

Absolute dating of three ancient kilns excavated at Canosa di Puglia through archaeomagnetism

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Abstract – Absolute dating techniques can offer important information about the chronological framework of archaeological findings mainly in the case of rescue excavations where the time and the resources for extended archaeological investigations are not available. In this study we present the dating results of three ancient kilns excavated near Canosa di Puglia, discovered during the construction of a new road. Archaeomagnetic investigation was carried out on 24 oriented *in situ* samples that allowed the determination of the direction of the Earth's magnetic field at the time of the kilns' last firing. The obtained results show stable remanent magnetization and well-defined mean archaeomagnetic directions. Comparison of the results with the geomagnetic reference Secular Variation curve available for Italy show that the two kilns were abandoned contemporaneously and no later than the first half of the VI century AD while the third kiln could have still been in use till the VII century AD. Such results are in good agreement with the available archaeological evidence and show that most probably there was an important workshop in the area used for at least a couple of centuries.

I. INTRODUCTION

Ancient wood-fired kilns are commonly used in antiquity to produce pottery and/or construction ceramic artifacts such as tiles and bricks. They are important findings from both archaeological and cultural points of view as they can offer significant information about the ancient firing technology and its evolution over time, the fuel used and the interaction between artisans and environment, as well as the fire and temperature control skills at different periods in the past. Moreover, they can be used for dating purposes based either on the style of the pottery and ceramic artifacts produced or on the physical properties of the baked clays from the kilns' walls and on the charcoal residuals from the combustion processes. In fact, absolute dating techniques such as radiocarbon [1, 2], thermoluminescence and archaeomagnetism [3, 4] are the

most promising techniques for the dating of ancient kilns [5], according to the suitable material and the resources available.

Here, we present the results of an archaeomagnetic investigation carried out on three ancient kilns excavated at the locality of Cava delle Murgette, around 1 km from Canosa di Puglia town (Southern Italy). This study is based on the ability of the clays used for the construction of the kilns to register the direction of the Earth's magnetic field during their last firing [6, 7] and to the possibility to experimentally retrieve this remanent magnetization record nowadays and compare it with reference Secular Variation (SV) curves, which describe how the Earth's magnetic field was changing in the past [8, 9]. Archaeomagnetic dating, even if much more recently developed technique and less broadly used in respect to radiocarbon and thermoluminescence, has already proved to be a promising dating tool for archaeology, contributing to the preservation and evaluation of the cultural heritage mainly in the case of rescue excavations [10, 11].

II. ARCHAEOLOGICAL SITE AND SAMPLING

In 2019, during the works for the expansion of a local road (province road N.2), a rescue archaeological excavation carried out by Cooperativa Archeologia (Firenze), in collaboration with the *Soprintendenza archeologia belle arte e paesaggio per la provincia di Barletta Andria Trani e Foggia*, brought into light three ancient kilns at the locality of Cava delle Murgette (asse 23 - area 1), around 1 km south from the modern city of Canosa di Puglia (Southern Italy). The kilns (A, B, C) constructed in a short distance one from the other, are characterized by different typology and dimensions (Fig. 1). Kiln A is of sub-quadrangular form with dimensions of around 6,5 m x 2,5 m. It has a long praefurnium corridor excavated in the clay while the entrance of the kiln is supported by an arch made by tiles (Fig. 1a). In the center of the main combustion chamber a central pillar made by bricks is still preserved. Kiln B is of clearly smaller

dimensions, around 2,8 m x 1,8 m, and has an elliptic form. It is characterized by several perimetrical pillars, mainly made by baked clay (Fig. 1b). Kiln C is circular, of around 2 m diameter. Four perimetrical pillars were found, probably used to sustain the baking floor, which was still partially preserved (Fig. 1c).

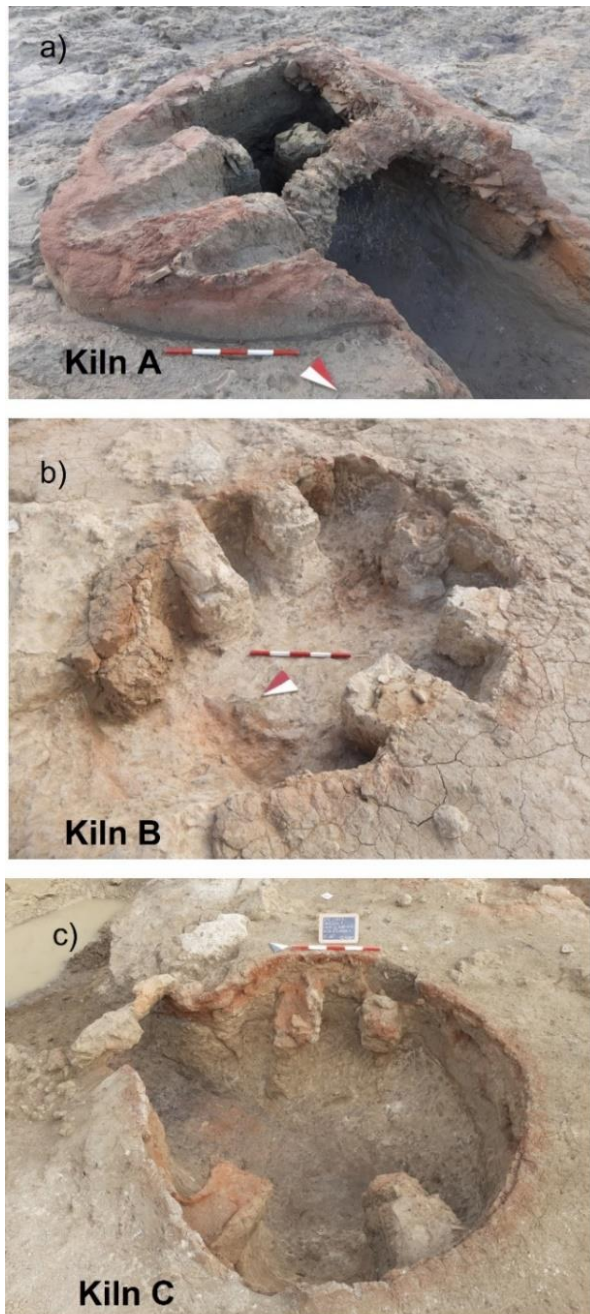


Fig. 1. Photos of the studied kilns: a) Kiln A; b) Kiln B and c) Kiln C (Photos courtesy: SABAP BAT and FG)

For archaeomagnetic investigation, at least 10 oriented *in situ* samples were collected from each kiln, mainly

baked clays and fragments of bricks and tiles from the kilns' walls and pillars, as well as some baked clay pieces from the baking floor (in the case of Kiln C). In all cases, the samples were oriented *in situ* with both a magnetic and a solar compass and an inclinometer before removing them from their original firing position.

III. METHODS AND RESULTS

Magnetic analyses were performed at the ALP-CIMaN Palaeomagnetic Laboratory (Peveragno, Italy). The Natural Remanent Magnetization (NRM) of all samples was first measured with a JR6 Spinner magnetometer (AGICO). Then a selection of samples was stepwise demagnetized in 10 to 12 steps. Tiles and brick samples were thermally demagnetized from room temperature up to a maximum of 540 °C with a TD 48-SC (ASC Scientific) furnace, while baked clay samples oriented with the use of small plastic disks were alternating field (AF) demagnetized up to a peak field of 100 mT with a D-2000 (ASC Scientific) AF demagnetizer. Demagnetization results were elaborated with the Remasoft software [12].

Samples from all three kilns showed a stable and single remanent magnetization component, with linear and well-defined Zijderveld diagrams (Fig. 2). Samples coming from the arch of Kiln A and tile samples from the pillars of Kiln B showed dispersed directions suggesting that the arch was slightly tilted in respect to its original position while the tiles found in the pillars were most probably not in their original position. These samples were excluded from any further interpretation.

The direction of the Characteristic Remanent Magnetization (ChRM) was determined for each sample according to principal component analysis [13]. Then, the mean direction for each kiln was calculated according to Fisher statistics [14] and is reported in Table 1, together with the statistical parameters of the semi angle of confidence α_{95} and the precision parameter k . In all cases, the mean direction is well defined with α_{95} angle of confidence lower than 5 degrees.

Table 1. Mean archaeomagnetic directions for the three studied kilns.

	N	D (°)	I (°)	α_{95} (°)	k
Kiln A	12	6.0	54.4	3.2	188
Kiln B	6	1.7	54.3	4.8	198
Kiln C	6	354.3	62.4	4.4	230

Symbols: N = number of independently oriented samples; D = mean declination; I = mean inclination; α_{95} = 95% semi-angle of confidence; k = Fisher's precision parameter

IV. ARCHAEOMAGNETIC DATING

The mean direction obtained from each kiln was used for calculating the time of the last firing after comparison with the reference Secular Variation curves recently published for Italy [15].

Such comparison was made separately for declination and inclination while the final dating interval was obtained after the combination of the separate probability densities using the `archaeo_dating` Matlab tool [16].

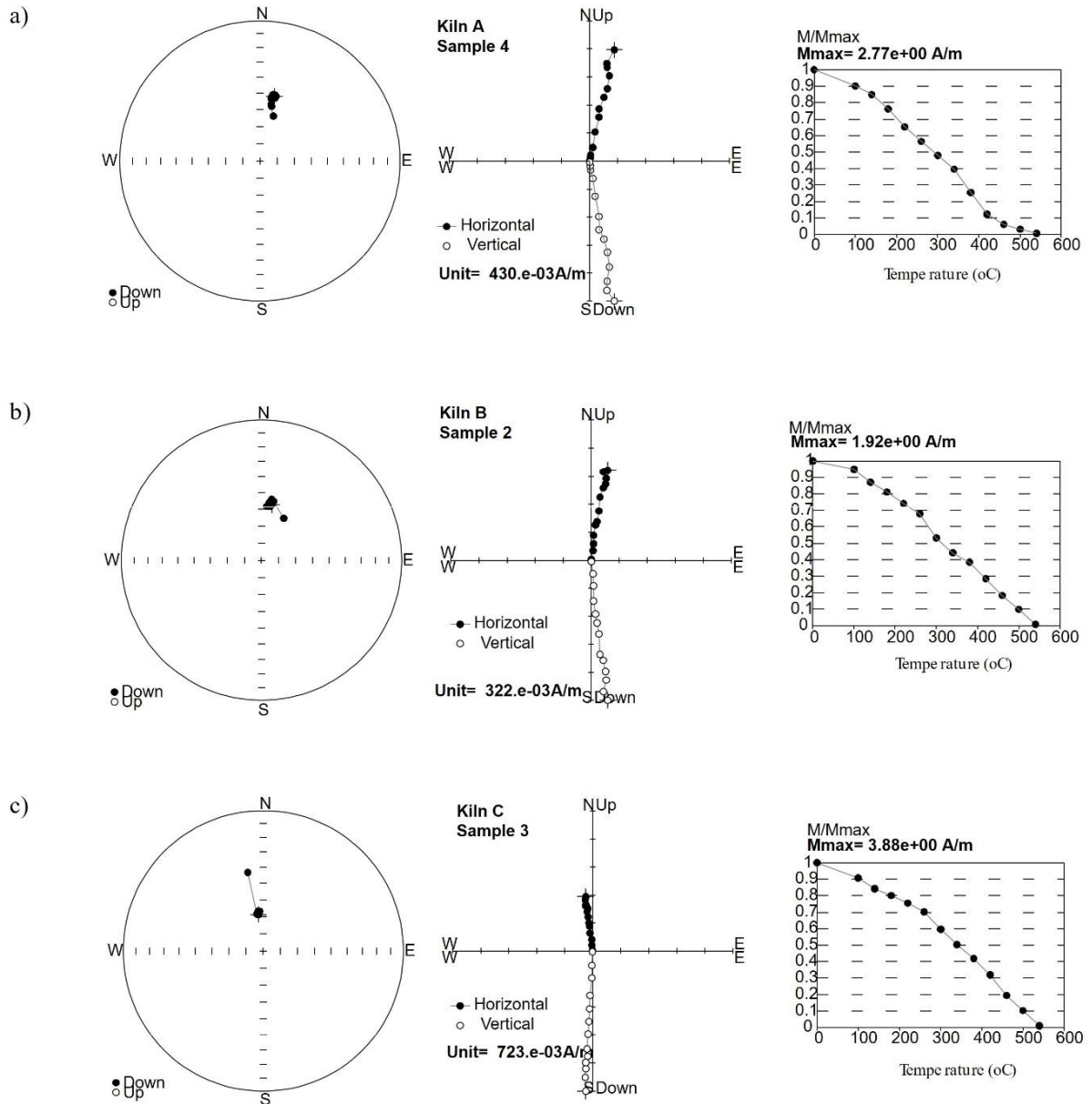


Fig. 2. Thermal demagnetization results for representative samples from a) Kiln A, b) Kiln B and c) Kiln C. Left: Equal area projection; Middle: Zijderveld diagram; Right: Intensity decay curve

Considering the time period from 0 to 1000 AD, archaeomagnetic dating suggests several possible dating intervals. However, based on the stratigraphy of the site and the available archaeological evidence which position the use of the kilns not earlier than the Late Antique period, among the various possibilities, it seems that the Kiln A was abandoned at 398-528 AD, the Kiln B at 223-499 AD and the Kiln C at 534-708 AD. All absolute dating intervals were calculated at 95% of probability and refer to the last firing of the kilns and thus correspond to their last use.

V. CONCLUSIONS

In the case of rescue excavations, the time and the resources available are limited and it is thus rare to have the possibility to explore large areas and carry out extended and thorough excavations which could permit the better understanding of the archaeological findings. In some cases, the findings themselves can be clear indicators of the importance of the site and its chronological framework while in others the use of laboratory-based dating methods is fundamental for obtaining more elements regarding the use and dating of the excavated discoveries. In this study, we used archaeomagnetic analysis in order to investigate the last use of three ancient kilns excavated near Canosa di Puglia. Our results suggest that the two kilns (Kiln A and B) have been most probably contemporaneously used and abandoned, while the third kiln (Kiln C) seems to be constructed and used after the abandonment of the others (Fig. 3).

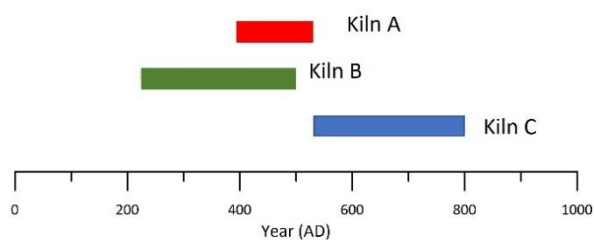


Fig. 3. Archaeomagnetic dating results for the three studied kilns

The obtained archaeomagnetic dating is in good agreement with the available archaeological evidence which suggest a Late Antique age (V-VI centuries AD) for the site based on the stratigraphy and few ceramic findings. The new data presented here suggest that the artisan

workshop found in the site could have been in use for several centuries, producing a large number of construction artifacts such as tiles and bricks. Based on these results, further archaeological study would be useful in order to investigate the use of such large quantity of bricks and their probable connection to important constructions in the nearby area.

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