* 2001), as they are, together with the site of Trasano Basilicata, from one of the two most ancient Italian Neolithic Impressed Ware sites where these tools have so far been identified (Figure 1).

In literature these types of tools have recently raised a certain interest as to their original purpose. Studies on this topic describe pottery smoothers according to a standard terminology (Binder *et al.* 1994; Godon and Lepère 2006; Godon 2010; Vieugué *et al.* 2010). Moreover they are analysed by means of both functional and experimental methods. Generally speaking the function attributed to them is that of tools used during activities of finishing pot surfaces (Skakun 1978; Anderson-Gerfaud *et al.* 1987; Shiffer and Skibo 1989; Hauzeur 1991; Sullivan *et al.* 1991; Skibo *et al.* 1997; López Varela *et al.* 2002; Van Gijn and Hofman 2008; Vieugué 2009; Maigrot and Vieugué 2010). Similar ethnographic comparisons confirm this hypothesis and suggest that pottery smoothers can be used during the finishing of pot surfaces, as well as other tools such as wood, bone or shell, sticks and pebbles (Gosselain and Livingstone Smith 2005; Gosselain 2010).

Smoothers: are they finishing tools for pot surfaces?

During pottery production, the use of tools of different materials and shapes is acknowledged throughout all phases of the *chaîne opératoire*. Overall, the paramount operations to produce pottery can be listed as follows: *selection and/or treatment of the raw materials, clay modelling techniques, finishing and surface treatments and decoration* which can be carried out prior to *firing*.

Modern investigation methods let us define production activities from a technological point of view and postulate reconstruction hypotheses of the operational sequence and of handcraft tradition. For example, mineral and petrographic analyses help to identify fabric groups, e.g. suggesting variables in paste preparation and firing temperature; but some questions are more difficult to answer, for example what tools were used to shape and finish the pottery? Macro-evidence studies on fractures or surfaces of pottery and sherds, including radiography, help us identify manufacturing techniques and thus acknowledge one or more handcraft traditions; which tools were used during different pot modelling phases?

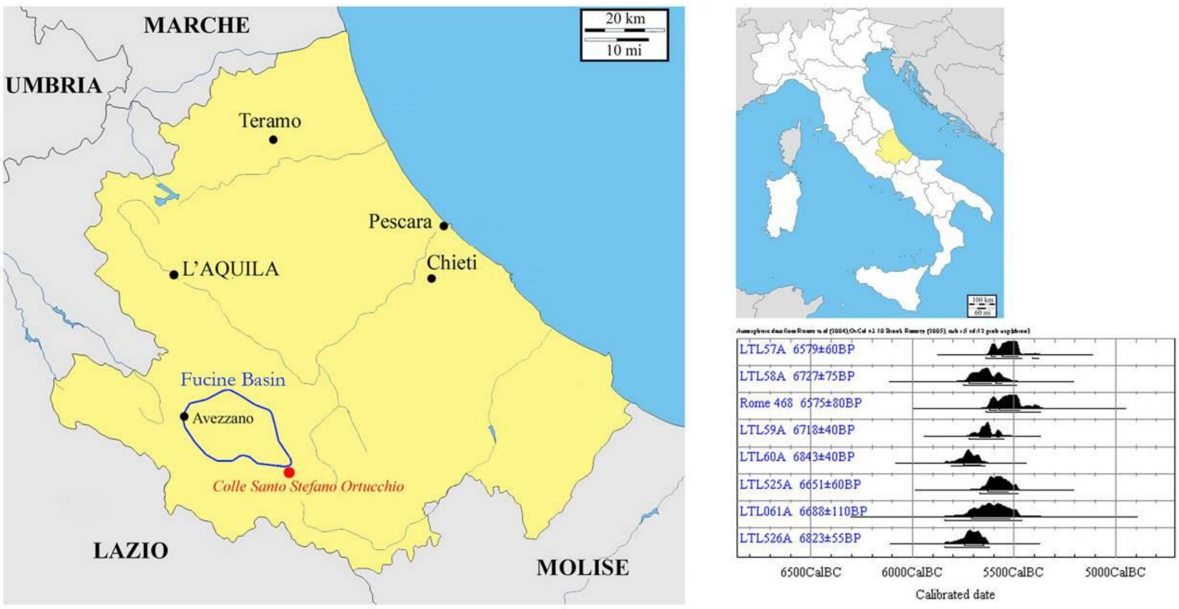


Figure 1. Colle Santo Stefano, Ortucchio in the Fucine Basin (Abruzzo, Italy): map of the site location and ^{14}C dates.

Observing tool impressions and replicating decorations by experiment are the basic grounds on which it is possible to classify decorative techniques (see Natali 2014); what can be said on the variety of tools for each phase of the operational sequence?

It is difficult to answer these questions because it is not simple to distinguish specific working areas within archaeological sites, and the tools used for these operations are not easy to identify in the archaeological record.

However, we can now assess experiments and functional analyses on surface finishing (Figure 2a) using tools made of bone (Maigrot 1997; Martineau and Maigrot 2004) and flint (Gassin 1993; Torchy and Gassin 2010). These enable the identification of tool marks on ceramic surfaces related to clay working.

Pottery smoothers - potsherds reused as and/or transformed into tools - are enlisted with other finishing and surface treatment tools. In the archaeological record pottery smoothers can be identified from the group of potsherds thanks to their worn fractures, the so-called *functional abraded surfaces*, characterised by *use-wear traces* (striations or polished areas), that can be the consequence of the tool's last use before it was discarded. *Production-wear traces* or evidence of a transformation into a particular shape are less likely to be preserved, as they are either erased or partly covered by later use-wear traces.

As discussed below, the Colle Santo Stefano archaeological record of pottery smoothers, even in its small number, shows evidence of both tool production and use. The studied samples were therefore suitable objects for experimental reconstruction to test the hypothesis of smoother tool production *chaîne opératoire* and their possible use.

In relation to pottery smoothers function, two main questions were considered in our research: are pottery smoother tools designed for surface finishing? In which pottery production phase of the operational sequence were they used?

By studying a small collection of pottery sherds used as smoothers coming from the two Italian Neolithic archaeological sites of Trasano (Angeli 2012) and Serra d'Alto (Angeli and Fabbri 2013), it was possible to acknowledge that a wide variety of wear and/or use evidence can be preserved. This variety led us to the hypothesis that pottery smoothers' use and function were not only to be linked to a pottery production operational sequence. Different evidence may be the result of other activities (scratching, scraping, smoothing and/or polishing) carried out on a variety of materials, for different periods of time, with strength and timings that did not conform to *standards*.

The work on the small collection of pottery smoothers from Colle Santo Stefano led us to distinguish them having two main types of abraded surfaces: *abraded surface type 1 with smoothed active surface* and *type 2 with striations on active surface*.

Abraded surface type 1 shows a smooth or slightly rounded active surface that can sometimes appear polished. No mechanical wear was identified: there were no *striations* or variations in the particle fraction of the mixture, which means that inclusions were not raised above the surface or removed creating holes during use. As all of the Colle Santo Stefano pottery smoothers show this kind of surface (Figure 2c), we may infer a short use of the tool or its use on a soft and non-abrasive material.

Abraded surface type 2 is characterised by light to strong *striations* on the active surface, which is matt and extremely rarely polished. *Striations* direction can determine a motion geometry of the tool (Vieugué 2009) and suggest the use on a hard and abrasive material. Confirming this hypothesis the examples analysed below seem to establish the link between this kind of wear and that of *striations* found on semi-fine fabric pottery from Trasano (Angeli 2012), where inclusions have been raised above the surface (Figure 2d), and on *figulina* pottery from Serra d'Alto (Angeli and Fabbri 2013), where *striations* are dense, superimposed and with the same direction (Figure 2e).

Colle Santo Stefano smoothers: *corpus* description

The description of the categories for the documentation of the smoothers, were completed according to previous works and to standard terminology (Godon 2010; Vieugué 2009). The following fields were considered: type of sherd; clay fabric mixture; dimensions (length, width, thickness and weight); exterior and interior surface appearance (wear or use evidence); fracture numbers, active or functional surfaces and number of angles. Eight smoother were identified (numbered sequentially 1-8) with combinations of these specific physical features (Figure 3). In addition, Colle Santo Stefano smoothers are all *abraded surface Type 1 with smoothed active surface* and no striations.

Colle Santo Stefano pottery smoothers have all been made from small body sherds both straight or curved

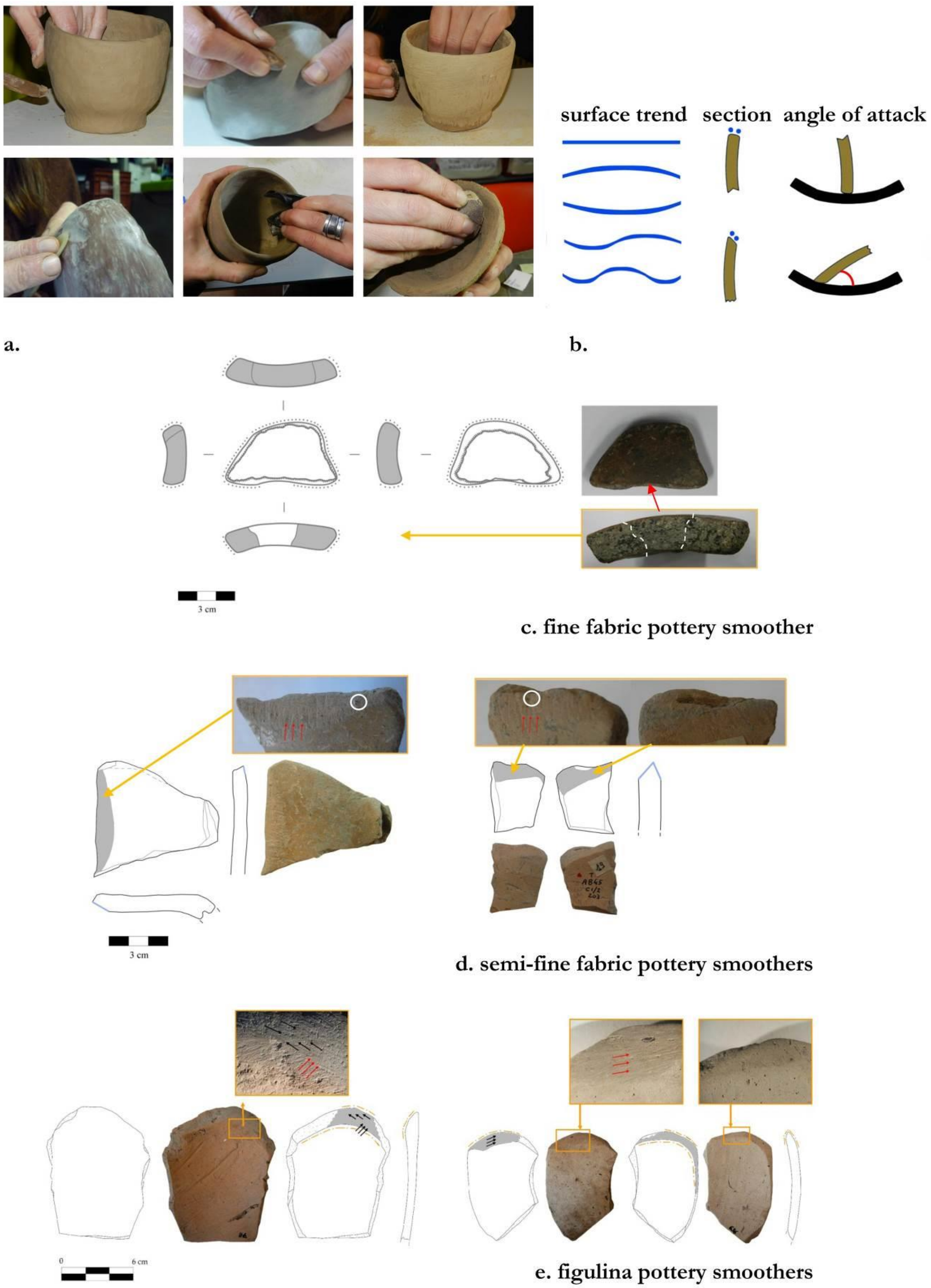


Figure 2. a) Surface finishing using wood, pebble, flint, bone, leather and pottery smoother (experiment by Lucia Angeli and Marcella Parisi); b) forms of description for use of a pottery smoother; c) smoothed active surface from Colle Santo Stefano, Ortucchio (Fabbri 2006); d) striated active surfaces from Trasano, Matera (Angeli 2012); e) striated active surfaces from Serra d'Alto, Matera (Angeli and Fabbri 2013).

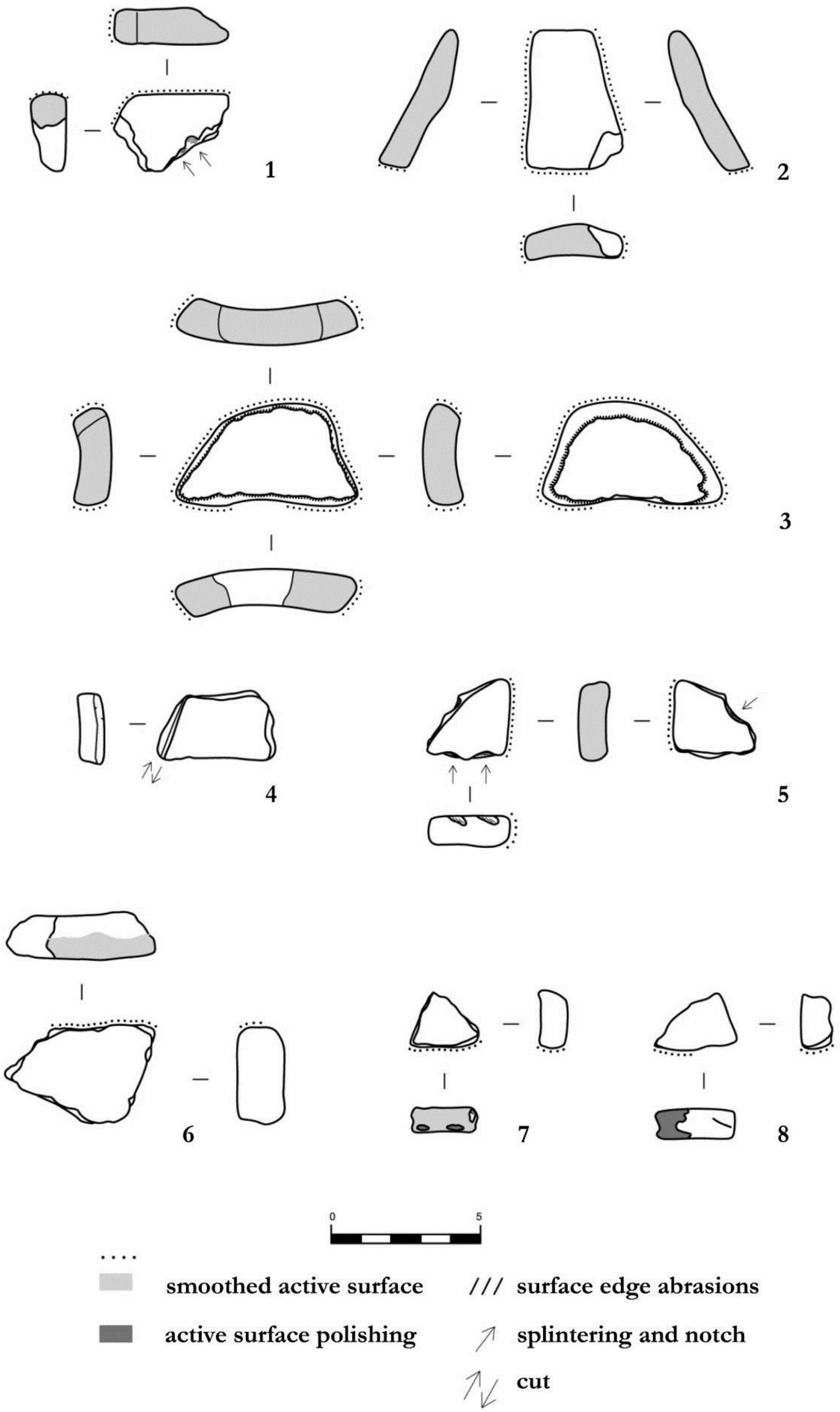


Figure 3. Colle Santo Stefano, Ortucchio: pottery smoothers corpus (drawing by Raffaella Milano).

(except Smoother 2 - rim sherd with inflexion). The sherds are all fine fabric pottery (except Smoother 6 - semi-fine fabric pottery): clearly, inclusions were not useful to the tool purpose and since they increase the abrasive effect of the smoother, choosing fine fabric pottery suggests use on quite soft material. Detailed analysis of abraded surfaces and of active angles was undertaken with a binocular microscope, that allowed us to describe both *abraded functional or active surfaces* morphology (shape, section, angle of attack) and, where they appeared, *active angles* morphology and range (90°, < 90°, > 90°).

Abraded surface shapes (straight, convex, concave, concave-convex and concave-convex-concave) show the surface trend; the section (flattened, rounded and oblique) shows the surface profile; the angle of attack (right-angle and >90°) describes the inclination of the smoother surface on the worked object. The angle of attack can be deduced by the section morphology, which therefore suggests how the tool was used (Figure 2b).

As discussed, Colle Santo Stefano smoothers are all *abraded surface type 1 with smoothed active surface* with no striations. Active surfaces are generally straight, with a flattened to rounded section, rarely oblique, and their angle of attack is almost always right-angled. Smoothers 1, 2, 3 also have active angles where two active surfaces meet.

Wear covers only the fractures and has no effect on nearby surfaces but only on a very small scale near their edges. The absence of wear on the surfaces might be due to a regular motion during use or simply to the use of the tool for a short period of time (Figure 3).

Evidence of three possible production methods for smoothers was found in the archaeological samples, together with use evidence: they are splintering or knapping (Smoother 1), a notch (Smoother 3), and a cut and/or groove (Smoother 4; Figure 4a, b, c).

Experimental reproduction: how to produce and use a pottery smoother

The experiments have been carried out on the basis of production and use-evidence observed in the archaeological record. Two different operational sequences have been reproduced: the first regarding the production of a pottery smoother and the second regarding its use on clay at different drying stages.

Particularly, abraded surface analysis propounds the hypothesis that Colle Santo Stefano pottery smoothers could be interpreted as tools used on soft material. The absence of mechanical wear (*striations*) and their being made out of fine fabric pottery, that is with a very low abrasive effect, led to the hypothesis of a contact with fairly plastic and moist clay, before it becomes leather-hard or completely dry.

The experiments were carried out only on clay (and on no other material), as the tests could be verified only if compared to the finished pot surfaces from the archaeological record (Figure 5a).

Experimental smoother production: *the chaîne opératoire*

The *chaîne opératoire* of smoother production was hypothesised from evidence of *débitage* observed in the archaeological record: splintering or knapping (Smoother 1), a notch (Smoother 3), and a cut (Smoother 4). Identification of these features suggested the use of Smoothers 1 and 3. Body sherds used for the experiments were selected showing similarities to the original smoothers: i.e. body sherds of fine fabric pottery (Fabbri and Angeli 2010), with a straight or curved profile (Fabbri 2006) and dimensions (length, width and thickness) that were the same as those measured on the archaeological smoothers.

The chosen sherds were worked into shape using the following techniques, solo or combined: *abrasion/polishing, cut/incision* (flint flake or blade), *direct percussion, indirect percussion* (a flint flake was struck with a boxwood hammer onto the potsherd) and *bending*. The direct percussion technique had already been tested using a pebble and a soft boxwood hammer; the experiments produced radial fractures and, in both cases, the sherd broke into three pieces, hence the method was considered not functional to shape a smoother tool (Angeli and Fabbri 2011).

The experiments of preparing sherds for tools (Figures 5b, 6, 7) resulted in the production of 9 experimental smoothers, of which: production *tests 1, 3, 4, 7, 8, 9* were subsequently used to finish surfaces on clay models; production *tests 2 and 5* were abandoned; eventually, production *test 6* was kept unused as comparison example for (cut) production of Smoother 4.

<u>Production *test 1*</u> - *abrasion/polishing*
The fractures were levelled by abrading/polishing them against a stone (a local limestone). No effort was required for this operation; moreover the fine fabric pottery ensured a short period of time required for the action.

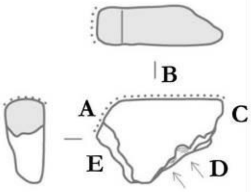
SMOOTHER 1 - SS H21			
		**sherd type** body **mixture** fine fabric **max. lenght (mm)** 39 **max. width (mm)** 26 **thickness (mm)** 12 **weight (gr)** 15 **external surface** edge D splintering or knapping (*débitage* ?)  **interior surface** not preserved	**N° fractures** 5 (A, B, C, D, E) **N° active surfaces** 2 (A, B) **N° active angles** 1
Surface A		**Surface B**	**Angle 1**
shape straight **section** levelled **angle of attack** right 		**shape** slightly convex **section** levelled **angle of attack** right 	> 90° 

Figure 4a. Colle Santo Stefano, Ortucchio: forms of description for smoothers showing one of three possible production evidences: splintering or knapping on Smoother 1.

Though abrasion is functional to obtain an extended levelled surface, this technique had no comparison in the archaeological record, as this polishing evidence can easily be removed by subsequent use.

Production *test 2 - cut/incision + direct percussion: abandoned*
Using a flint flake, a deep cut was produced on the interior surface of a curved body sherd and then it was hit directly with a soft boxwood hammer.

The resulting fracture appeared on the other side of the sherd and it ran parallel to the cut, not along it. This technique does not seem appropriate to produce a regular sherd. *Test 2* was abandoned as morphology and dimensions of the sherds were not suitable to carry on the shaping of the smoother.

Production *test 3 - indirect percussion + abrasion/polishing*
Indirect percussion was used on the interior surface of a curved body sherd. A regular piece snapped away, its fractures could be identified as the point of impact, where a notch appeared. Abrading the broken surface against the same stone, as in production *test 1*, finished the smoother.

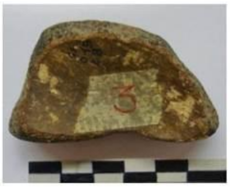
Production *test 4 - indirect percussion*
Indirect percussion was used on the interior surface of a curved body sherd. A regular piece snapped away, its fractures could be identified as the point of impact, where a notch appeared. The method was repeated to reduce the sherd: two pieces snapped away, each one with its own notch.

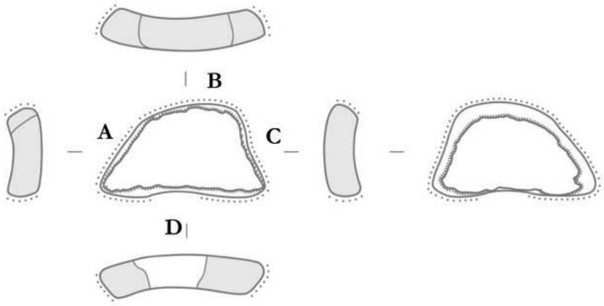
Production *test 5 - indirect percussion + incision/cut + bending: abandoned*
An indirect percussion forms a sherd with a fracture not corresponding to the point of impact. The piece was cut/incised with a flint flake and was then bent inwards, but it broke. The pottery fabric was poorly compacted and it broke, which was the main cause of the failure of the test.

Production *test 6 - incision/cut + bending*
Using a flint flake the piece was cut and then bent inwards. The result was a perfect replica of Smoother 4 from the archaeological record, which still shows cut features.

Production *test 7 - incision/cut + indirect percussion*
Using a flint flake the piece was cut, then indirect striking was used. The result conformed to Smoother 1.

SMOOTHER 3 - SS O19 cut 8





sherd type rounded body sherd
mixture fine fabric
max. lenght (mm) 61
max. width (mm) 34
thickness (mm) 13
weight (gr) 40
exterior surface slight wear on edges

interior surface middle notch on edge D

N° fractures
4 (A, B, C, D)
N° active surfaces
4 (A, B, C, D)
N° active angle
1

Surface A

shape concave-convex
section oblique towards interior surface
angle of attack < 90°

Surface B

shape convex
section oblique towards interior surface
angle of attack < 90°

Angle 1

< 90°

Surface C

shape concave-convex-concave
section oblique towards interior surface
angle of attack < 90°

Surface D

shape concave-convex-concave
section levelled-rounded off
angle of attack right

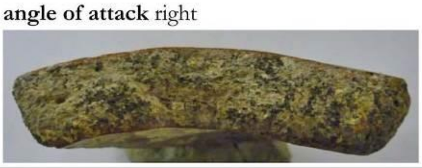
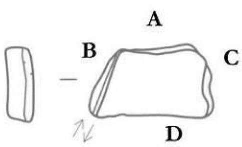


Figure 4b. Colle Santo Stefano, Ortucchio: description form for smoothers showing the second possible production evidence: notch on Smoother 3.

SMOOTHER 4 - SS O25 cut 10



sherd type body
mixture fine fabric
max. lenght (mm) 39
max. width (mm) 23
thickness (mm) 10
weight (gr) 21

exterior surface edge A cut
interior surface -

N° fractures
4 (A, B, C, D)
N° active surfaces
-
N° active angle
-

Fracture A with cut

shape rough with cut
section uneven
angle of attack -

Figure 4c. Colle Santo Stefano, Ortucchio: forms of description for smoothers showing the third possible production evidence: cut and/or incision on Smoother 4.

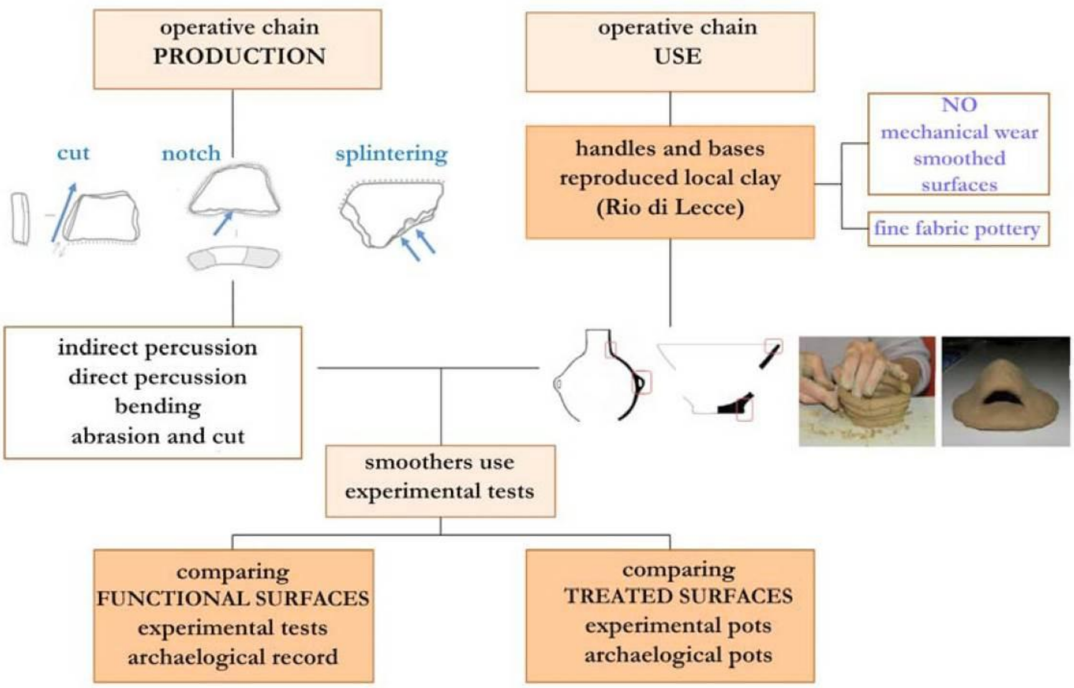


Figure 5a. Experimental reproduction flow chart.

Figure 5b. Production operative sequence: production test 1 and test 2.

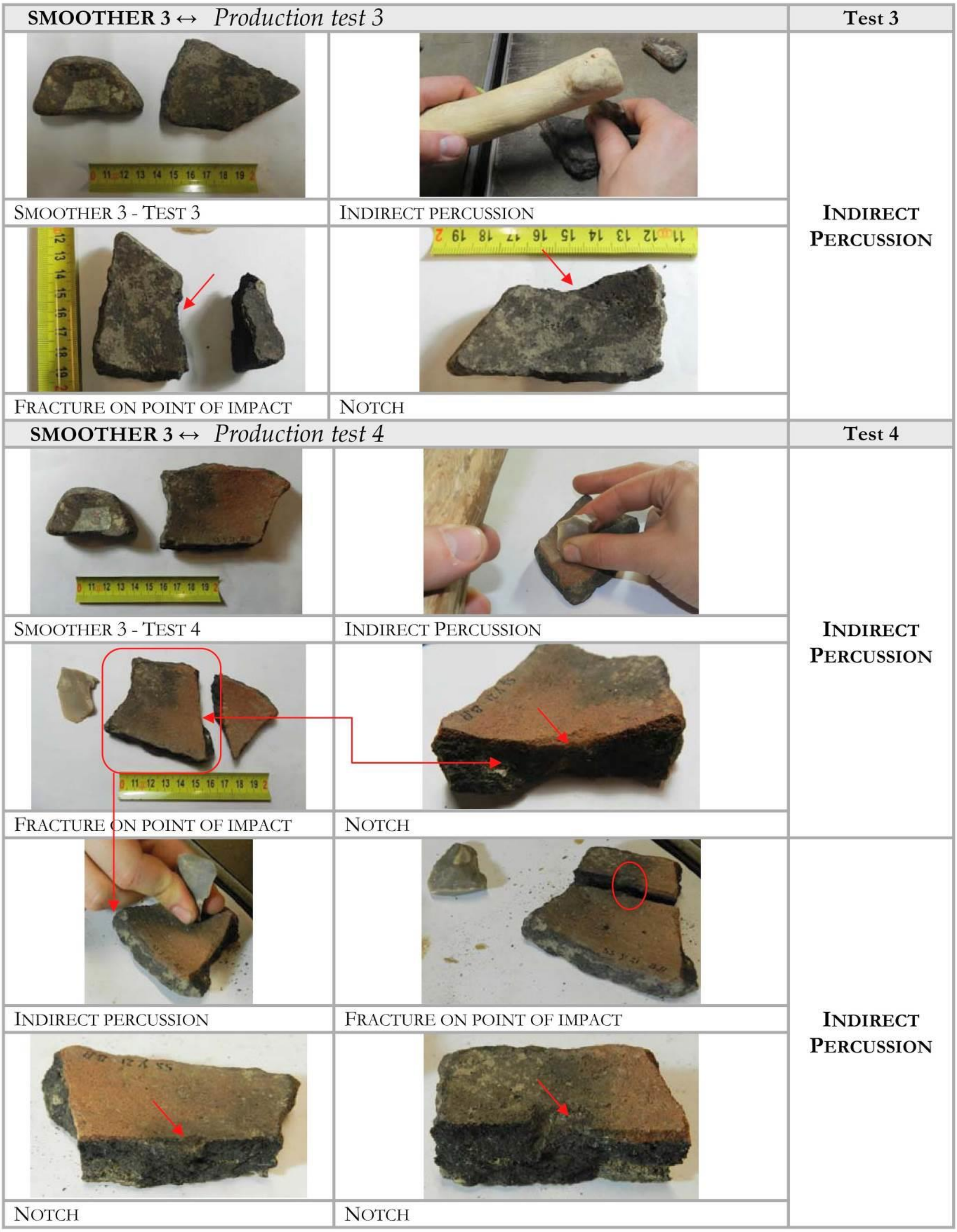


Figure 6. Production operative sequence: production test 3 and test 4.

Figure 7. Production operative sequence: production test 5, test 6, test 7, tests 8-9.

<u>Production *test 8 and 9*</u> - *abrasion/polishing*
The chosen pieces' morphologies were already very similar to the archaeological evidence. As a consequence, the only operation to be carried out was abrading the fractures on a stone (see *test 1*).

Use of experimental smoothers to finish pots:
the chaîne opératoire

Binocular microscope analysis of the archaeological finds gave rise to a specifically planned experimental protocol: the goal was to try and obtain experimental replicas that could be compared to the archaeological data.

The experimental smoothers (production *tests 1, 7, 8* to reproduce Smoother 1 and production *tests 3, 4, 9* to reproduce Smoother 3) were used on parts of newly prepared clay models, such as strip handles and bases. The clay used for the models was dug from the location of the Rio Lecce stream, in Ortucchio (sample of clay number RL3B). An experimental drying curve (Martineau 2010) was used to evaluate the solidity of this clay during the tests.

The experimental use of the *production test* smoothers (Figure 8) has been carried out on plastic clay (24h), hard plastic/moist clay (48h) and eventually on leather hard/dry clay (72h); it did not seem useful to test the smoothers during the very first modelling stages (0h) as the plasticity and moisture content of the raw material would have not allowed a good surface contact.

TEST 1	Test 1

TEST 3

PLASTIC CLAY 24 HOURS

MEMO: CLAY IS TAKEN OFF AND IT IS REDEPOSITED ON THE ACTIVE SURFACE, CREATING A DEEP LAYER. POT SURFACE APPEARS IRREGULAR AND LUMPY.

TEST 7	Test 2

TEST 9

HARD PLASTIC/MOIST CLAY 48 HOURS

MEMO: LITTLE AMOUNT OF CLAY IS MOVED AND REDEPOSITED ON ACTIVE SURFACE.
POT SURFACE IS MORE REGULAR AND SHOWS LARGE STRIATIONS.

TEST 8	Test 3

TEST 4

LEATHER HARD/DRY CLAY 72 HOURS

MEMO: NO CLAY IS MOVED. USING THE TOOL PRODUCES DUST AND ON THE SMOOTHER'S ACTIVE SURFACE SOME FLAKES FALL OFF. POT SURFACE IS ABRADED AND SHOWS SHALLOW STRIATIONS.

Figure 8. Finishing steps of the operative sequence: experimental use test 1 (plastic solidity 24h), test 2 (hard plastic/moist solidity 48h) and test 3 (leather hard/dry solidity 72h).

Figure 9. Surfaces of the experimental smoothers after tests. Legend: SM. 1 = Smoother 1.

Experimental use test 1 – *production test 1 and test 3 on plastic clay (24h)*
This experiment was not functional as large amounts of clay were moved as it spread on the smoother's surface. No use evidence was formed on the tool's active surfaces; indeed, it was not possible to distinguish between evidence of use and abrasion obtained while shaping the tool.

Experimental use test 2 – *production test 7 and test 9 on hard plastic/moist clay (48h)*
Hard plastic/moist clay appeared to be most suitable for modelling pots: walls could be thinned and both interior and exterior surfaces could be levelled. Moreover, small dimensions of smoothers were extremely useful to finish every part of the pot with high precision, including rims, handle holes and the points where body and base meet. On the smoother's active surfaces morphology modifications could be noticed: after a short period of use (between 7 and 10 minutes) flattened or rounded surfaces and smoothed angles appeared. These surfaces were smooth to touch, with a matt appearance and a rounded section.

Experimental use test 3 – *production test 8 and test 4 on leather hard/dry clay (72h)*
Leather hard/dry clay was unsuitable for our purposes. After a similar short period of use (between 7 and 10 minutes) the active surfaces showed clearly only small polished areas and a few small chips which came off: this has no parallels with the archaeological record. Moreover, experimental pot surfaces showed no similar characteristics to those of the archaeological data. However, it is necessary to take into consideration that the shallow *striations* made by smoothers on the pot surfaces may have been erased by a subsequent finishing treatment on archaeological pots.

Conclusions

Colle Santo Stefano pottery smoothers are reused fine fabric potsherds that were selected specifically for their low abrasive capacity. Both wear/use analysis on abraded surfaces and experiments carried out, led us to make a series of observations on this peculiar tool class (Figure 9). According to *débitage* evidence identified on the archaeological record (splintering or knapping, cutting and notching) and by comparison with experimental production replicas, it appears that smoothers' shaping could have been done using indirect percussion and bending techniques, while direct percussion has to be ruled out.

Indirect percussion produced good results both after a cut/incision action (production *test 7*) or alone (production *tests 3* and *4*). Furthermore, it showed that the socket observed in the archaeological record (Smoother 3) could be obtained by indirect percussion alone, without a previous cut.

Bending is a good technique when used together with prior cutting (production *test 6*), which assures a planned and controlled fracture line on the sherd.

A selection of already pre-shaped pieces appears most likely in antiquity: some of the experiments revealed that when this happens, shaping of the tool is unnecessary, as it is already suitable in both morphology and dimensions, although it is plausible that a minimal shaping and levelling of the edges using abrasion would have been useful to even rough fractures (production *tests 1, 8, 9*). It is not to be denied that sherds with characteristic fractures could have been used, for instance potsherds that broke along the coil line: in this case, the fracture line is already quite even and convex, so active surfaces are ready to use.

Noticing smoothers' active surface wear (rounded off appearance and lack of mechanical wear/*striations*) and comparing them with experimental tests suggests that these tools were used to model clay, particularly on pot surfaces without protruding inclusions and when the clay is hard plastic/moist (48h). It appears that Colle Santo Stefano pottery smoothers, when used in pottery production, were suitable tools to remove small amounts of clay, even surfaces and improve specific parts of the pot (i.e. handles and bases). Lack of clear comparisons between surface replicas and the original ones confirms that these sherd tools are unsuitable for fired pot surface finishing or for final surface treatments. Moreover, experiments showed that wear on active surfaces appears after a short period of time, thus consolidating the hypothesis that Colle Santo Stefano pottery smoothers were not part of a specialist's kit, but opportunistic tools used only once and then discarded.

Acknowledgements

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OLD CERAMICS FIRING KILNS IN SOUTHERN RUSSIAN FAR EAST: FROM PREHISTORY TO THE RECENT PAST

Irina S. Zhushchikhovskaya and Yuri G. Nikitin

Institute of History, Archaeology & Ethnography of the Peoples of the Far East, Far Eastern Branch of Russian Academy of Sciences
Email: irina1zh@mail.ru; urgen55@yandex.ru

Introduction

The purpose of this article is to present our research on the history of old ceramics firing kilns in the southern part of present day Russian Far East. The research area is the Primor'e region bordering northeast China and the northern part of the Korean peninsula (Figure 1).

The earliest appearances of ceramic technology in the studied territory date to around 13,000-12,000 years ago (Zhushchikhovskaya 2011; Kuzmin 2013). Pottery-making was one of the most important crafts of local populations from the Neolithic to the Early States epoch. In the course of pottery production history, technique and technology developed gradually. As archaeological records show, the earliest kiln-like structures for pottery firing were invented in