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Climate change versus land management in the Po Plain (Northern Italy) during the Bronze Age: New insights from the VP/VG sequence of the Terramara Santa Rosa di Poviglio

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ABSTRACT

The sedimentary infilling of the moat surrounding the *Villaggio Piccolo* of the Terramara Santa Rosa di Poviglio was analysed in order to obtain palaeoenvironmental inferences from sediments and pollen assemblage. The high-resolution stratigraphic sequence preserves evidence of the environmental changes that occurred in the Po Plain, in Northern Italy, during the Late Holocene. Our interdisciplinary approach permitted to study climatic and anthropic contributions to the environmental changes in this region. The relationships between these changes and land-use changes were investigated focussing on adaptive strategies of the Terramare people during the Middle and Recent Bronze ages (1550–1170 yr BC). The Terramare are archaeological remains of banked and moated villages, located in the central alluvial plain of the Po river. The Terramara of Santa Rosa consists of two adjoining settlements (*Villaggio Grande* and *Villaggio Piccolo*); the moat that separates the two parts of the site is c. 23 m large and reaches a maximum depth of 4 m from the extant ground level. The stratigraphic sequence VP/VG exposed by archaeological excavation inside the moat was sampled for pedosedimentary, thin section, and pollen analyses. Chronology is based on archaeological evidence, stratigraphic correlations and radiocarbon dating. Pedosedimentary features and biological records (pollen of aquatics and algal remains) demonstrate that shallow water, probably subjected to seasonal water-level oscillations, has always been present in the moat. In the lower units of the sequence, the laminations indicate standing water, while occurrence of reworked pollen testified the supply of sediments to the plain from catchment zones located in the Apennine. Open vegetation was widespread; economy was based on wood management, fruit collection on the wild or from cultivated woody plants, crop fields with a fairly diversified set of cereals especially increasing in variety during dryness or phases of water crisis. Probably, grapevines were cultivated near the moat, where the wet habitat was favourable to the growing of wild plants. The extraordinary high-resolution of this sequence makes visible the management of woods (including coppicing) at the Middle Bronze and early Recent Bronze ages. The economy of Santa Rosa di Poviglio should have been probably less based on animal breeding than it was in the other Terramare villages already studied for pollen. This research also confirms the chronological correspondence between an environment stressed by dry conditions and the collapse of the Terramare civilization.

1. Introduction

The joint action of climate and cultural variables has been found to be responsible for the trajectories of ancient people, whose survival relied on a responsible interplay with the natural resources

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available in lands hosting settlements (e.g., Galop, 2000; Brooks, 2006; Roberts et al., 2011; Mercuri, 2014; Mercuri et al., 2015c; see for a contrasting position: Magny et al., 2012). This is the case, for instance, of the Terramare culture of the Po Plain, in Northern Italy, dating back to the Middle and Recent Bronze ages (Cremaschi, 2014). The crisis of this early European society is reasonably related to a regional climate change. This coupled with the incapacity of the Terramare people to manage natural resources that were progressively reduced (Cremaschi et al., 2006; Mercuri et al., 2011).

The availability of water played a crucial role for the Terramare culture, which was based on irrigated agriculture, and developed some rituality connected to water procurement and storage (e.g., Bernabò Brea and Cremaschi, 2009). Climatic crisis, including depletion of water, is among the claimed causes of the disappearance of the Terramare settlements in Northern Italy (Cremaschi et al., 2006; Cardarelli, 2010; Cremaschi, 2010). From this, it is evident that climate change took a critical part in the determination of the cultural trajectory of the Terramare villages of the Po Plain. Climate possibly represents one of the main motors of the expansion of the Terramare civilization, initially triggering it for the positive evolution of the settlement pattern, and then largely contributing to its collapse.

In the present paper we investigate the sedimentary fill of the moat that separates the *Villaggio Piccolo* from the *Villaggio Grande* of the Terramara Santa Rosa di Poviglio (Figs. 1 and 2). The interdisciplinary study has been carried out in order to obtain palaeoclimatic and environmental inferences from sediments and pollen assemblage. The moat and its fill played an outstanding role in the local hydraulic system of water collection and re-distribution at this Terramara (Mele et al., 2013). But its importance goes beyond this interest. In fact, thanks to its distinct pedosedimentary and palynological evidence, it represents a paradigmatic feature owing supra-regional palaeoenvironmental significance. The stratigraphic sequence that we identified therein preserves evidence for the environmental changes that occurred in the Po Plain during the Late Holocene (*sensu* Walker et al., 2012). Our interdisciplinary study permitted to investigate climatic and anthropic contributions to environmental changes in this region, and their relationships with the different land-use adopted by Terramare people during the Middle and Recent Bronze ages (1550–1170 yr BC).

2. The Terramare culture and its climatic context

The Terramare are the archaeological remains of banked and moated villages of the Middle and Recent Bronze ages (1550–1170 cal yr BC), located in the central alluvial plain of the Po river (Cremaschi, 2014, Fig. 1). This culture reached its apogee at the beginning of the Recent Bronze Age and suffered, at the end of this period, a societal collapse that led to the abandonment of the villages in a few generations (Cardarelli, 2010). The Terramare villages are evidence of a complex society, whose subsistence was based on intensive agriculture, pastoralism, and long distance trade (Barfield, 1994; Bernabò Brea et al., 1997; Cardarelli, 1997).

The Terramare-type villages were squared in shape with houses on posts, distributed in regular rows and enclosed inside earthen rampart. They were surrounded by moats connected to the local fluvial network with the purpose to collect water and distribute it to cultivated fields by means of irrigation ditches (Balista, 1997; Cremaschi and Pizzi, 2007, 2011). This was necessary to sustain the irrigated agriculture, a subsistence strategy on which the Terramare culture was based. As confirmed by palynological studies, villages had performed a complex and diversified land-use, involving crop field (cereal/legume) rotation, alternation of fields and pastures, manuring and wood management since their establishment (Mercuri et al., 2006a, b).

Referring to the Alpine systems, by the palaeoclimatic point of view the development of the Terramare (1550–1170 cal yr BC) is fairly coincident with a period of generalized cooling (the Lobben glacier advance; e.g., Magny, 2004; Magny et al., 2010; Pelfini et al., 2014).

The collapse of the Terramare culture occurred just at the beginning of the following warm period, often indicated as the Bronze Age Warm Period (BAWP) or Bronze Age Climatic Optimum (with reference to the spread of sites on piles of the Final Bronze Age to the North of Alps; Holzhauser, 2007; Magny, 2004; Leroy et al., 2015). This collapse was coincidental (Cremaschi et al., 2006; Cremaschi, 2009) with one or more short dry episodes, which are recorded from different proxies in the Italian sub-alpine lakes (Baroni et al., 2006; Valsecchi et al., 2006), and may also be observed as a prominent warm spell in the residual $\Delta^{14}C$ curve (Blaauw et al., 2004; see also the conclusion section of this paper).

3. General background

3.1. The site of Santa Rosa di Poviglio, geomorphology and archaeological structure

The Terramara Santa Rosa di Poviglio (Lat. 44°52′21″N; Long. 10°34′31″E) is located in the alluvial plain, about 3 km southward from the present-day course of the Po River (Fig. 2). A swamp has occupied the site area until the 15th century AD. Also today, this area is poorly drained (Cremaschi, 2004). Geomorphological evidence suggests that the site was located near a palaeochannel of the Po river, which was active during the lifetime of the Santa Rosa village (Cremaschi et al., 1980; Cremaschi, 2004).

More than 30 years of archaeological excavations of the site and a recent geophysical survey (Mele et al., 2013) have revealed the archaeological structures of the settlement (consisting of an earthen rampart, wood fences, and dwelling areas) and their relationship with the surrounding moats.

The site consists of two dwelling areas indicated as "*Villaggio Piccolo*" (that in Italian means 'Small Village'; therein: VP) and "*Villaggio Grande*" ('Large Village'; therein: VG), dating back to the Middle Bronze Age and to the Recent Bronze Age, respectively (Figs. 2 and 3). The moat separating the VP from the VG was investigated during the field season 2012 (Fig. 4); it appeared to be exceptionally deep (4 m) in the context of the hydraulic structures of the site (Cremaschi and Pizzi, 2010, 2011). Its high-resolution sedimentary sequence, with well-preserved pollen content, covers the entire chronological span of the Terramare civilization. The aim of this paper is to report on geoarchaeological and palynological data obtained from the sequence of the VP/VG moat to understand the main landscape transformations that occurred at the Middle and Recent Bronze Age phases considering climate, vegetation, and human activity changes in the area.

3.2. Local environmental settings

The climate of the area is semi-continental with 12–14 °C mean annual temperatures, minimum in January (between −2 °C and 0 °C, on average), and maximum in July (between 24 °C and 26 °C). Mean annual rainfall varies between 600 and 800 mm, with snowfalls in winter. Human environments have replaced the natural potential vegetation. In the plain, woods consisting with dominant *Quercus robur* L. and *Carpinus betulus* L., mixed with *Acer campestre* L., *Fraxinus excelsior* L., *Ostrya carpinifolia* Scop., *Ulmus minor* Mill. and *Tilia cordata* Mill. represent the most common tree cover recorded from past pollen diagrams in the region (Valsecchi et al., 2006; Vescovi et al., 2010; Bosi et al., 2011, 2015; Mercuri et al., 2012). Hygrophilous woods are actually the only 'natural'

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