The role of grinding tools at Masseria Candelaro (southern Italy): an integrated approach of raw material, technological, use-wear and residues analysis

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Zusammenfassung – Der Fundplatz "Masseria Candelaro" ist in der sogenannten "Tavoliere" (Süditalien) gelegen, einer weiten durch das Adriatische Meer begrenzten Ebene. Die Siedlung ist eines der für die Region im Neolithikum typischen „befestigten Dörfer". Einzelne oder wehrhaftere Gräben schließen bewohnte Gebiete ein, die durch größere unbewohnte Regionen abgetrennt sind. Im Zentrum des umschlossenen Gebietes von Masseria Candalero wurde eine Konstruktion (Gebäude Q) aufgedeckt. Die beachtliche Größe dieser Konstruktion und das Fehlen von Pfostenlöchern oder Pflastern suggerieren, dass diese Anlage nicht bewohnt wurde. Das Gebäude ist zusätzlich durch rituelle Aktivitäten gekennzeichnet. Nachgewiesen sind Geräte aus Feuerstein und Obsidian, Keramik, Knochen und Geweihobjekte, schwere Steine, roter Ocker und Überreste einer häuslichen Fauna. Am Ende der Mittleren Neolithischen Phase III wurden alle drei Gräben im Rahmen von Bestattungszeremonien genutzt. Gebäude Q ist weiterhin wohl für verschiedene Zwecke in Benutzung, so werden die „Becken" und die Gruben verfüllt. Etwa 70 schwere Steine wurden in Schichten der Phasen II und III geborgen. Diese Funde konzentrieren sich innerhalb von Gebäude Q und repräsentieren im Besonderen kleine Mahl- und Schleifsteine sowie Stößel. Ein interdisziplinärer Ansatz mit Untersuchungen bezüglich der Rohmateriallagerstätten, typologischen und technologischen Analysen, sowie Gebrauchsspuren- und Rückstandsanalysen wurde durchgeführt, um zu einer Interpretation der sozio-ökonomischen Bedeutung dieser Objekte zu gelangen.

Schlüsselwörter – Masseria Candelaro – Süditalien – Neolithikum – Mahl- und Schleifsteine –sozio-ökonomische Bedeutung

Abstract – Masseria Candelaro is located in the so-called "*Tavoliere*" (Southern Italy), a wide plain bounded by the Adriatic Sea. This settlement is one of the Neolithic "entrenched villages" that distinguish this region. Single or more defensive ditches enclosed inhabited areas which were partitioned by wide empty spaces. In the central part of the enclosed area of Masseria Candelaro a structure (Building Q) has been found. The remarkable dimensions of this structure and the lack of post-holes and plaster suggest that this unit has not residential function. Evidence for ritual activities characterises also the building. Flint and obsidian industry, pottery, bone or antler objects, ground stone tools, red ochre and remains of domestic fauna are attested.
During Final Middle Neolithic phase III, all the three ditches were used for burial purposes. At this time building Q is still in use but, probably, for different purposes, as the "basins" and the pits are filled up. About 70 ground stone tools have been found in phases II and III. These remains are concentred in building Q and are represented especially by small grinding tools and pestles.
With the aim of interpreting the socio-economic role of these objects an interdisciplinary approach has been carried out which includes the study of raw material sources, typological, technological, use-wear and residues analyses.

Keywords – Masseria Candelaro – Southern Italy – Neolithic – grinding tools – socio-economic role

The archaeological context

The settlement of Masseria Candelaro is one of the "entrenched villages" that characterise Neolithic of the Apulian "*Tavoliere*" (Southern Italy), a wide plain bounded by the Apennine Mountains to the West and by Adriatic Sea and the Gargano Promontory to the East (**fig. 1**).

These villages are organised in one or more defensive ditches enclosing inhabited areas which are partitioned by wide empty spaces (**fig. 2a**). Because of the remarkable dimension of the settlement sample areas were chosen to be systematically investigated. Three main phases of habitation were identified (**fig. 2b**):

1 – At the beginning of VIth millennium BC, during Early Neolithic (Candelaro I), a small ditch 1.50 m-2.20 m wide, encloses an area of about 0.5 ha, where no structures are visible. A small amount of pottery and lithics have been found in the deposit. The presence of few remains suggests that the ditch has been regularly cleaned and maintained in use.

The Early Neolithic phase of Masseria Candelaro is characterised by exploitation of local raw materials such as flint and clay. Technological sequences applied to local flint pebbles have been directed to very expedient products, namely flakes, rarely retouched, and choppers. Early Neolithic pottery shows very simple shapes as to ovoid pots, with smoothed or impressed surfaces ("*impressa*" ware) and smaller open vessels, with burnished surface (plain ware).

No evidence of ground stones is attested in this phase.

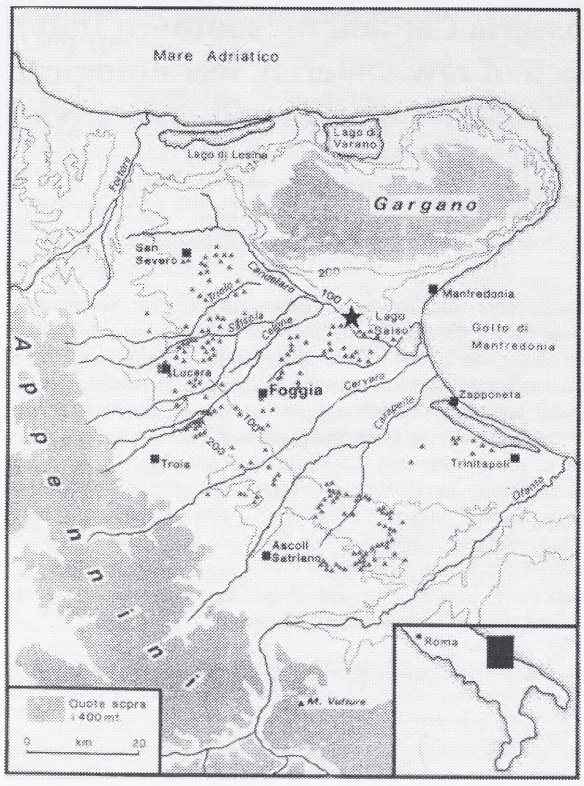


Fig. 1 Distribution of Neolithic entrenched villages of Tavoliere: Masseria Candelaro is marked by a star.

2 – The village was abandoned until the half of VI millennium BC, when three big concentric ditches have been dug. The diameter of the biggest one measures approximately 300 m. At the end of this Middle Neolithic phase (Candelaro II) the ditches were progressively filled up, probably having lost of their original use.

In the central part of the enclosed area, a structure (Building Q) has been found. Building Q is characterised by large "basins" and "pits" with no clear function, apart from two of them which have been used as storage pits for cereals and chaff. The remarkable size of Building Q and the lack of post-holes and plaster suggest that this unit has not a residential function. The results of lithic analysis and pottery agree with this hypothesis.

On the other hand strong evidences for ritual activities characterise the building. Three pebbles painted with red ochre and three legs of *Ovis aries* in a pit, a big oval stone, which probably had been standing during the use of the site, and few bones of an infant have been found in the centre of the structure.

A great amount of flint and obsidian industry, pottery, bone and antler objects, ground stones, and domestic fauna are present both in the ditches and in Building Q.

3 – At the end of VI millennium BC, during Final Middle Neolithic (Candelaro III), all the three ditches were partly re-excavated and used for burial purposes. At this time Building Q was not more in use, as the "basins" and the pits are almost filled up. They were re-used for burials and ritual purposes.

During the Middle Neolithic important changes occur to Masseria Candelaro community. Both lithic and pottery are no more only a local production and the village seems to be part of a wide exchange network. Circulation of Lipari and Palmarola obsidian, in terms of raw material and knapped products, is well attested.

Flint raw material comes mainly from the quarries of Gargano district about 50 kilometres far from Masseria Candelaro. The fine textured Gargano flint has been exclusively used for blades production.

Middle Neolithic pottery shows some substantial shift in the whole production sequence as suggested by the use of non local clay sources (cropping out about 30 km apart) and the appearance of three main classes of pottery, among which is a fine red-painted ware (*figulina*) strictly related to ritual and/or funerary uses.

The geological context

The Tavoliere is the most extensive plain in Southern Italy. It is a Mesozoic-Palaeogene limestone depression filled with marine deposits of Plio-Pleistocene silty clay (Bradanic cycle), often overlaid by post-Calabrian marine sands (Terraced marine deposits), Upper Pleistocene (Terraced alluvial deposits) and Holocene alluvial and lacustrine deposits of continental origin. The outcrops characterizing the Gargano Promontory consist of calcareous and dolomitic formations, the age of which varies between Upper Jurassic and Plio-Pleistocene (Caldara/Pennetta 1993) (**fig. 3**).

Sites settled in the Manfredonia Gulf's area show a river alignment on small Pleistocene-Holocene outcrops covered by a thick limestone layer ("*crusta*"). Geological deposits, outcropping in the Manfredonia Gulf hinterland, are composed of Pleistocene-Holocene clastic sediments, the basement of which is formed by Pleistocene clays and Mesozoic carbonatic rock, the latter pertaining to the Apulian foreland. The sedimentary

Fig. 2 a, Aerial view of Masseria Candelaro (after JONES 1987); b, Plan of the excavated area. Light grey: Candelaro I; medium grey: Candelaro II; dark grey: Candelaro III.

deposits, lying all around Masseria Candelaro, are extremely diversified. Sand layers with pebble lenses and clay horizons, and with ballstone intercalations are one of the main lithic characteristics of the sedimentary sequences. Clays and marly and fossiliferous clays are present locally, together with polygenic conglomerates highly cemented in a sandy matrix. All over the area

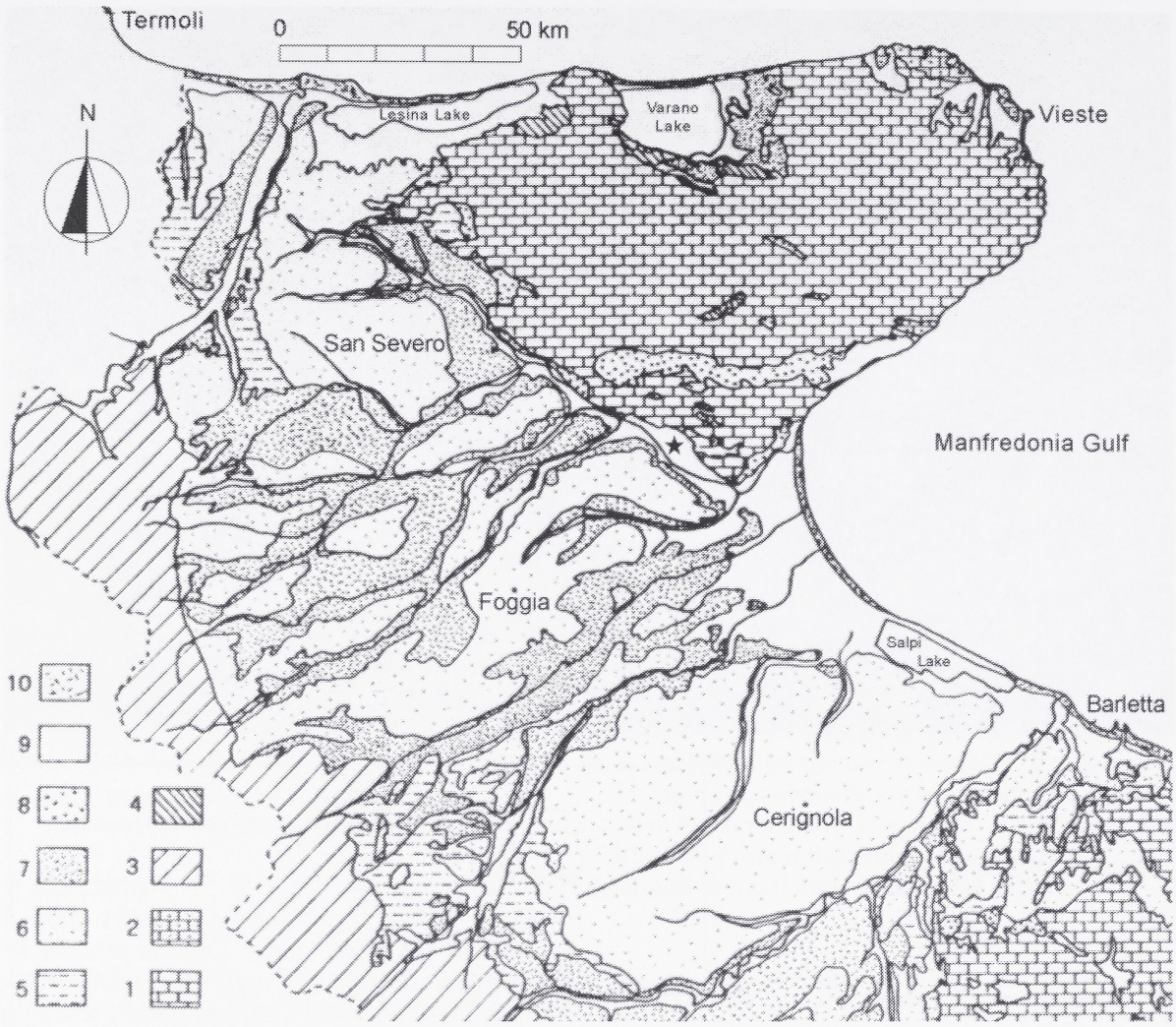


Fig. 3 Geological sketch map of Tavoliere area (modified after CALDARA/PENNETTA 1993, fig. 3): Masseria Candelaro is marked by a star. 1: Limestone (Mesozoic); 2: Calcarenites (Eocene); 3: Apenninic Chain Units (from Cretaceous to Pliocene); 4: Calcarenites (Miocene); 5: Bradano Units (Pliocene-Lower Pleistocene); 6: Terraced marine deposits (Upper-Middle Pleistocene), 7: Terraced alluvial deposits (Upper Pleistocene), 8: Detritic deposits; 9: Alluvial and lacustrine deposits; 10: coastal dunes and beaches.

there are ballstones and calcareous layer outcrops. Alluvial terraces are mainly constituted by sandy and clayey sediments; late alluvial deposits are formed by pebbles and other heteromorphic elements derived by flysch (CALDARA ET AL. 2004).

Ground stones

Ground stones come from Building Q and from the external ditch and are related to Phases II and III (**fig. 4**).

Raw material

Mineralogical studies were carried out by powder X-ray diffraction analysis (PXRD) using a Philips diffractometer (PW 1710) with Ni-filtered CuKα radiation and employing NaF as an internal standard. They have been completed by petrological observation on thin sections, with a polarized light microscope (OM). Major element determination was performed by X-ray fluorescence (XRF), using a Philips PW 1480/10 spectrometer (Cr anticathode for major and minor elements), following analytical techniques outlined by FRANZINI ET AL. 1975 (ACQUAFREDDA ET AL. 2004).

The ground stones were formed of various types of stone: sandstone, limestone, calcarenite, dolomite and calcareous dolomite, which occurred in different quantities and with a notable variability of lithotypes. The limestones, although there were only two examples of them,

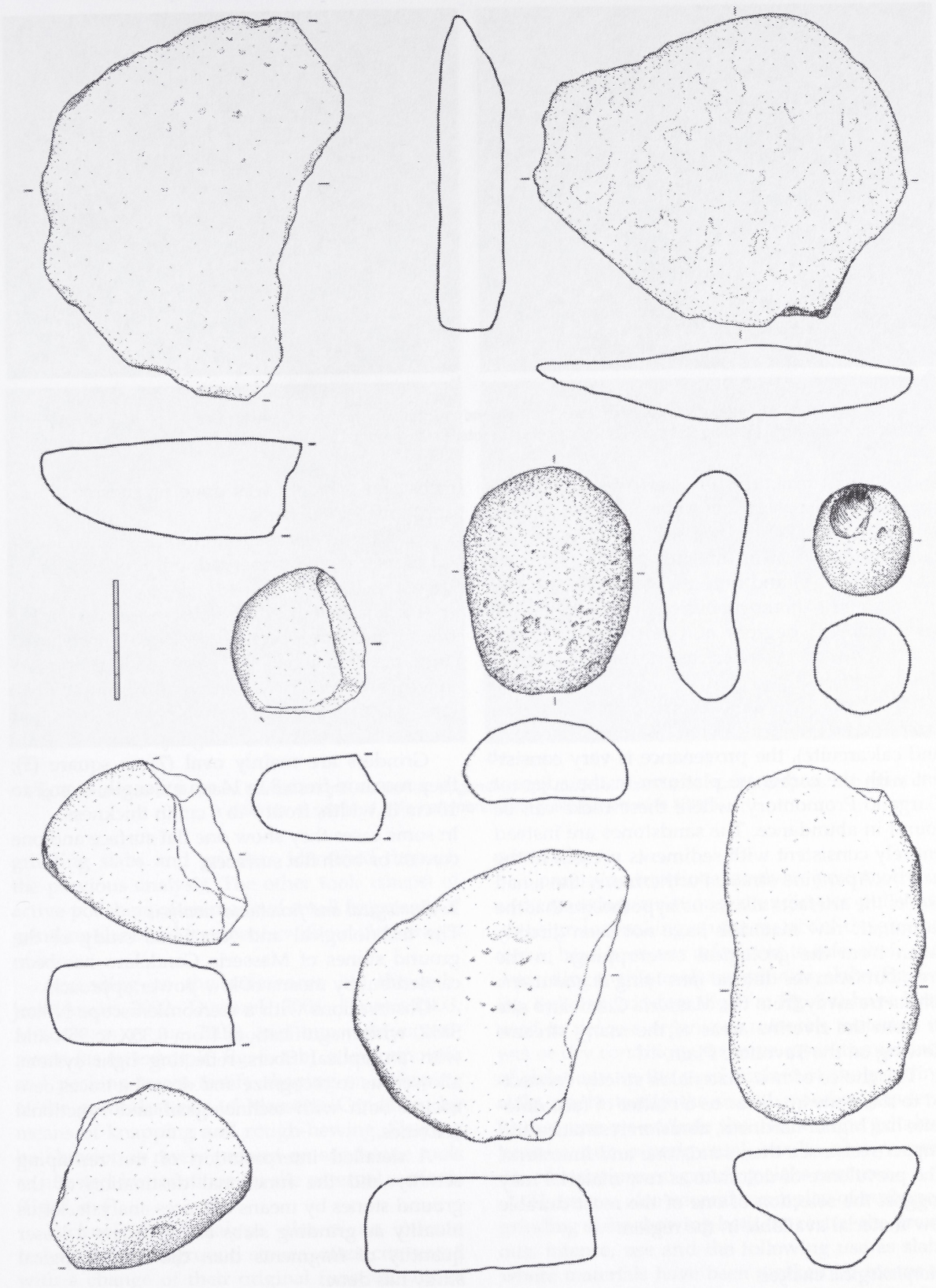
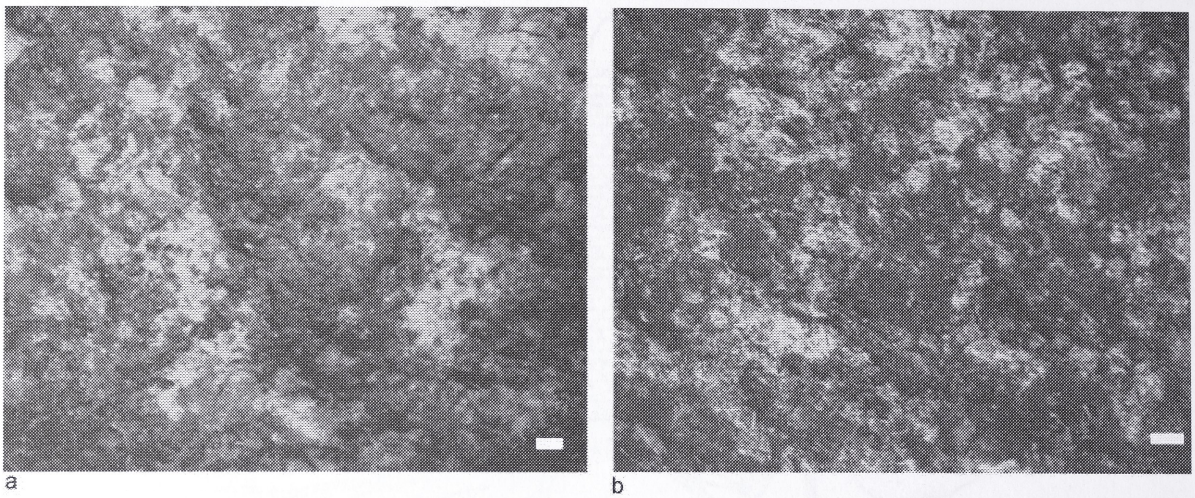


Fig. 4 Ground stone tools from Masseria Candelaro.



a b

Fig. 5 Experimental ground stones: a, slab used to pestle and to grind nuts, hazelnuts, seeds (note the pecking traces that affect the surface); b, grinding slabs used to grind cereals (note the flat topography of the surface); scale bar equal to 1mm.

had different structures, one was a *wackestone* and the other was a *packstone*. Among the two largest groups, the sandstones had slightly different proportions of the main minerals (quartz, feldspar and carbonates) and only the dolomites seemed to have a more homogenous composition, though with different degrees of porosity. Finally the last two samples were calcarenite and calcareous dolomite.

With regard to the carbonatic ground stones (made of dolomite, calcareous dolomite, limestone and calcarenite), the provenance is very consistent with the carbonate platform in the adjacent Gargano Promontory, where these rocks can be found in abundance. The sandstones are instead entirely consistent with sediments present in the nearby Apennine strata. Furthermore, the small size of the artefacts allows us hypothesise that the carbonatic raw materials have not been directly taken from the geological outcroppings in the area, but from the detrital fans lying at about one kilometre away from the Masseria Candelaro site or from the riverine areas of the many streams flowing on the Tavoliere Plain.

The choice of raw material is strictly connected to the stone qualities: as a matter of fact, dolomite has higher hardness, abrasion resistance and impact resistance than sandstone and limestone. The prevalence of dolomite as raw material may suggest the selection of one of the most durable raw material available in the region.

Morphological analysis

The site provided a total amount of 46 pieces: 34 were identifies as grinding slabs, 12 as grinders. The preliminary distinction between grinding slabs and grinders was done on morphological and dimensional basis.

Grinding slabs are found in fragments, while grinders are well preserved, only 5 pieces being fragmented.

The shape of grinding slabs is mostly oval. The dimensions have been reconstructed measuring the fragments which have one edge preserved: length is from 20 to 40 cm, width from 10 to 16 cm. Working surfaces are mainly flat, only four are concave, and two are slightly convex.

Grinders are mainly oval (7) or square (5); they measure from 8 to 14 cm in length, from 7 to 10 cm in width, from 3 to 6 cm in thickness.
In some cases they show one flat surface and one convex or both flat surfaces.

Technological and functional analysis

The technological and functional study of the ground stones of Masseria Candelaro has been carried out by means of low-power approach.

Observations with a stereomicroscope Nikon SMZ, with magnifications from 0,35X to 35X and with an optical fibers reflecting light system, allowed us to recognize and describe traces connected both with technological and functional activities.

A detailed interpretation of the reshaping activity and the functional destination of the ground stones by means of traces analysis, let us identify as grinding slabs and grinders a lesser quantity of fragments than the morphological study has done.

As a matter of fact, traces analysis showed that 26 ground stones were used as grinders, grinding slabs and multipurpose slabs versus the 46

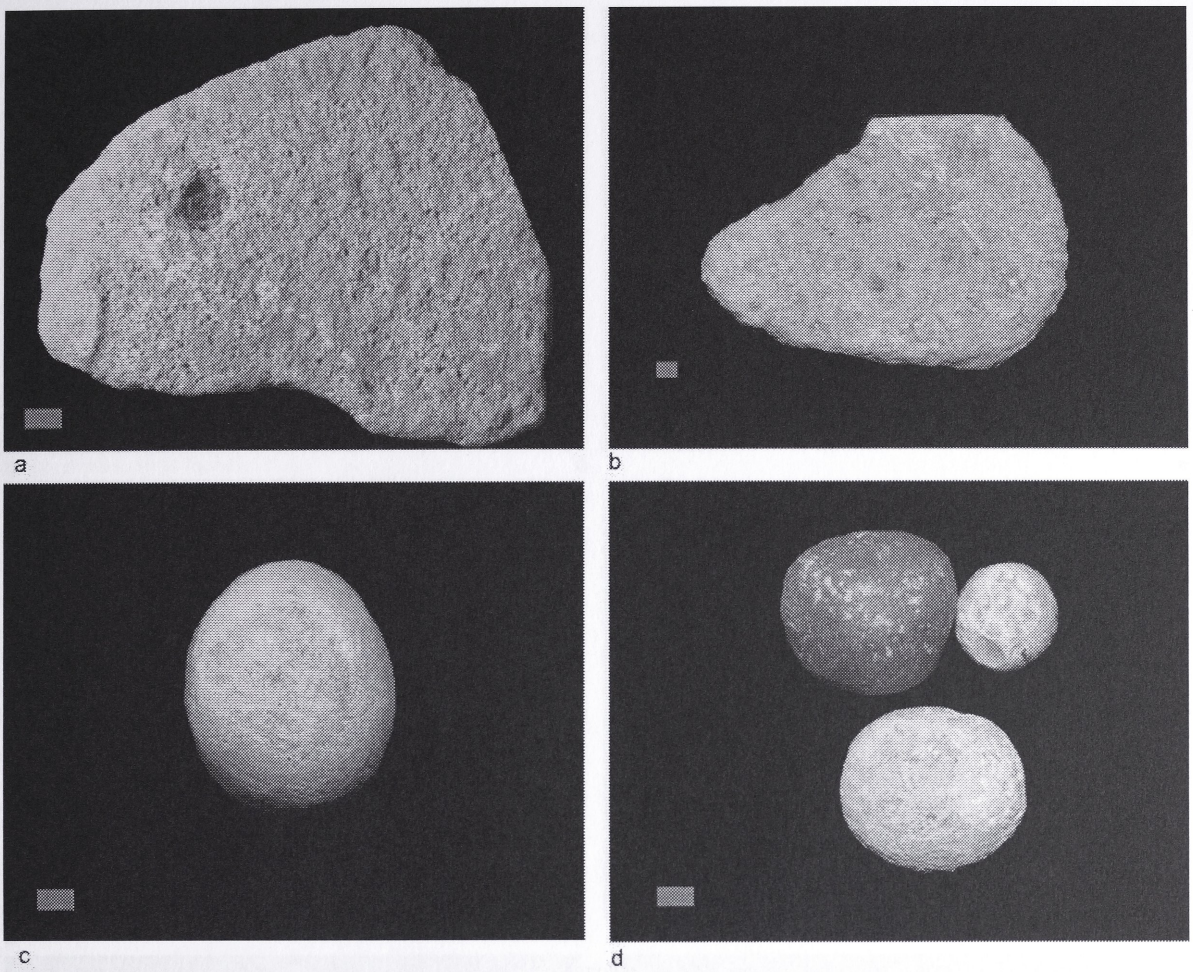


Fig. 6 Examples of Masseria Candelaro ground stones: a, grinding slab made of dolomia; b, multiple-purpose slab made of dolomia; c, pestle; d, little hammerstones; scale bar equal to 50mm.

grinding slabs and grinders identified through the previous analysis. The other tools consist of active polishers often made of small fragments of grinding slabs and fragments without clear traces of use.

According to the references on the subject (Adams 2002; Dubreuil 2004; Hamon 2003; Menasanch et al. 2002) and our own experiments (as an example, fig. 5, a-b), edge-removals and pecking traces testify shaping or reshaping of the ground stones of Masseria Candelaro by means of knapping and rough-hewing. Shaping by abrasion is rarely present on sandstone tools as attested by striations on the external surfaces (**fig. 8, e-f**).

Technological analysis shows an intense reshaping of the ground stones, often connected with a change of their original function. As an example, small fragments of grinding slabs or grinders became active polishers or many big fragments of grinding slabs became multipurpose slabs.

Concerning functional analysis, pecking traces and removing, striations, rounding or polishing of the grains making up the matrix of the ground stones have been our references to infer their use. According to this analysis, grinding slabs (**fig. 6 a; fig. 8 e**) and grinders (**fig. 7 a; fig. 8 c**) have been used to process organic or minerals materials in wet or dry conditions. In some cases, the absence of striations on the used surface of the grinding slabs might testify the use of wooden grinders. In that case we exclude the use of stone grinders because our experimental results always produced striations on grinding slabs surfaces.

There are also several examples of reshaped grinding slabs showing both the rest of the previous, intense, use and the following use as slabs where materials have been worked by means of thrusting and resting percussion (**fig. 6 b; fig. 8 a; fig. 9**).

On the worked surface of the grinding slabs

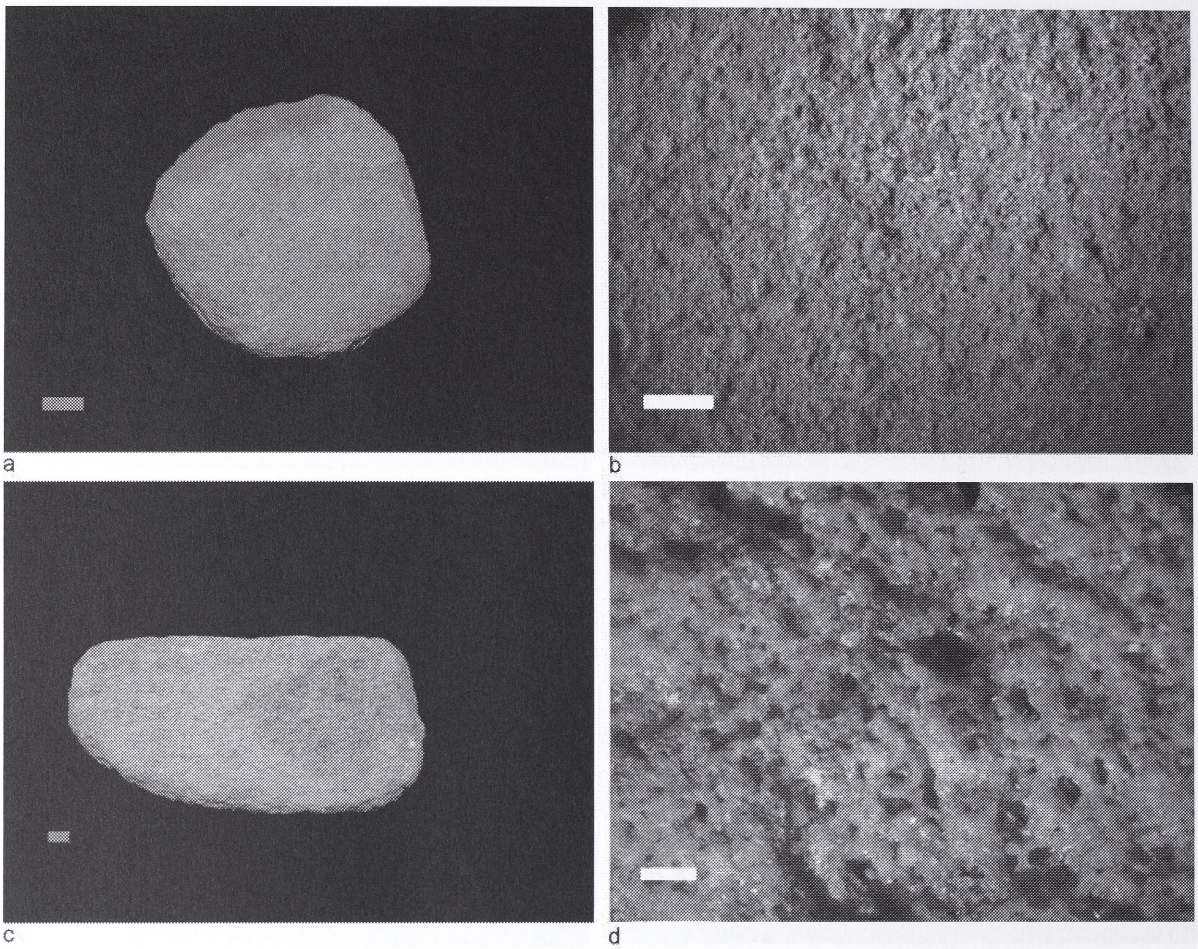


Fig. 7 Masseria Candelaro Phase II: a, grinder made of dolomia used to grind ochre; b, detail of the rounded and very flat surface, characterized by striations and spots of ochre (dark grey spots); c, active polisher made of dolomia; d, detail of the rounded, bright polished surface, characterized by spots of ochre (dark grey spots); scale bar equal to 50mm (pictures a, c) and equal to 1mm (pictures b, d).

we rarely observed the removals of matrix particles. Only one fragment of limestone slab shows this type of stress fatigue. Both dolomite and sandstone have a cemented matrix which prevents from loosing stone particles during use. Maybe, this was a pursued characteristic, especially for food processing.

In addition, four hammerstones (**fig. 6 d**) attest the reshaping activity and six pestles (**fig. 6 c**) confirm thrusting percussion.

In the following parts of our presentation we will discuss our techno-functional results in a chronological perspective, according to the two phases of the Middle Neolithic of Masseria Candelaro, and in a spatial perspective comparing the ground stones of Building Q with those collected from the ditch.

Middle Neolithic – Candelaro Phase II

The 11 tools come exclusively from the Building Q. The ground stones are all made of dolomite (**fig. 6 a-b**).

Three grinders have been recognized, one of them has been shortly used as well as little slab. One grinder has been used to work medium hard material, while the other two grinders have intensively ground red ochre on a stone surface (**fig. 7 a**).

As a matter of fact, the two small grinders show rounded griping surfaces that testify a very long manipulation. Moreover, the grains of the active surface are very rounded, with a developed polish and dense striations which suggest red ochre processing on a stone surface (**fig. 7 b**). It is interesting to point out that in the same area an active polisher has been found (**fig. 7 c**), showing red ochre residues, with light but diffuse edge-rounding, bright polish and few shallow striations (**fig. 7 d**) that suggests the contact with a soft and abrasive material like skin.

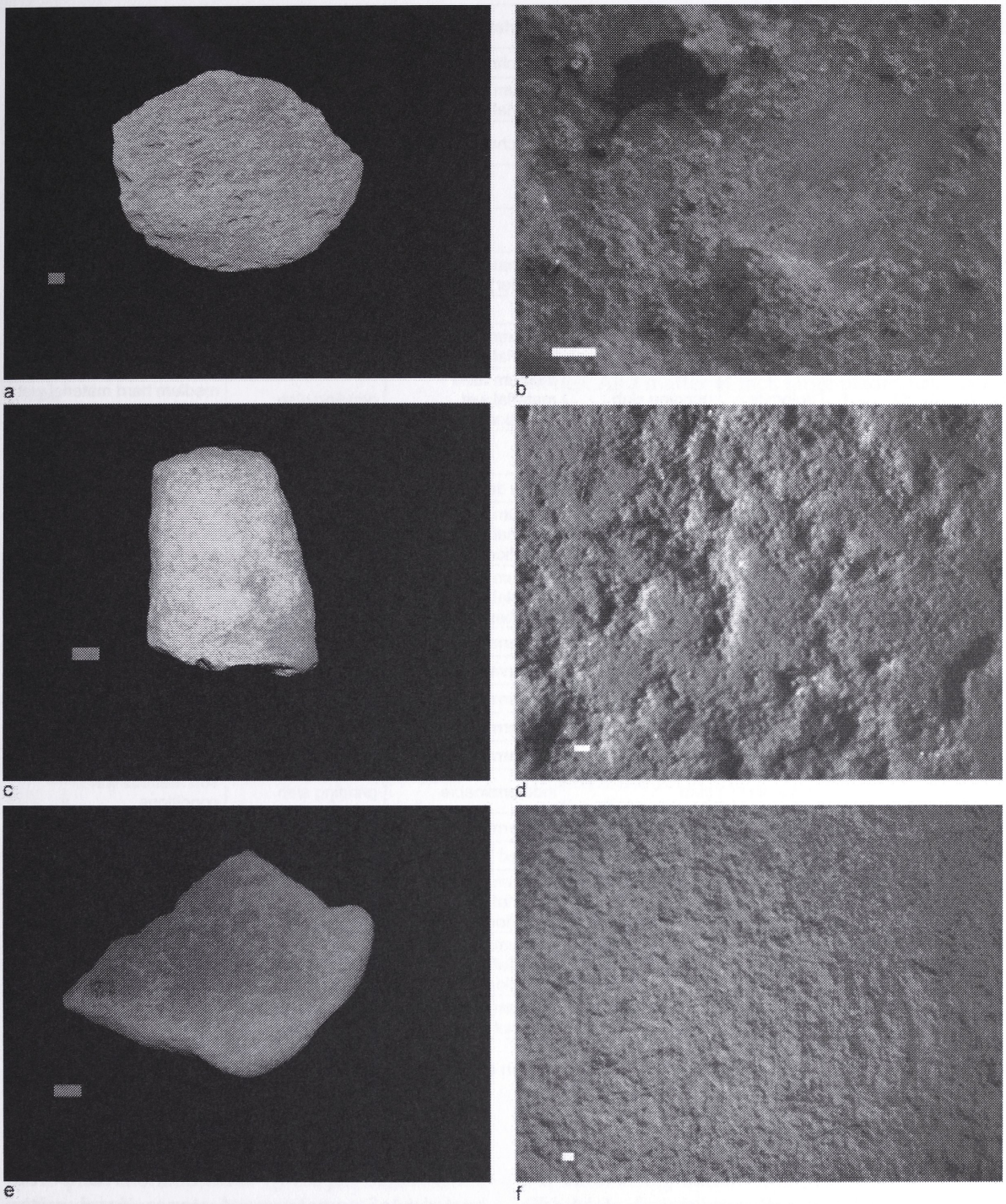


Fig. 8 Masseria Candelaro Phase II: a, fragment of multiple-purpose slab; b, detail of the surface carachterized by pecking traces that affect a flat topography related to a previous use as grinding slab; Masseria Candekaro III: c, grinder made of sandstone used to grinding medium hard material; d, detail of the flat surface; e, fragment of a grinding slab made of sandstone; f, detail of the external surface of the grinding slab showing striations related to technological shaping by abrading; scale bar equal to 50mm (pictures a, c, e) and equal to 1mm (pictures b, d, f).

These data suggest that the treatment of this mineral should have been connected with the colouring of tanned skin. This hypothesis is supported by the functional data coming from traces analysis of the chipped stones. In this phase, many large blades have been intensively used both to remove the subcutis from the fresh skin and to cut tanned, red colored skin or, more

Phase	Area	N°	Raw material	Interpretation	Material worked	Previous use	Previous material worked
II	Q	2	dolomite	grinders	red ochre		
II	Q	1	dolomite	grinder	medium hard material		
II	Q	1	dolomite	slab	red ochre	grinding slab	medium hard material wet conditions
II	Q	1	dolomite	slab		grinding slab	medium hard material wet conditions
II	Q	1	dolomite	slab		grinding slab	abrasive material wet conditions
II	Q	1	dolomite	grinder+slab (occasional)	soft material (grinder)		
II	Q	1	dolomite	grinder+slab		grinding slab	soft material
II	Q	1	dolomite	grinding slab or grinder	medium hard material	grinding slab	medium hard material
II	Q	1	dolomite	grinding slab	medium hard material wet conditions	grinding slab	medium hard material wet conditions
II	Q	1	dolomite	grinding slab or grinder			
III	Q	1	sandstone	grinder	fleshy tissues		
III	Q	1	sandstone	grinder	medium hard material dry conditions		
III	Q	1	dolomite	grinding slab	medium hard material wet conditions		
III	Q	1	dolomite	grinding slab	indeterminable		
III	Q	1	dolomite	grinder-pounder	abrasive material		
III	Q	1	dolomite	grinding slab	indeterminable		
III	Q	1	sandstone	grinding slab	indeterminable		
III	Q	1	sandstone	grinding slab	indeterminable		
III	Ditch	1	dolomite	slab	indeterminable	grinding slab	soft material wet conditions
III	Ditch	1	dolomite	slab	indeterminable	grinding slab	
III	Ditch	1	dolomite	grinding slab	unused		
III	Ditch	1	dolomite	grinding slab	medium hard material dry conditions		
III	Ditch	1	sandstone	grinding slab	medium hard material dry conditions		
III	Ditch	1	limestone	grinding slab	medium hard material		

Fig. 9 Techno–functional interpretation of Masseria Candelaro ground stones.

rarely, to scrape red ochre on the skin.

Moreover, red ochre was frequently used for *figulina* pottery decoration, painted in red exquisite geometric patterns, typical of Middle Neolithic of Southern Italy. Middle Neolithic potters of Masseria Candelaro village probably exploit, as colouring materials, a continental sedimentary deposit (*terra rossa*), very rich of iron oxides, which could be gathered from the calcareous slopes of the Gargano Promontory. Inorganic red deposits, observed on the interior surfaces of some open black burnished pots, were previously analysed and interpreted as dyes used in vessel and/or skin decoration (Muntoni 1999).

The residues of reddish-colour inorganic materials, macroscopically identified on the porous surfaces of some ground stones, were micro-analysed with a Cambridge Instruments S360 Scanning Electronic Microscope (SEM), equipped with an Oxford-Link ED spectrometer. The aim was to verify the hypothesis that these incrustations were residues of the materials that have been ground in the past and that have been conserved on the surface of the ground stones, due to the porosity of the stones (Acquafredda et al. 2004) (**fig. 10**).

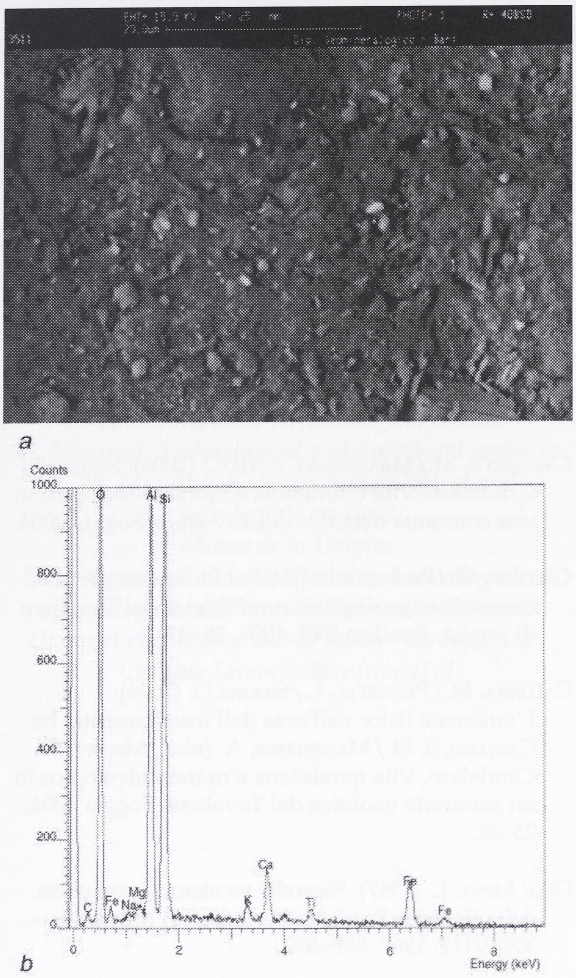


Fig. 10 BSD image (a) and EDS microanalysis (b) of reddish-colour inorganic residues (terra rossa).

The EDS microanalyses on some reddish lumps showed a chemical composition largely made up of SiO_2 (x=46%) and Al_2O_3 (x=35%), and a smaller amount of FeO (x=11%). These results are not dissimilar from those for *terra rossa*. "*Terra rossa*" are silty-clayey continental sedimentary deposits, which are very poor in carbonate (Dell'Anna 1967; Dell'Anna/Garavelli 1968), and are composed of dominant clay minerals (illite and kaolinite) and Fe-oxides/hydroxides, with subordinate quantities of quartz, feldspars, micas and pyroxenes. SiO_2, Al_2O_3 and Fe_2O_3 were the main oxides, both in the clay fraction, and in the specimen as a whole. Considering the absence of this type of sediment at the findingspots of the artefacts, these materials, seen on the surface of the ground stones, could be the residues of dyes used in one or more activities.

As far as the other ground stones from Candelaro Phase II are concerned, grinding slabs consist of only one fragment. This tool has been used to work medium hard material.

Four other tools, defined as slabs, show traces of diffuse thrusting and resting percussion. On one tool, residues of red ochre have been found on both its working surfaces (**fig. 6b**). All the four tools show on their surface traces of a previous, sometimes intense, use as grinding slabs processing soft, medium hard and abrasive materials.

These small recycled slabs have probably had various expedient functions as breaking seeds, breaking and smoothing vegetal fibers and tendons or minerals. Evidence of these activities also comes out from the use-wear data of the chipped stones. As a matter of fact, large blades have been used, other than to work tanned skin, also to cut fleshy tissues and a big variety of herbaceous plants and wood. In addition, the light abrasion of the cutting edge observed on some tools and the presence of calcite residues, detected by Infrared Fourier Spectroscopy, suggests that the activities were carried out on stone slabs.

Final Middle Neolithic - Candelaro Phase III

15 ground stones constitute the assemblage of this phase (**fig. 8c-f**). Eight tools are made of dolomite, six are made of sandstone (**fig. 8 c, e** and one of limestone (*packstone*). The unique functional difference between the two groups concerns the recycling that was carried out only on the dolomite tools changing their use from grinding slab to multipurpose slabs.

Eight ground stones come from Building Q. Five fragments of grinding slabs (three made out of dolomite and two made out of sandstone) have been recognized. Only one dolomite tool shows unambiguous traces of both a resting circular percussion and a contact with a medium hard material in a wet condition.

Two grinders made of sandstone have been used respectively to work medium hard material in a dry condition (**fig. 8c-d**), as the lacking of polish suggests, and, probably, fleshy tissues in the other one, as indicated by light and diffused edge-rounding and polish. There is one more fragment of dolomite grinder/pounder, which has been related to the intense work of abrasive materials.

The ditch provided seven ground stones, four fragments of grinding slab, made of different kinds of raw materials (dolomite, sandstone and limestone), two dolomite slabs recycled from grinding slabs and one intensively used fragment of grinders or grinding slab made of sandstone.

Except for one unused grinding slab, the

remaining tools have been used to work medium hard materials both in dry and wet conditions.

The ditch and the Building Q don't show any significant difference concerning their ground stones assemblage except for the presence of the recycled slabs in the ditch deposit.

The functional picture seems quite homogeneous and oriented to the process of organic materials (animals and plants) by grinding. These data agree with the results of use-wear analysis of chipped industry, which testify an important presence of meat cutting and cereals harvesting during this phase. As observed for Phase II, the abrasion of the edge testifies the use of stone slabs.

Conclusions

Phase II and Phase III of Masseria Candelaro are both characterized by ground stones related to a great variety of organic and mineral materials. This apparently uniform picture shows, nevertheless, some significant distinctions, which can be summarized as follows.

During Candelaro Phase II ground stones are exclusively present in Building Q, while in Candelaro Phase III both Building Q and the ditch provided grinding stone tools.

Phase II is characterized by a greater recycling of dolomite tools in order to obtain multipurpose slabs for grinding, pounding, cracking related to both food preparation and craft activities. On the contrary, in Phase III recycling is rare and the choice of the raw materials is less selective, suggesting a minor care in the maintenance of the ground stones.

Nevertheless it is important to point out that recycling reduces the visibility of previous activities, so that the complex history of each grinding stone tool cannot be completely detected.

As far as the use of ground stones is concerned, during Phase III grinding of organic materials is the most testified function, suggesting a shift towards a major presence of food preparation versus craft activities. It is notworthy that this major change in Phase III is related to a discontinuous use of the site, which at this time was especially devoted to funerary and ritual practices.

An intriguing picture is therefore emerging: typical daily-life activities are attested in a non-domestic context, giving us some clues about the ideological world of these agricultural Neolithic communities.

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