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Archaeomagnetic study and thermoluminescence dating of Protobyzantine kilns (Megali Kypsa, North Greece)

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ABSTRACT

The large Protobyzantine settlement of Megali Kypsa was excavated at the NW part of Chalkidiki peninsula (North Greece). Among the numerous residential buildings a big ceramic complex with twelve kilns was unearthed. Nine of the kilns were preserved fairly well and the archaeological investigation suggested a large ceramic production for local use and exportation. The three best preserved kilns were sampled for an archaeomagnetic study, while numerous TL dating results in combination with archaeological information constrained the last use of the kilns from the end of the 4th to the middle of the 5th century AD. Rock magnetic analyses have been performed on pilot samples and identified magnetite as the main carrier of the natural remanent magnetisation. The samples were subjected to both alternating field and thermal demagnetisation providing reliable directions. Intensities were calculated with the Triaxe protocol and yielded a mean value of 61.2 ± 1.8 μT. The obtained results are compared with regional and global geomagnetic field models (SCHA.DIF.3K and ARCH.3K). Our study provides 3 new full-vector data, improving the resolution of the Greek secular variation curve for this poorly documented period.

1. Introduction

The number of archaeomagnetic studies is nowadays increasing worldwide, with a particular flourishing in Europe. Constant progress during the last decades resulted in several regional databases and Secular Variation Curves (SVCs) for directions (Gallet et al., 2002; Schnepp and Lanos, 2005; Gómez-Paccard et al., 2006; Márton and Ferencz, 2006; Tema et al., 2006; Zananiri et al., 2007), as well as for intensities (Kovacheva et al., 1998, 2009; Genevey et al., 2013; Gómez-Paccard et al., 2008, 2012; Tema et al., 2013b). The use of both archaeodirections and archaeointensities enriched all databases and, consequently, geomagnetic field models (GMF) have been substantially improved on regional (Pavón-Carrasco et al., 2009, 2010) as well as on global scale (e.g. Korte et al., 2005; Genevey et al., 2008; Donadini et al., 2009). Despite this progress, the temporal and spatial coverage of data used to build the reference curves remains uneven, especially at the country scale (Genevey et al., 2008; Tema and Kondopoulou, 2011). Such curves are also available for Greece, both for intensities (De Marco et al., 2008; Tema et al., 2012; Fanjat et al., 2013) and directions, which were recently compiled by De Marco et al., 2014. Intensity data cover the last 8000 years, while directions extend within the last 4500 years only. Nevertheless, data from older periods are emerging as well (Aidona and Kondopoulou, 2012). Wider time ranges can be covered by combining datasets from the broader Balkan area (Tema and Kondopoulou, 2011), however, the Greek SVC need still new data from specific periods where a lack of adequate, well-dated, structures hampers further archaeomagnetic research. In the period corresponding to the one of the present study only eight directional and twelve intensity data are available between 415 and 565 AD. Therefore accumulating new, high-quality, data remains an important target.

The number of cooperations between geophysicists and archeologists is increasing; however archaeomagnetic dating remains the most common application of archaeomagnetism. Successful archaeomagnetic dating highly depends on the quality of the available reference curves, and consequently on the possibility to accurately study relevant structures dated with independent methods. Several archaeometric techniques offer reliable dating tools but one of them, namely thermoluminescence (TL) presents an important advantage for archaeomagnetic studies: it can be applied, under certain conditions, to the same material, in order to date the same event that is the last firing of the studied object or structure. There are two prerequisites for such application: the degree of heating should be sufficiently high and the material should have remained undisturbed since cooling down from the last firing (Aitken, 1985). If these are fulfilled, the method offers a valuable opportunity to obtain reliable reference points for the completion of the Secular Variation Curves.

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In the present archaeomagnetic study we investigate two pottery kilns (SAN6, SAN10) excavated within a spacious, archaeologically fairly well-dated, Protobyzantine settlement, situated at the western part of Kassandra, the first of the three fingers of Chalkidiki Peninsula in North Greece (Fig. 1). The TL method has also been applied in order to date as accurately as possible the end of the settlement activity. A third kiln (SAN8) of the same site, previously studied by Aidona et al. (2010), has also been dated with TL, as well as a fourth one (SAN5), for cross checking reasons. On the latter one no archaeomagnetic study was performed, due to its very poor preservation. The combined archaeological and TL dates from the two kilns (SAN6, SAN10) provide two new, high-quality, full vector reference points for the Protobyzantine period in Greece, while the new TL age assigned to the third, published one (SAN8), improves the dating precision.

2. Site description and sampling

The settlement of Megali Kypsa is located at the NW part of Kassandra, the western finger of Chalkidiki peninsula, in the immediate vicinity of the Thermaikos Gulf. (Fig. 1a).

Kassandra is largely formed of Neogene sediments and older rocks crop out only at its southernmost tip. These older rocks include Upper Jurassic ophiolitic material associated with Upper Jurassic limestones, Cretaceous black limestones and calcareous schists and sandstones. Eocene sediments occur also along the southern part of the west coast (Kockel et al., 1977; Bornovas and Rondogianni-Tsiambaou, 1983). The Neogene sequence, from bottom to top, consists of brown marls and micaceous clays, marly conglomerates, Miocene brown sandstones, upper Pliocene limestones and Plio-Pleistocene red marls of brick-red silty clay. Recent alluvial deposits occur along the SE and NW cost and along numerous valleys, which traverse the peninsula.

The Megali Kypsa settlement lies within the Quaternary alluvial deposits, closely surrounded by the red marls and brown sandstones. It is very likely that these formations provided the raw material used for the construction of the kilns as well as their products. Excavations in the area started in May 2006, and lasted until December 2007. The unearthed findings revealed an important settlement of a Late Roman-Early Byzantine age, belonging most probably to an officer or magistrate. The complex, named "Megali Kypsa" hosted, apart from residential buildings and a Basilica, several ceramic kilns, which impressed by their size and state of preservation (Fig. 1b). Such important workshops are not very common within the excavated Greek antiquity. In her compilation of ancient Greek kilns, Hasaki (2002) and Hasaki and Palyvou (2006) refers to 459 examined firing structures, corresponding to at least 296 workshops. Among them, 14% have two kilns whereas workshops with three or more kilns represent only 10% of all sites. Though the above total number has certainly increased due to recent excavations, as the one studied here, it is very unlikely that these proportions changed dramatically.

A total of 9 kilns were excavated and archaeologically studied in order to understand their construction and usage. Their stratigraphic relation suggests a possible, but not certain contemporary use. Their upper part – the dome – was not preserved mostly because of the friable clays and the "rebuilding" practice, which consisted in destroying and rebuilding it after every use. Therefore, only the lower parts and "hypocaustes" were investigated, providing useful information about their form, functioning, baked products and relation to the settlement.

These kilns were of "updraft" style, constituted by two superimposed compartments, separated by the perforated floor or "eschara," which allowed the upward heat flow. The lower part is the combustion chamber where the gases from the fuel are concentrated, while the upper part is the firing chamber, which is rarely preserved. The whole structure was built into a pit, initially excavated within the surrounding sediment mass, in order to ensure economy in energy and heat, and thermal isolation of the combustion chamber. The walls and floors were covered by clay coating, which was indurated after the repeated heatings. A complicated architectural structure within the kilns, with parallel walls, arch-shaped junctions and corridors was meant to guarantee the best possible support of the "eschara", as well as the easy and isothermal transmission of heat. Firing temperatures reached 800 °C–950 °C after several hours of progressive heatings, starting from initial temperatures of 300 °C–500 °C at which organic inclusions burned and water evaporated, through 500 °C–600 °C at which ceramic products started being fired (Johnson et al., 1988) After the high temperature was stabilized, a

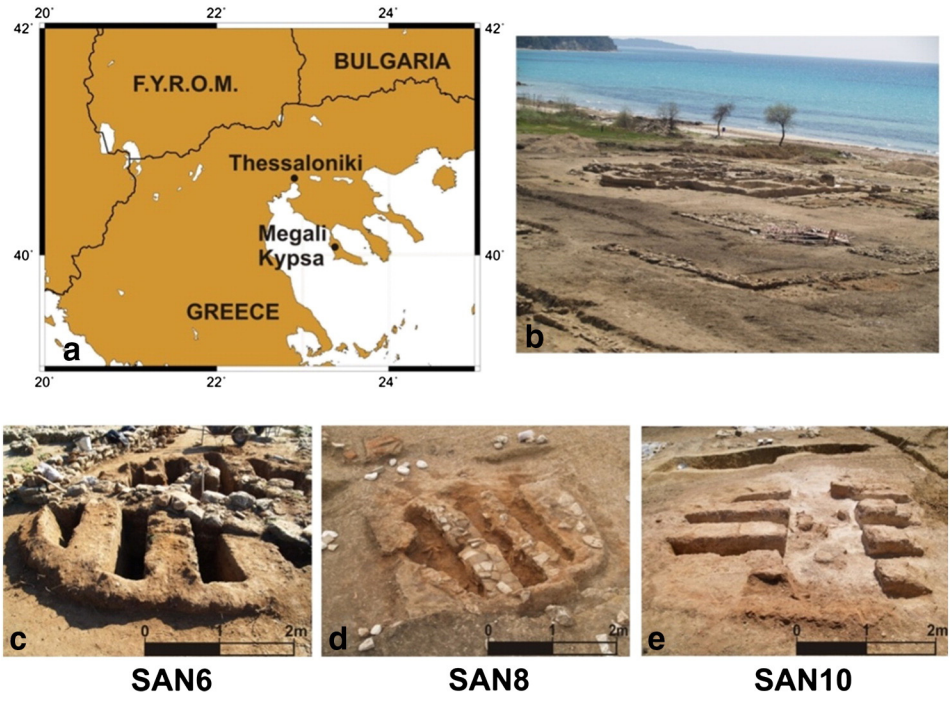

Fig. 1. (a) Map showing the location of Megali Kypsa. (b) General view of the settlement and (c)–(e) corresponding photos of the three studied kilns.