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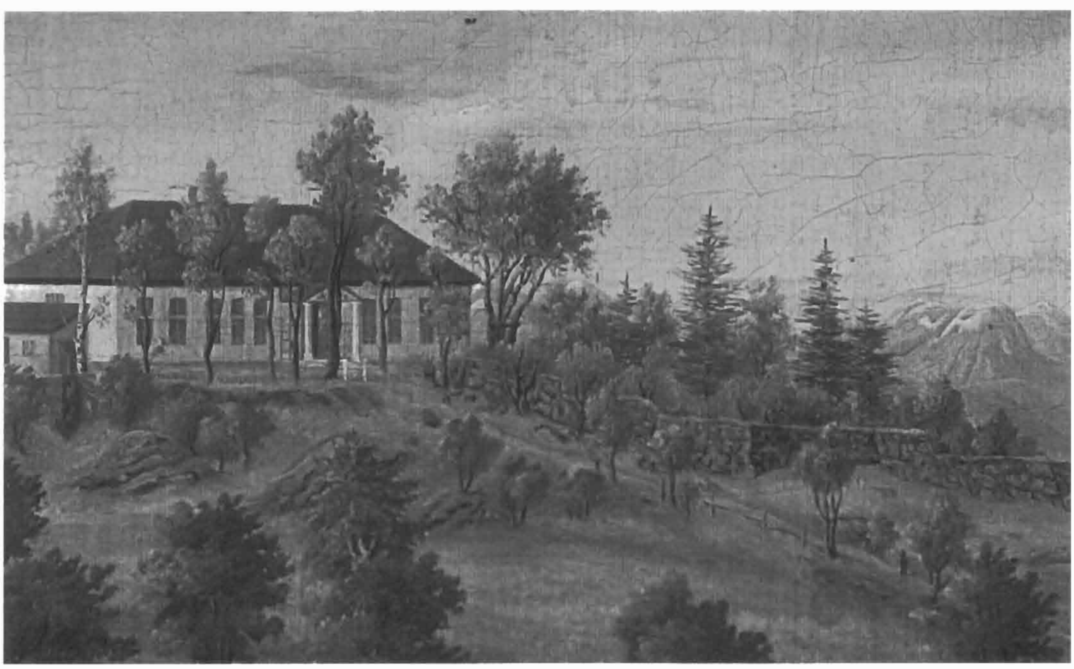
THE ARCHAEOLOGY OF CROP FIELDS AND GARDENS



edited by
Jean-Paul Morel
Jordi Tresserras Juan and **Juan Carlos Matamala**

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Recovering Crop Fields and Gardens in Archaeological Parks of Europe

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Cover photo: The Milde estate with its 'Sleeping Beauty Fairy Tale Garden' AD 1851, section from painting by Tycho Chr. Jaeger (from Rosland 1990).

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PER I BENI CULTURALI
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STUDIO, TUTELA E FRUIZIONE DEI BENI CULTURALI

THE ARCHAEOLOGY OF CROP FIELDS AND GARDENS

Proceedings of the 1st Conference on Crop Fields and Gardens Archaeology

Barcelona (Spain), 1-3 June 2006

edited by
Jean-Paul Morel
Jordi Tresserras Juan and **Juan Carlos Matamala**

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SUMMARY

Cereal fields from the Middle-Recent Bronze Age, as found in the Terramara di Montale, in the Po Plain (Emilia Romagna, Northern Italy), based on pollen, seeds/fruits and microcharcoals

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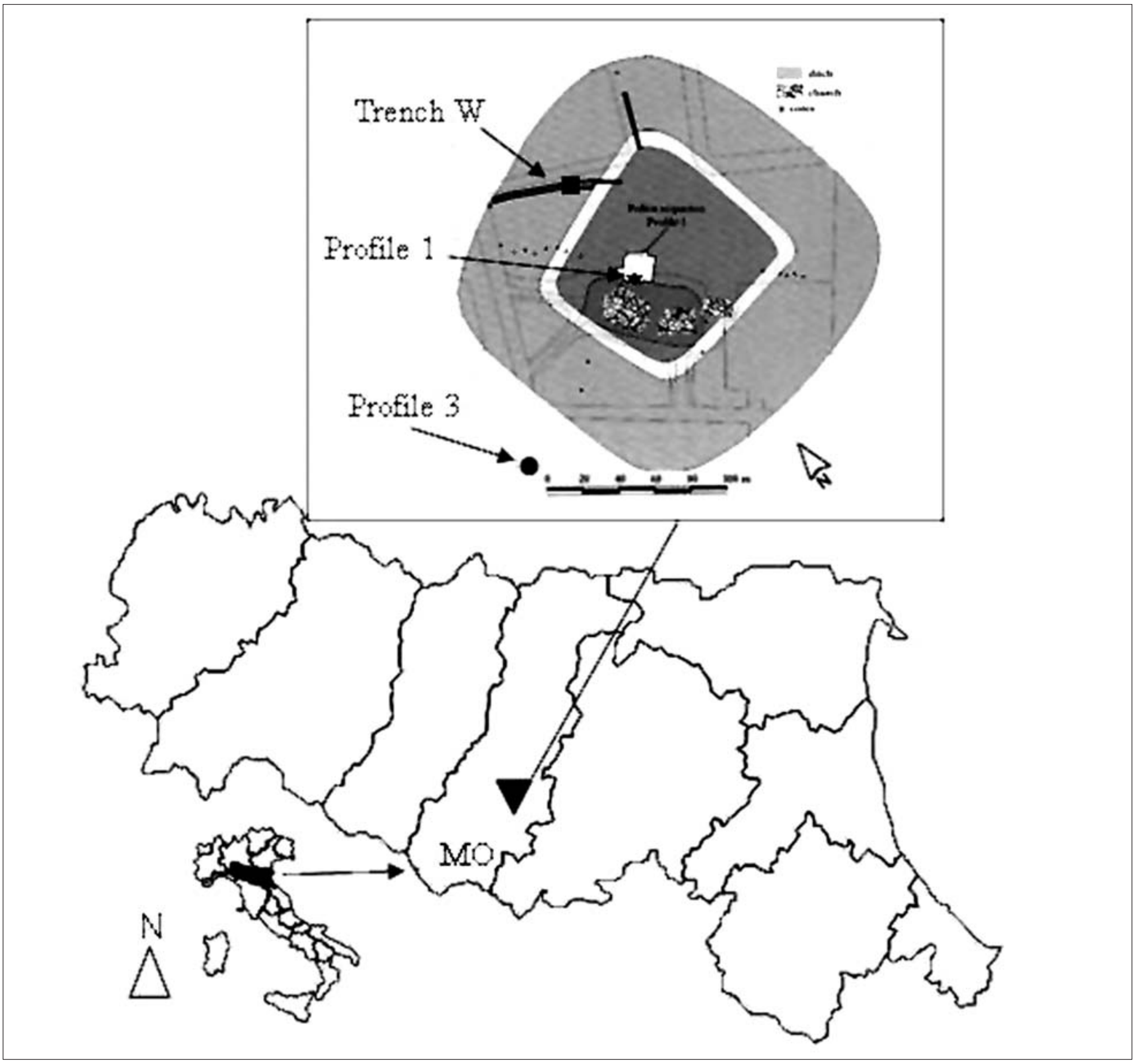
Riassunto

Nell'ambito del Progetto Europeo 'Cultural Landscapes of the Past: recovering crop fields and gardens in archaeological parks of Europe' (coord. Jordi Tresserras Juan), lo studio archeobotanico della Terramara di Montale è stato portato avanti con lo scopo di giungere a una ricostruzione dei campi di cereali. Il sito è uno dei più importanti per lo studio delle terramare, una società che caratterizzò la Pianura Padana durante il Bronzo Medio e Recente. Il lavoro qui presentato mostra una sintesi dei dati archeobotanici relativi alla ricostruzione dei campi. I campioni (pollinici/microantracologici e di semi/frutti) sono stati raccolti in diversi punti: a) all'interno del villaggio (Profilo 1, campionato nel 1996, e unità stratigrafiche delle fasi di vita del villaggio), b) nel fossato che circondava l'abitato (Trincea Ovest, campionata nel 1994), c) in un punto a circa 50 m all'esterno del fossato (Profilo 3, campionato nel 2002). I risultati mostrano una presenza molto alta di cereali nel villaggio, mentre all'esterno i cereali sono più scarsi. Nel Profilo 1, dentro il villaggio, polline di *Avena/Triticum* gruppo, *Hordeum* gr., *Panicum* cf. e *Secale cereale* è in media ca. 20%, mentre le cariossidi carbonizzate di *Triticum aestivum/durum*, *T. dicoccum, T. monococcum*, *Hordeum vulgare*, *Panicum miliaceum, Avena* sp. e *Secale cereale* sono il 98% dei semi/frutti studiati. I microcarboni documentano episodi di incendio o presenza di focolari, in parte connessi alle attività antropiche. I campi, pur essendo presenti nell'area di influenza della Terramara, non dovevano trovarsi in stretta vicinanza dei punti campionati alla periferia (Trincea Ovest) e vicino al villaggio (Profilo 3). Nell'area, i campi di cereali erano alternati a pascoli, e soggetti a varie pratiche agricole.

Introduction

Within the framework of the EU Project Culture 2000 'Cultural landscapes of the past: recovering crop fields and gardens in archaeological parks of Europe' (coord. Jordi Tresserras Juan), the archaeobotanical study of the Terramara di Montale was carried out in a specific attempt to reconstruct cereal fields.

The archaeological site of the Terramara di Montale is a key place for understanding the civilization which developed in the Po Plain during the Middle and Recent Bronze Age (1650 - 1170 B.C.; Bernabò Brea *et al*. 1997). As a general rule, terramaras consisted of a fortified village, with rows of houses, surrounded by an embankment and a ditch. Each site had an *area of influence*, i.e. a territory devoted to the exploitation of subsistence resources, which was more or less extended depending on the size of the settlement, its distance from other existing sites and the chronological phase (Cardarelli 1988). Terramaras must have been extremely close to each other as, at present, more than 220 sites have been discovered by archaeologists. This gave rise to the estimation that one site per 9-10 km, and sometimes per 2 km, would have been occupied, and that about 150,000 people would have lived in the terramara area in the



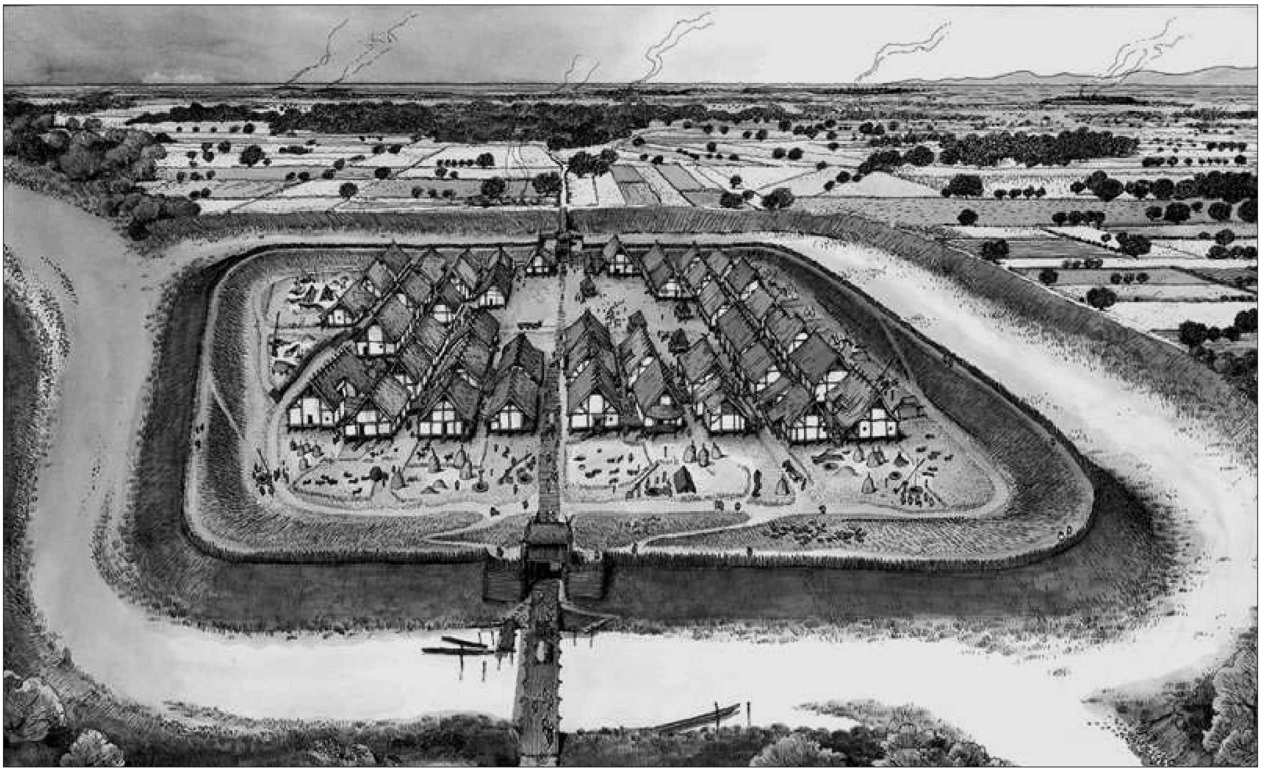
1. - Location map of the Terramara di Montale, in the province of Modena, Emilia Romagna, and planimetry of the site. The latter shows the embankment (in white) and the ditch (in light grey) which surrounded the village (in dark grey). Arrows mark the sampling points of the three pollen sequences discussed in the paper.

Emilian region around the 14th – 13th century B.C. (Cardarelli 1997; Cremaschi 1997; Cardarelli 2004). At the end of the Recent Bronze Age, this society rapidly vanished, probably forced by a combination of climatic, environmental and socioeconomic causes (Bernabò Brea *et al*. 1997; Mercuri *et al*. 2006).

The Terramara di Montale was a small settlement (see below), first excavated by Carlo Boni in 1871, and then almost completely destroyed to manure fields (as occurred in most of these sites due to the extraction of layers rich in organic matter). Since the '90s, archaeological, stratigraphical, archaeobotanical and archaeozoological studies have been carried out on what was left of the original site. This research has permitted the reconstruction of the organisation of the Terramara, its people's lifestyle, and the natural and cultural landscape of the site (Cardarelli 2004).

To carry out the archaeobotanical research, pollen samples were collected from stratigraphic sequences inside and outside the perimeter of the village, and samples for macroremains were collected from occupation layers discovered during the excavations. First pollen data from on-site **Profile 1** suggested that the settlement had had a strong impact on the area since its origin. Consequently, the landscape around the Terramara di Montale was a proper cultural landscape, with open areas and most of its land devoted to fields and pastures. In actual fact, since the inhabitants of the Terramara were probably skilful cereal-farmers, they largely founded their economy on cereals (Mercuri *et al*. 2006).

In this paper, the focus is on pollen and fruits

a


b


2. - The Terramara di Montale in Riccardo Merlo's reconstruction drawings for the Archaeological Park (by permission of the Archaeological and Ethnological Museum of Modena): **a. -** The settlement established during the Middle/Recent Bronze Age; **b. -** The tree cutting to take place for the settlement at the onset of the Terramara.

which were the most useful to obtain information on both the presence of cereal fields in the territory and some agricultural techniques used for their growth (Faegri, Iversen 1989; Pearsall 1989; Birks *et al*. 1998). To investigate the topic, new pollen data, from **Trench W** and **Profile 3**, and micro-charcoal analyses from the three series were added to previous archaeobotanical data. Trench W and Profile 3 were collected outside the village's perimeter, and included Bronze Age soils and layers deposited in periods preceding and following the settlement's phases of life. They were compared and integrated with data from both Profile 1, collected inside the village, and macroremains giving details about the species of cereals cultivated. Most of the Profile 1 and macroremains corresponded to a time range which includes large part of the period of occupation of the Terramara (1600 to 1250 B.C.).

The site and the archaeological park

The site of the Terramara di Montale (Lat. 44°30'N, Long. 10°55'E; 71 m a.s.l.) is located in the centre of the small town of Montale - Modena, Emilia Romagna, on the Po plain, below the hill belt of the Tusco-Emilian Appennines (fig. 1).

The Terramara was settled on a natural hillock approximately 4 m high, surrounded by a defensive embankment with a base approximately 10 m wide and a ditch. The ditch was 40 m wide and 3 m deep, filled by water from the nearby river (fig. 2).

Based on archaeological data also from other terramaras and their necropolises, it was estimated that the Terramara di Montale originally consisted of a village with embankment of approx. 11,000 m^2 in extent, with 30-40 houses and ca. 130 people. It was inhabited from about 1600 to 1250 B.C., i.e. from the Middle to Recent Bronze Age (Cardarelli *et al*. 1997; Cardarelli 2004). In the central phase of the BM2 (Middle Bronze Age phase 2), the site had an *area of influence* of approx. 14 km^2 which would have provided resources (Cardarelli in press). The Terramara was located ca. 4 km from the little settlement of Gazzade (east) and ca. 2 km from the small settlement of Cà del Vento (west).

In 1994 first surveys were carried out in the area, and in 1996-2001 a stratigraphic excavation by the "Museo Civico Archeologico Etnologico" of Modena was carried out on a surface of 45 m^2. The excavation made it possible to identify the village's establishment, mainly shown by hundreds of holes from house piles and a charred trunk, subsequently identified as oak, which marked the bottom level of the Terramara.

Archaeobotanical data from the multidisciplinary research mentioned above permitted scientific data to be obtained with which to perform the realization of an archaeological park, formerly funded by the European Project ARCHAEOLIVE. One of the main aims of the park is to show the cultural landscape in which the Terramara civilization developed. This is continuously achieved by means of panels and educational/exhibition trails organised in the park. The archaeological park was opened in April 2004 and its construction includes the excavated site and surroundings. In accordance with Andrea Cardarelli and Riccardo Merlo's project, the park consists of two parts distributed over 23,000 m^2: a) the archaeological excavation area, and the educational/exhibition workshop; b) the open-air museum with two huts built following the multidisciplinary research.

Materials and methods

Many samples for microscopical analyses were collected from three profiles excavated in different years. The profiles were located in the Terramara's area of influence, in different positions with respect to the village: *on-site*, *peripheric* and *near-site*, i.e. among the houses; in the nearby ditch, outside the village's perimeter; and outside both the village and the ditch, respectively.

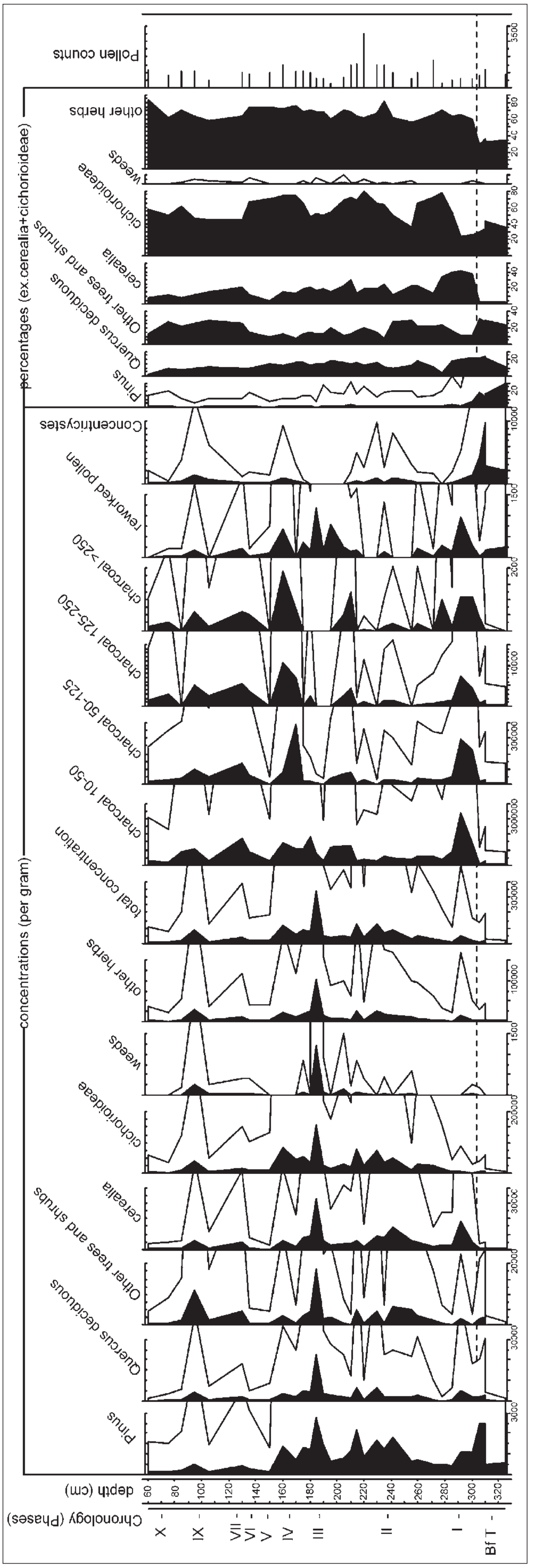
Pollen. A total of 78 pollen samples have been analysed so far (Tab. 1), collected from three sequences, i.e. Profile 1, Trench W and Profile 3, and ranging from before the Terramara to post-Mediaeval and Modern Age.

Profile 1 – *on-site* sampled in 1996, about 350 cm deep; 43 pollen samples (P1) dated from before the Middle Bronze Age to the Recent Bronze Age. Depth 0 in the profile is the top of the sequence, actually located at 25 cm depth (Cremaschi 1997). A paleosol was present at the bottom, at 350-300 cm, and, above it, was the archaeological deposit consisting of organic layers with scattered floors of silt or organic matter, and lens of ash. Archaeological and radiocarbon chronologies are in agreement and dated the eleven phases of life of the Terramara di Montale from the end of the 16th to the mid 13th century B.C. Details on chronology (8 radiocarbon dates - OxA Oxford University, Radiocarbon Accelerator Unit) and stratigraphy are reported elsewhere (Cardarelli 2004; Mercuri *et al*. 2006). The main archaeological traits of the village's eleven phases of life are (Cardarelli, Labate 2004): **I** (1605-1510 B.C.; 1605-1515 B.C.) - first rectangular hut, 9 x 6.5m, first built and then eliminated by demolition and cutting; **II** (1600-1450 B.C.) - second hut on piles built in the same place, destroyed by fire; **III**, third hut on piles destroyed by fire; **IV**, fourth hut with a muddy and sandy floor, without piles, then abandoned; **V** (1490-1320 B.C.) - fusion pit for metallurgical activity linked to bronze tool production; **VI** (1495-1400 B.C.) - a new hut, the fifth, as in Phase IV, was probably edified; **VII**, no structural evidence; **VIII** (1440-1320 B.C.) - granary destroyed by fire, showing millions of charred caryopses; **IX**, no structural evidence; **X** (1410-1315 B.C.) - no structural evidence; **XI** (1415-1315 B.C.) - no structural evidence.

Trench W – *peripheric*, located about 20 m from Profile 1, in the ditch, collected in 1994; 6 pollen samples (PW) dated from before the Bronze Age to the Middle Bronze Age. Samples were taken from the ditch fill stratigraphy and were not in a vertical sequence. To make graphs, depths were assigned to the samples from 50 to 0 cm taking into account their chronology, and by correlation with the archaeological deposits mentioned above (Tab. 1). Depth 0 of the top sample is actually located at approx. depth 100 cm. The bottom sample was a sandy silt deposit and corresponded to the paleosol at the bottom of Profile 1 (preceding the Middle-Recent Bronze Age). Then there are two layers of silty matrix archaeologically dated to Phases I and II of the life of the

Chronology	**On-site, village** P1 = pollen samples from Profile 1; macroremains		**Peripheric, ditch** TW = pollen samples from Trench W	**Near-site, 50 m far from the ditch edge** P3 = pollen samples from Profile 3
Post Mediaeval Age – Modern Age	_P1-43 (Modern Age)_* _P1-42 (Modern Age)_* _P1-41 (Modern Age)_*			P3-1 cm 0 (L 502) Paleosol 5 P3-2 cm 10 (L 503) P3-3 cm 20 (L 503) P3-4 cm 30 (L 504) Paleosol 4 P3-5 cm 40 (L 504) Paleosol 4 P3-6 cm 50 (L 505) P3-7 cm 60 (L 505) P3-8 cm 70 (L 506) P3-9 cm 80 (L 506)
Mediaeval Age				P3-10 cm 90 (L 507) Paleosol 3 P3-11 cm 97 (L 507) Paleosol 3
Post Roman period				P3-12 cm 103 (L 508)
Roman period				P3-13 cm 110 (L 509) Paleosol 2 P3-14 cm 120 (L 509) Paleosol 2
Post Bronze Age (Iron Age?)				P3-15 cm 130 (L 510) Paleosol 2 P3-16 cm 140 (L 510) Paleosol 2
Bronze Age (BR1)	_P1-40 (Ph XI)_* P1-39 cm 60 (Ph X) P1-38 cm 75 (Ph X) P1-37 cm 85 (Ph IX) P1-36 cm 95 (Ph IX) P1-35 cm 105 (Ph IX)	macroremains	PW-1 cm 0 (L 32)	P3-17 cm 150 (L 511) Paleosol 2 P3-18 cm 160 (L 512) Paleosol 2
Bronze Age (BM3)	_P1-34 (Ph IX)_* _P1-33 (Ph VIII)_* P1-32 cm 130 (Ph VII) P1-31 cm 135 (Ph VI) _P1-30 (Ph VI)_* P1-29 cm 150 (Ph V) P1-28 cm 160 (Ph IV) P1-27 cm 170 (Ph IV) P1-26 cm 175 (Ph III) P1-25 cm 180 (Ph III) P1-24 cm 185 (Ph III) P1-23 cm 190 (Ph III) P1-22 cm 195 (Ph III)	macroremains	PW-2 cm 8 (L 33) PW-3 cm 18 (L 34)	
Bronze Age (BM2)	P1-21 cm 205 (Ph II) P1-20 cm 210 (Ph II) P1-19 cm 215 (Ph II) P1-18 cm 220 (Ph II) _P1-17 (Ph II)_* P1-16 cm 230 (Ph II) P1-15 cm 235 (Ph II) P1-14 cm 242 (Ph II) _P1-13 (Ph II)_* P1-12 cm 255 (Ph II) P1-11 cm 260 (Ph II) _P1-10 (Ph II)°_ P1-9 cm 272 (Ph II) P1-8 cm 278 (Ph I) P1-7 cm 285 (Ph I) P1-6 cm 292 (Ph I) P1-5 cm 300 (Ph I)	macroremains	PW-4 cm 30 (L 35) PW-5 cm 38 (L 36)	
Before-Terramara	P1-4 cm 306 P1-3 cm 310 P1-2 cm 310.5 P1-1 cm 325		PW-6 cm 50 (L 37)	P3-19 cm 170 (L 513) P3-20 cm 180 (L 513) P3-21 cm 190 (L 513) P3-22 cm 200 (L 513) P3-23 cm 210 (L 513) P3-24 cm 220 (L 514)
Eneolithic/ Neolithic				P3-25 cm 230 (L 515) Paleosol 1 P3-26 cm 236 (L 515) Paleosol 1 P3-27 cm 247 (L 515) Paleosol 1
Pre-Neolithic ?				P3-28 cm 255 (L 516) P3-29 cm 265 (L 516)

Table 1. - List of samples from the Terramara di Montale: chronology, label and number of the pollen samples, depths in centimetres from the top of the sequence, as reported in the diagrams, and archaeological phases or layers (Ph = Phase; L = Layer). In Profile 1, ten pollen samples were excluded from the diagram in fig. 3 (* = sterile samples; ° = dung sample).



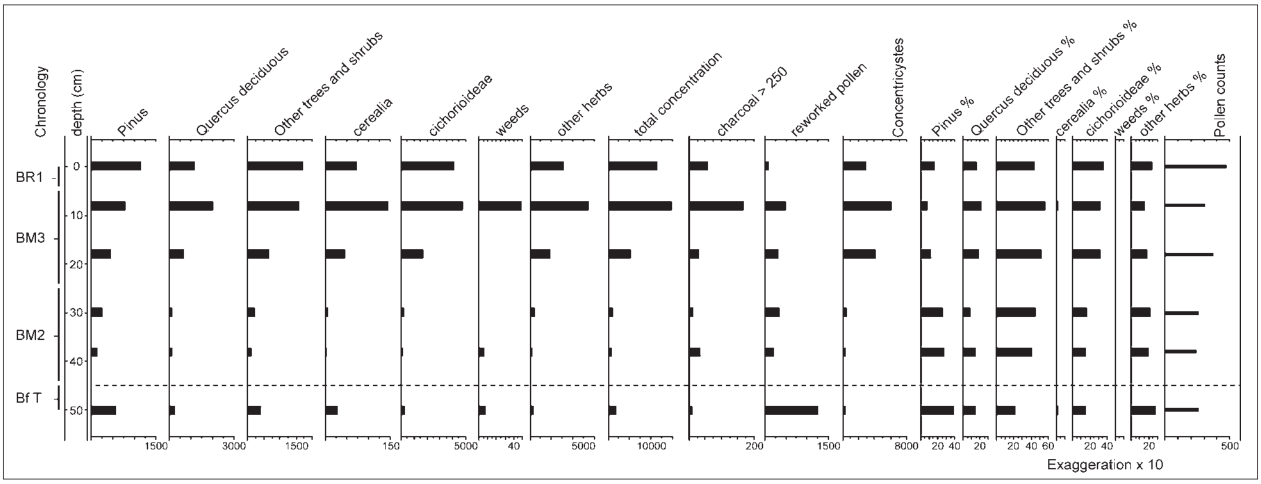
3. - *Profile 1*. Pollen concentration and percentage diagram, including selected pollen taxa, concentration of microcharcoals, reworked pollen and *Concentricystes*. Dotted line marks the base line of Phase I of the Terramara di Montale. In the Chronology, 'Bf T' means 'Before the Terramara'.

Terramara. The other three layers were of sandy matrix with some gravel archaeologically dated to the Phases III, IX-XI, of the settlement.

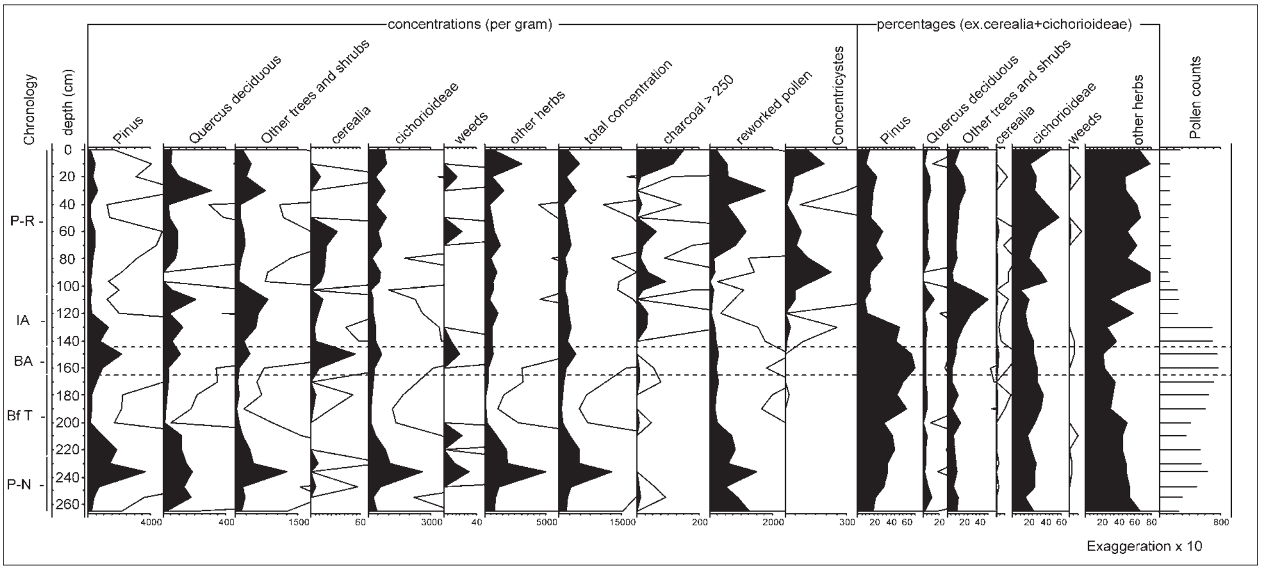
Profile 3 – *near-site*, sampled in 2002 in a palaeo-channel, an old riverbed approximately 150 m to the south-west, far from the centre of the village and 50 m away from the ditch, about 265 cm deep; 29 pollen samples (P3) dated from before the Middle Bronze Age to the present. Depth 0 in the profile is the top of the sequence, actually located at 340 cm depth. At the bottom, the deposit consisted of alluvial sands. Then, further along the profile, there are five paleosols alternating between sandy silt and silty sand deposits. The most ancient paleosol, from the Eneolithic/Neolithic age, was grey-brown at 250-230 cm; then, a second, thick brown paleosol was located at 165-110 cm, which, based on pottery, dated to the Roman period at the top; the third, thin paleosol at 100-85 cm was Mediaeval, based on archaeological records; the other two paleosols were post Mediaeval/Modern. Based on stratigraphy, it was assumed that in the second, thick paleosol, there must have been Bronze Age soil below the Roman soil, in the same thick layer, i.e. at around 165 cm depth. The Bronze age soil offered no possibility of further distinction within the Bronze Age.

About 5-10 g dry weight samples were treated using tetra-Na-pyrophosphate, HCl 10%, acetolysis, heavy liquid separation (Na-metatungstate hydrate), HF 40% and ethanol (Lowe *et al.* 1996). Permanent pollen slides were mounted in glycerol jelly. *Lycopodium* tablets were added to calculate pollen concentration (pollen grains per gram = p/g). Microscopical analyses were carried out at 1000 x magnifications with light microscope. Identification was performed with the help of keys, atlases and reference pollen collection. Cerealia pollen identification was based on Beug (1961), Andersen (1979), Faegri, Iversen (1989, with correction factor for glycerol jelly) and Kohler, Lang (1979).

Percentages were calculated in a pollen sum which excluded Cerealia and Cichorioideae, the most overrepresented anthropogenic taxa in Profile 1 (fig. 3). The excluded pollen taxa and Pteridophyta spores were calculated as percentage on the pollen sum plus themselves. Ten



4. - *Trench W*. Pollen concentration and percentage diagram, including selected pollen taxa, concentration of microcharcoals, reworked pollen and *Concentricystes*. Dotted line marks the base line of Phase I of the Terramara di Montale. In the Chronology: 'Bf T' means 'Before the Terramara'; BM2, Middle Bronze Age phase 2, includes Phases I and II; BM3, Middle Bronze Age phase 3, includes Phases from III to VIII; BR1, Recent Bronze Age, includes Phases from IX to XI.



5. - *Profile 3*. Pollen concentration and percentage diagram, including selected pollen taxa, concentration of microcharcoals, reworked pollen and *Concentricystes*. Dotted lines mark the Bronze Age soil samples. In the Chronology: 'P-N' means 'Pre-Neolithic/Neolithic'; 'Bf T' is 'Before the Terramara'; 'BA' is 'Bronze Age'; 'IA' is 'Iron Age/Roman'; 'P-R' is 'from post-Roman to Modern Age'.

samples were excluded from the Profile 1 diagram, i.e. nine samples with very few, badly preserved pollen, and one with a clear overrepresentation of *Carpinus betulus* (84%; P1-10 in Tab. 1). The overrepresentation of *Carpinus* and of Cichorioideae was interpreted as the result of deposition of materials through anthropic and animal dung origin in the site (Mercuri *et al*. 2006).

Microcharcoals were counted in the three series investigated for pollen according to Bosi *et al*. (in press). The same pollen analysis slides were examined. In Profile 1, four classes were observed according to the maximum length of particles: small, 10-50 μm; medium > 50-125 μm; large >125-250 μm; very large > 250 μm. In Trench W and Profile 3, to search for extended local fires, only very large microcharcoals were counted in all samples. In fact, in general, small/medium-sized microcharcoals are considered good indicators of regional fires, while when large/very large-sized, they indicate local fires (Blackford 2000; Hannon *et al*. 2000; Mooney *et al*. 2001; Hounslow, Chepstow-Lusty 2002; Caramiello, Arobba 2003). Microcharcoal analysis is provisional.

Macroremains were systematically collected during the excavation, and corresponded to the chronological Phases of the village's life from I to X mentioned above for Profile 1. Carpological samples (totally 1109) were collected from floors, fire layers, hearths and pits inside the site by systematic grid-sampling. The samples, between 10 and 16 l each, were floated and separated by archaeologists in the field using sieves (mesh size 0.5 and 0.2 mm). Seeds and fruits were sorted under a stereomicroscope at 80x magnifications. Detailed results on state of preservation and carpological flora are reported elsewhere (Mercuri *et al*. 2006).

Pollen and microcharcoal diagrams were drawn using Tilia 2.0 and TGView. Plant names follow the Flora d'Italia (Pignatti 1982).

Results

Samples had a sufficient/good pollen content, in a state of preservation varying from bad to good. In general, pollen preservation in Profile 1 and Trench W was better than in Profile 3. Pollen concentrations were decidedly higher in Profile 1 (53,900 p/g on average) than in Trench W (7800 p/g) and Profile 3 (2600 p/g; figs. 3, 4, 5). Besides the better pollen preservation within deposits richer in organic matter, the different concentrations should be regarded as a result of anthropic transport of plants into the village.

Trees and shrubs are less represented than herbs, and are slightly higher in Profile 1 (37% on average) and Trench W (36%) than in Profile 3 (33%). Cichorioideae are very abundant in the three profiles, and the mean of Profile 1 (55 %) is almost double that of Trench W (25 %) and Profile 3 (28 %).

Algal spores of *Concentricystes* (Zignemataceae; Grenfell 1995) are particularly abundant in Trench W (2400 p/g < versus 885 p/g in Profile 1 and 40 p/g in Trench W > on average), reflecting the ditch's freshwater depositional setting. In Profile 1, *Concentricystes* are more abundant before the Terramara, and in Profile 3 they notably increase after the Terramara.

Concentrations of reworked pollen, especially *Classopollis*, decrease slightly from Profile 3 (520 p/g on average) to Trench W (400 p/g), and Profile 1 (200 p/g; figs. 3, 4, 5), possibly reflecting fluviatile deposits obviously prevalent in the paleo-channel.

Microcharcoals were abundant in all samples. In Profile 1, the trends of the different classes of microscopical charcoals is fairly similar, showing common peaks (around $3x10^6$ for the small, 10^3 for the large, and $2x10^3$ for the very large sizes). The first peak common to all three classes occurs soon after the onset of the Terramara, at around 290 cm in Phase I, indicating the widespread use of fire to gain space in the village and in fields in the village's area of influence. A second remarkable peak, concerning large and very large particles, is at around 180-160 cm in the archaeological Phases III and IV, after then the third hut on piles was destroyed by fire (see above).

Cereal records

Altogether, focusing on the Bronze Age layers, it resulted that 36 samples had pollen useful for obtaining data on cereal fields at the time of the Terramara di Montale. In Profile 1 (29 samples, from sample P1-5 to P1-39 in Tab. 1) and Trench W (5 samples from PW-5 to PW-1), samples belonged to the Middle and Recent Bronze Age, and were therefore coeval to the Terramara. In Profile 3 (2 samples, P3-18 and P3-17), samples were attributed to the Bronze Age based on stratigraphical/archaeological correlations (see above, Tab. 1), and we assume that they were contemporary to the Terramara.

Cereal pollen. Four cereal pollen types were found: a) *Avena/Triticum* group, with most records from Profile 1 belonging to *Triticum* (according to Beug 1961). The group includes wheats (*Triticum* ssp.), cultivated oat (*Avena sativa*), plus a few wild grasses; b) *Hordeum* group, which includes barley (*H. vulgare*), einkorn (*Triticum monococcum*), plus some wild grasses; c) *Panicum* cf., which includes common millet (*P. miliaceum*), plus wild grasses; d) *Secale cereale*.

Cereal pollen was present in all the Bronze Age samples. In Profile 1, it was very abundant (ca. 20% on average; about 5000 p/g), with prevalence of *Avena/Triticum* group (on average 10%) and *Hordeum* group (6%); a few *Panicum* cf. and *Secale cereale* were also found. In Trench W and in Profile 3, cereal pollen was decidedly lower (0.9% - 53 p/g and 2.1% - 32 p/g, respectively). It consisted of *Hordeum* group and *Panicum* cf. The *Avena/Triticum* group was present in the samples that immediately preceded (PW-6, Trench W) and followed (P3-16, Profile 3) the Bronze Age samples (figs. 4, 5).

Cereal macroremains. These were found in the all Bronze Age samples as they represented 98% of the carpological record of the site occupation phases (Phases X to I; Tab. 2). They largely consisted of grains and a few chaff (only a dozen of *Triticum monococcum*). The remains were charred (or partially charred) and their state of preservation was generally poor: sometimes fragmented or deformed, and also puffed in the granary (destroyed by

CARPOLOGICAL DATA - SELECTED TAXA													
Chronology (B=Bronze Age; M=Middle; R=Recent)			BR1		BM3						BM2		
Archaeological Phases			**X**	**IX**	**VIII**	**VII**	**VI**	**V**	**IV**	**III**	**II**	**I**	**TOTAL**
No. of samples			41	85	88	127	60	65	39	223	271	110	1109
Vol. (litres)			320	910	840	1230	590	670	690	3790	4750	2210	16000
CEREALS	*Hordeum vulgare*	charred	33	87	5137	652	380	204	142	452	260	101	**7448**
	Triticum (aestivum/durum, diccoccum, monococcum)		121	378	11566	659	361	515	327	2084	579	235	**16825**
	% T. aestivum/durum		*67*	*55*	*46*	*47*	*61*	*54*	*57*	*44*	*44*	*32*	*48*
	% T. dicoccum		*31*	*43*	*53*	*52*	*38*	*42*	*34*	*37*	*50*	*67*	*43*
	% T. monococcum		*2*	*2*	*1*	*1*	*2*	*3*	*9*	*19*	*5*	*1*	*9*
	Other cereals (*Secale cereale, Panicum miliaceum, Avena* sp.)		6	2	23	14	17	19	2	23	31	10	**147**
	Indeterminable cereals		273	1614	40821	1600	1650	1266	388	3060	1224	531	**52427**
	SUM OF CEREALS		**433**	**2081**	**57547**	**2925**	**2408**	**2004**	**859**	**5619**	**2094**	**877**	**76847**
	[records / 10 litres]		**[14]**	**[23]**	**[685]**	**[24]**	**[41]**	**[30]**	**[12]**	**[15]**	**[4]**	**[4]**	**[48]**
OTHER RECORDS	OTHER RECORDS	charred/uncharred/mineralised	168	130	480	79	38	66	25	216	173	136	**1511**
TOTAL RECORDS			601	2211	58027	3004	2446	2070	884	5835	2267	1013	**78358**
%	***% CEREALS***		***76***	***95***	***99***	***98***	***99***	***97***	***97***	***97***	***93***	***87***	***98***
	% OTHER RECORDS		***24***	***5***	***1***	***2***	***1***	***3***	***3***	***3***	***7***	***13***	***2***

Table 2. - Seeds and fruits recorded per archaeological phase: state of preservation, total number, concentration per 10 l and percentages of cereals. All other records are included in 'Other records'.

fire, Phase VIII), frequently so deteriorated as to be unidentifiable. Charred grains mainly belonged to *Triticum aestivum/durum* and *T. dicoccum*, followed by *T. monococcum*, *Hordeum vulgare* (hulled forms). A few *Panicum miliaceum, Avena* sp. and *Secale cereale* were present too. Interestingly, the highest concentration was found in the samples from the granary, where obviously most cereals had been stored. On the contrary, low concentrations were found in samples from huts (Phases I to IV), and in Phase X with no structural evidence (Tab. 2).

Weed records

Weeds from cereal fields were recorded in traces in the three profiles (0.2% on average each). They consisted of pollen of *Aphanes* cf. and *Papaver rhoeas* type, found in all profiles, plus *Agrostemma* cf. in Profile 3, and *Adonis* cf. and *Centaurea cyanus* in Profile 1. Macroremains of *Valerianella dentata* (L.) Pollich and *Mentha suavolens/longifolia* also point to fields, together with *Fumaria officinalis* L. and Chenopodiaceae sp.pl., which are more frequent in manured fields. Moreover, *Galium* sp., *Sambucus ebulus* L. and *Buglossoides arvensis* (L.) Johnston grow at field edges, in fallows or even in pastures. These records were few (ca. 250 sf/16,000 l), but the seeds/fruits' poor state of preservation suggested that most of the carpological record, including weeds, had probably been lost (see below).

Discussion

Transport of cereals inside the village

The high presence of cereal pollen in the on-site Profile 1 and charred grains are a major feature of the Terramara di Montale's archaeobotanical record. They point to a clear anthropic accumulation of cereal inside the village, which occurred continuously during the life of the Terramara (fig. 3; Tab 2).

Pollen. High pollen concentrations in the layers are commonly interpreted as a result of transport of organic matter into archaeological contexts, including both collection of plants and faeces containing pollen from eaten plants (Dimbleby 1985: 17; Faegri, Iversen 1989: 181; Pearsall 1989: 300; Joosten, Brink 1992). In the case of economic plants, a significantly higher amount of pollen than normal in the pollen rain indicates that plant accumulation on floors had occurred and that plants were not dispersed by subsequent human activities (Macphail *et al*. 2004; Kelso *et al*. 2006).

Specifically, a large amount of cereal pollen testifies that spikes with pollen trapped in the glumes, or pollen trapped underfoot were brought to the site by people (Robinson, Hubbard 1977; Greig 1982; Bottema 1992). Cereal food remains may also be the source of large amounts of cereal pollen. This is the case with pollen retained in spikes, which remained in food after processing, survived the digestive apparatus and ended up in human faeces (Greig 1982). Animal dung may also contain cereal pollen when animals were fed straw from cereals (Greig 1982; Faegri, Iversen 1989). At the Terramara di Montale, some data suggested that cereal food remains were probably deposited in the village: a) preliminary pollen analyses from two coprolites found in the village, which were interpreted to be of human origin, showed some pollen of *Triticum* (unpublished data), thus providing further proof of the consumption of wheat food; b) the practice of feeding domestic animals by transporting plants into the village was detectable in one on-site pollen sample. This sample reflected the use of hornbeam trees as fodder by overrepresentation of *Carpinus* pollen (84%; Phase II-Profile 1, Tab. 1; the sample was excluded from the diagram; Mercuri *et al*. 2006). Interestingly, in the same sample, cereal pollen, especially *Avena/Triticum* but also barley, millet and rye, had high percentages (31%), and this proves the use of fed straw from cereals. However, generally, in the case of cereals, it proves impossible to distinguish samples owing high amount of cereal pollen to fodder from those corresponding to food accumulation.

Therefore, we concluded that the high amount of cereal pollen in Profile 1 demonstrated the large use of cereals, mainly for food and fodder. Their use for flooring, roofing and animal bedding should not be excluded either (but see below). Large and very large microcharcoals show several peaks following episodes of fire inside the village that probably involved cereals and other grasses used in these ways (fig. 3).

Macroremains. Cereal grains also testified the continuous transport of cereals, which were even stored in granaries (Phase VIII) in the Terramara. This supports the idea that cereals were an important element of people's diet. Food processing, instead, appears to have been substantially performed outside the village, as shown by the negligible amount of waste remains from cereal processing. It was not possible to clearly establish if this had occurred because of the state of preservation of macroremains (see below). Most grains belonged to common/durum wheat (*Triticum aestivum/ durum*) and emmer (*T. dicoccum*) followed by einkorn (*T. monococcum*), suggesting that these cereals were those most appreciated by people. Other uses than food were not clearly testified. In fact, macroremains of straw were too few in number (only a few chaff, and no culms) to support the hypothesis of their use in floors, roofs and animal bedding also mixed with animal dung for manuring fields.

Most of these cereals, and especially *T. dicoccum*, were frequent in the Bronze Age deposits found in the Po Plain (for example, Canàr, 2nd millennium B.C. - Castiglioni *et al*. 1998, Castelletti *et al*. 2001). Only *Secale cereale*, found solely in the village of Monte Castellaccio, was rare (Middle Bronze Age; Bandini Mazzanti *et al*. 1996).

The Terramara as a producer site

The great abundance of cereal pollen and grains discussed above suggested that cereals were grown locally and that there was good availability of cereal fields in the area, inviting one to consider the Terramara a producer site, i.e. a site surrounded by crop fields. However, the state of preservation of macroremains prevents the unambiguous inclusion of the Terramara di Montale within the producer sites according to classical models. The latter require higher quantities of waste products and weeds reflecting all stages of cereal processing in the archaeobotanical record (Harvey, Fuller 2005). At the Terramara, cereal macroremains were almost all grains which came into contact with fire, with the result that they were preserved by charring. This would not always have been conducive to preservation, as conditions therefore differ for waste products/weeds and grains. In fact, chaff and weeds could have been destroyed by overly high temperatures. Contrarily, they are unlikely to have been preserved by slight charring (i.e. without direct contact with fire) because they are early processing products which would hardly ever have come into contact with fire (Harvey, Fuller 2005).

This strongly suggests that, at the Terramara, a loss of macroremains, especially chaff and weeds, occurred during subsequent fire episodes (Phases II, III and VIII). These were testified by archaeological evidence and by subsequent microcharcoal peaks in the on-site diagram (fig. 3). Thus not all stages of cereal processing were preserved on-site. Moreover, it is possible that part of the cereal processing, such as threshing and winnowing after harvest, were carried out in open fields away from the place of excavation (used, throughout the different phases, solely for building huts or a granary). These activities resulted in the dispersion of most chaff and weeds through more open parts of the settlement.

Therefore, though it is difficult to recognise the early stages of crop processing at the Terramara di Montale, cereal pollen and grains were found in such high amounts that they alone must be considered clear markers of the presence of cereal growing around the site (Mercuri *et al*. 2006).

Cereal fields in the area of influence

Data from the peripheric Trench W and the near-site Profile 3 could support the hypothesis that cereal fields, especially barley or einkorn, both included in the *Hordeum* pollen group, and millet (*Panicum* cf.) were grown in this area. However, setting the on-site data discussed above aside for a moment, several problems must be considered when evaluating this hypothesis. In fact, records from the two profiles belonged to pollen types which also include several wild plants (see above), and thus they do not bear unquestionable witness of cultivated fields. Nevertheless, the *Avena/ Triticum* group which includes certain cereals was present immediately before (peripheric) and after (near-site) the samples coeval to the Terramara (see below). This suggests that cereal fields were present during the Bronze Age.

The low pollen values of cereal pollen recorded outside the village (1-2% on average in the Bronze Age samples from Trench W and Profile 3) is due to several reasons: a) cereals have low production and disperse only small amounts of pollen; b) both *Hordeum* and *Triticum* have self-pollinating (autogamous) species which do not disperse pollen into the air (Booth, Richards 1978; Behre 1986; Rempel 1997); c) cereal pollen size is > 40 μm and its fall speed is approximately double that of wild grasses (0.06 ms^{-1} versus 0.035 ms^{-1} according to Fyfe 2006). This means that it is not easily transported by air over long distances, and that it is not easily found too far from the fields.

Moreover, the low image of crop fields from the out-site pollen spectra is unsurprising as their visibility in past pollen spectra outside archaeological sites is known to be usually low. For example, a small percentage of cereal pollen (<0.3%) was interpreted as reflecting little intensive cultivation of land in the direct vicinity of a lake (Neolithic; Dreßler *et al*. 2006). In the Terramara of Santa Rosa di Poviglio, cereals from trenches excavated near the terramara frequently had values ranging around 1-3%, occasionally reaching about 8-10% (Ravazzi *et al*. 2004). According to Marvelli *et al*. (1998), these different percentages can be interpreted as different points of sampling within or outside the field edges. Cereal pollen is highest in the vicinity of the plant producing it, as might be expected for all pollen types. Hall (1989) observed that cereal pollen represented 9-22% of recent spectra from grass leaves collected beneath the crop, and that values consistently decreased to 3% in samples taken at distances of over 1.5 m from the edge of the crop.

Archaeobotanical data indicated that the pollen sampling from Trench W and Profile 3 must have been rather far from the fields. These sampling points were in lands not specifically devoted to cultivation. This is reasonable for Trench W, which was in the ditch. The latter, instead, could have contained animal faeces, which would have resulted in the large amount of herbs, especially Gramineae, and Cichorioideae visible in the diagram (fig. 4). As regards Profile 3, during the Bronze Age the area may have been used initially for pastures and then for cultivation, as can be inferred from the diagram (percentages of Cichorioideae are higher at the bottom, then decrease, while cereals and weeds appear; fig. 5).

Moreover, though lower than in the on-site profile, they confirmed that cereal fields would have grown in the vicinity of the terramara, even if fairly far from the peripheric and near-site sampling points, situated about 0-50 m from the ditch.

Absence of wheat pollen near site. Altogether, *Avena/Triticum* group (and especially *Triticum*) was the dominant cereal pollen in on-site Profile 1 spectra, and since *Triticum dicoccum* and *T. aestivum/durum* both had that pollen type, they were prevalent among the charred grains. Thus, we are justified in supposing that wheat fields were notably important among the crop fields cultivated at the terramara. Nevertheless, in the Bronze Age samples from the peripheric and near- site sequences, this pollen type was absent. Interestingly, it was found in the samples from both just before (Trench W) and just after the terramara (Profile 3; Figs. 4, 5). It was also found in a Bronze Age sample from a short sequence still under study (Trench N, collected from a northern position in the ditch, unpublished data).

On the whole, data suggest that oat/wheat fields were present in the area but their pollen was not detected in the peripheric and near-site samples. This could have several reasons: a) the autogamy of many species, mentioned above (Rempel 1997); this determined that pollen of emmer wheat was even absent in some surface samples taken outside an emmer field (Bottema 1992: 24); b) the large size of most of the tetraploid and exaploid wheat pollen grains, up to 60-70 μm (types II and III according to Bottema 1992), which limits the airborne transport of this pollen. Because pollen counts were sufficiently high to recover this pollen (about 400 pollen grains from the near-site, excluding Cichorioideae and *Pinus* which were overrepresented) we can conclude that wherever the wheat fields were grown around the village, it was too far from the sampling points to be represented in these samples.

The land surface devoted to cereal fields

Archaeological data demonstrated that, within the Middle Bronze Age, the Terramara's area of influence changed, passing from chronological phases BM2 to BM3 depending on social and environmental changes. According to demographic data, the estimated area of influence experienced a slow increase from 1430 ha at BM2 to 1575 ha at BM3 (Cardarelli 1997; Bernabò Brea *et al*. 1997; Cardarelli in press). Archaeobotanical data, in turn, contributed evidence which was in agreement with archaeological data in affirming that cereals were surely cultivated within this territory. One of the major query concerning the work should be answered now: 'How large were the cereal fields? How much of the land influenced by the settlement was devoted to cereal fields?'

To answer these questions, models for estimating landscape openness within the RSA (Relevant Source Area) can be helpful (POLlen-LANDscape CALibration network; Sugita 1993; Broström *et al*.

1998; Gaillard *et al.* 1998). The quantitative estimation of landscape openness (e.g. percentage of open land and forested land) is made considering i) the RSA of the study site and ii) the percentage of non-arboreal pollen (Broström *et al.* 1998; Sugita *et al.* 1999). It must be stressed that the model described by Sugita *et al.* (1999) also considers other parameters, such as background pollen, pollen production and fall speed of pollen in the study area. In actual fact, these parameters are difficult to estimate in the different contexts, but some model-based relationships between non-arboreal percentages and open land cover percentages are useful to estimate the percentage of open land in agricultural contexts (Ravazzi *et al.* 2004; Valsecchi *et al.* 2006).

1) The RSA, which is the smallest spatial scale of vegetation that can be reconstructed from pollen records, is considered to be different in different contexts. Thus, in traditional cultural landscapes from modern open agricultural and semi-open forested regions it was estimated at around 800-1000 m (Sugita 1993), and at the Terramara di Poviglio, it was put at around 500-1000 m (Ravazzi *et al.* 2004). Therefore, we assumed that the RSA radium at the Terramara di Montale was also 1000 m. This indicates that pollen data mainly refer to the deforested and cultivated/exploited area around the 1000 m wide sampling points during the Middle and Recent Bronze Age.

2) At the Terramara di Montale, the Bronze Age samples had a low/medium tree-shrub cover. At an estimate of landscape openness in the area, altogether, the Bronze Age samples shows a tree-shrub cover of 36% on average, and consequently the percentage of non-arboreal pollen was an average of 64%.

Following the abovementioned models (Broström *et al.* 1998; Gaillard *et al.* 1998), this value suggests that 75-90% of the territory would have been open areas, which included areas without any woody plants (25-35%), areas with sparse shrubs and some trees (25-35%), and areas with shrubby pastures with some trees. These cover estimates do not change when only the peripheric and near-site samples are considered, even though in the latter case non-arboreal pollen decreased to 50% (Broström *et al.* 1998).

Recalling that the Terramara di Montale had an area of influence of 14 km^2 (radium = 2110 m), the piece of land described by our diagrams is about one quarter of that, i.e. 3.14 km^2 (RSA = 1000 m). This corresponds to 314 ha located near the village. Thus, pollen indicated that in a radium half the radium of the area of influence, 70-90% (220-280 ha) of the territory would have been occupied by open areas in which 25-35% of the land was without woody plants. Cereal fields would have been included in this open space. As they were a major cultivation, they would have occupied a large part of this land, i.e. they covered a surface ranging from 55-77 ha to 70-98 ha.

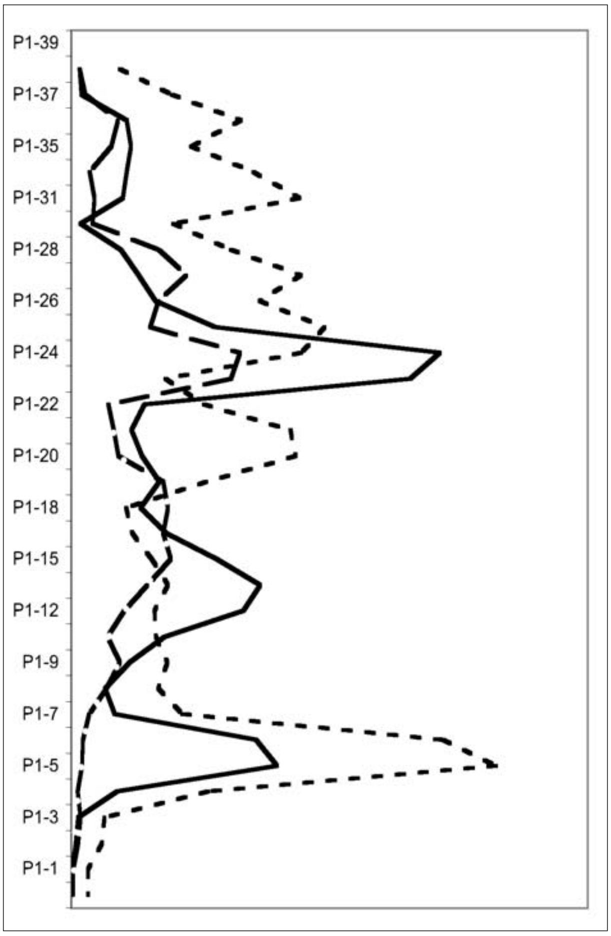
This surface corresponds to about 75 ha on average, which agrees with the estimation of the cereal field needs of the people who lived at the Terramara di Montale calculated by archaeologists based on a combination of data concerning demographics, daily nutritional needs and estimated nutritional power of the foodstuffs (Fraulini 2003-2004; Cardarelli in press).

Pastures in the open areas

The very high values of Cichorioideae, good markers of animal grazing (Behre 1986), suggested that a great part of the land was devoted to pastures. Actually, preliminary data showed that ovicaprines were dominant in the archeozoological record, followed by pigs and a few cattle (de Grossi Mazzorin, Ruggini 2004). Moreover, the presence of animal dung was also suggested by pollen (see above). Thus, a large part of the Terramara's area of influence was occupied by pastures. These were constituted of areas with sparse shrubs and some trees, and areas with shrubby pastures with some trees. Following the same model as above, the territory which was devoted to pastures within the 314 ha described by pollen profiles would have been about 239 ha on average during the Bronze Age. Obviously, these surface estimates do not represent a rigid subdivision of different sectors within the territory. As some pollen suggests (see below), it was highly probable that fields and pastures were rotated as presently occurs in crop-pasture alternation farming.

Agricultural practices

The maintenance of cereal field productivity for a long time, such as the approximately 300 years of the Terramara's lifetime, required certain agricultural practices to be adopted in order to assure good yields. Alternation of field and pastures including



6. - *Profile 1*. Mobile mean on two periods about concentrations of cereal pollen (continue line), Cichorioideae pollen (long dotted line), and small microcharcoals (short dotted line) from Profile 1. Only the trend is shown (for values see fig. 3). Exaggerations: cereal concentration x 100, and Cichorioideae concentration x 10.

i) crop-pasture alternation and ii) ignicoltura, iii) crop rotation, and iv) field manuring are known to have been used in earlier times and then again in the Bronze Age (van Joolen 2003; Bellwood 2004). Evidence of such agricultural practices are hardly observable in pollen diagrams as a high sample resolution is needed to detect the oscillations in land use these determine on an annual basis or every few years. Moreover, in archaeological sites anthropic transport prevails over airborne transport (Dimbleby 1985), and this was certainly the case of cereals on-site at the Terramara di Montale (see above). Nevertheless, we attempted to infer agricultural practices from Profile 1, which offered the highest temporal resolution among the sequences studied here. Considering that the deposition rate of archaeological layers is not at all regular, and was actually highly variable in this case through the phases of the Terramara's life (see chronology), an age-scale model will add chronological precision to the interpretation.

1) *Crop-pasture alternation* is the practice of devoting one piece of land to fields for a few years, then leaving it fallow and using it as pasture. Crop-pasture alternation can be recognized, for example, at the onset of the Terramara at around 300 cm (percentages of P1-4 and P1-5, Phase I, in fig. 3), when cereals increased and Cichorioideae decreased. Then, at around 280-270 cm (P1-7 and P1-8; Phase II), an inversion of the two curves was observable for some time. Later on, further alternations are visible. This suggests that cereal fields were rotated with pastures on the same territory, and that periodically one of them possibly prevailed.

2) *Ignicoltura* was cultivation with long fallow in areas where grass, bush or forest vegetation was cleared using fire and hoes then put to prolonged use until yields decline. New fields were then created, whereas the old ones were abandoned or used for stock pasturage (Barber 2003). After some years, the farmers returned to the first fields again (van Joolen 2003). Burning removes the vegetation and may release ashes, which can become buried, their nutrients fertilizing the soil. Some evidences of ignicoltura can be recognized in our diagram, throughout the relationships between the curves of the microscopical charcoal and the cereals. This practice, a sort of slash-and-burn method, occurred at the onset of the Terramara, where the two curves suddenly increased together (Phase 1, fig. 3; P1-5 – P1-6 in fig. 6). In the near-site diagram (fig. 5), large microcharcoals possibly marked this extended fire in the bottom Bronze Age sample. Moreover, the presence of burnt oak wood at the village's base floor and all the archaeological contexts favoured this interpretation. In subsequent phases, oscillations were not synchronous or charcoal peaks alternated with cereal peaks. For example, a peak in small microcharcoal corresponds to a decrease in cereal and Cichorioideae concentrations at about 190-210 cm (fig. 3; from P1-20 to P1-22 in fig. 6), and then the trend underwent inversion. This might reflect periodical activities of burning fields after harvesting or fallows, producing ash to fertilize. Nevertheless, the presence of hearths and fires in the village strongly influenced the diagram, making it difficult to distinguish ignicoltura from other human activities requiring fire.

3) *Crop rotation* is the use of a sector of land for a few years, alternating cultivations and fallow for some years (van Joolen 2003). In the Bronze Age, a cereal-fallow-pod plant cycle regenerated farming ground (Barcelo 1999). In particular, legumes are a source of nitrogen whose presence in the soils improves crop yields (Haque *et al*. 1986). At present, a rotation cycle may involve two/three years (short-cycle), four/six years (middle-cycle), or even ten years. This system consists in rotating depleting crops (*depauperanti*; e.g., wheat, barley, millet, oat, rye) and enriching crops (*miglioratrici*; e.g., forage and grain legumes). In traditional farming practices, the cultivation of two or more crops, including legumes and cereals, growing simultaneously and in proximity on the same field (intercropping) was also known (Haque *et al*. 1986; Innis 1997; Sullivan 2003; Jensen *et al*. 2006).

The archaeobotanical record of the Terramara di Montale shows both pollen and seeds of Leguminosae. A few seeds of *Vicia faba* var. *minor* plus *Vicia* spp. and *Lens culinaris* were found (< 0.1% of seeds/fruits). These are the same species sporadically found at other Bronze Age sites in the region, together with *Pisum sativum* and *Vicia ervilia* macroremains (Bandini Mazzanti, Taroni 1988a, 1988b; Bandini Mazzanti *et al*. 1996; Nisbet, Rottoli 1997; Castelletti *et al*. 2001). Therefore, legumes are known to be generally few in these archaeological contexts, possibly being a minor feature of the Bronze Age diet/economy in the region. At the Terramara di Montale, leguminosae pollen percentages were scarce (on average, 1.1% on-site, 0.6% in peripheric and 0.3% in near-site sequences) and belonged to *Vicia faba*, some forage legumes such as *Astragalus* cf., *Medicago*, *Trifolium* and *Vicia* type, plus *Lotus*, *Melilotus* and other Leguminosae undifferentiated**.** Considering that legumes are low pollen-producing plants, these percentages should represent some growth of legumes in the area. Moreover, as legume and cereal pollen grains were simultaneously present in 81% of the Bronze Age samples, crop rotation, and possibly also intercropping, were probably practiced by the farmers. Nevertheless, the low pollen and macroremain values suggested that legume fields would have occupied a minor part of the cultivated area.

4) *Field manuring* was possible using animal dung and mud or silt from swamps and rivers as fertilizers (Barber 2003). As already said the presence of animals on-site is supported by archeozoological and palynological evidence, and it is well known that dung would have been collected and used in Bronze Age farming (van Joolen 2003; Kooistra, Kooistra 2003). However, initial and still hypothetical estimates suggested that the number of domestic animals would not have been enough to cover all the territory's manuring needs (Cardarelli 2004; Cardarelli in press, and unpublished data).

Therefore, farmers might also have enriched their fields with mud. This can be observed in our diagrams by the algal spores of *Concentrycistes* which indicate the presence of free water or matter from fresh water deposits. In fact, most members of these algae inhabit shallow, stagnant, clean, oxygen-rich freshwater, where they form green slimy masses ('pond scums') on the surface, and their spores are dispersed in the water (van Geel, Grenfell 1996; Horrocks *et al*. 2002). Bakels (1997) interpreted a high percentage of freshwater algae, mostly *Pediastrum*, alongside the usual low percentages of cereals in Bronze Age spectra, as a result of transporting mud from swamps for manuring fields. At the Terramara di Montale, *Concentrycistes* could indicate such a practice. Also, the presence of algae suggested that seasonal or periodical river floodings were a natural help to people for manuring and irrigating fields. They could also be a sign of deliberate irrigation but channels or structural elements which confirmed this were not found at Montale. These structures are well known from other Terramaras (Bernabò Brea *et al*. 1997).

As reported above, these algae were more abundant in Trench W, as they were either free in the water or accumulated in the bed of the ditch. Profile 1 and 3 showed, at a different resolution, that *Concentrycistes* were more abundant before the Terramara and afterwards (from the Roman period onwards). It was found that that water or matter containing algal spores must have also been deposited in the area outside the river bed, and that this might have more frequently occurred before and after the Terramara than during the phases of its life. In other words, inundations might not have been as frequent during the phases of the Terramara's life as in the previous period and successive (Roman) period, and the land was not naturally subject to the frequent arrival of silt-rich fluviatile deposits that would act as fortuitous manure.

All considered, diagrams suggest that, during the Bronze Age, animal dung must have prevailed greatly over mud in field manuring. Nevertheless, dung was probably insufficient to ensure the regeneration of fields to the extent calculated above. Again, this suggests that people also had to adopt crop-pasture alternation, crop rotation, and possibly ignicoltura, to assure continuity in crop productivity from the onset to the decline of the Terramara.

Depletion of fields

The decline of the Terramara di Montale was part of the overall decline of the Terramara society (Bernabò Brea *et al*. 1997; Cardarelli in press). Though this is not the topic of this paper, it must be stressed that, if some environmental – climatically or anthropically forced – causes had been involved in determining such a decline, these would have resulted in the cereal fields experiencing a form of suffering/stress. Among the cereals found at the Terramara di Montale, barley, tetraploid/exaploid wheat, oat and rye are known to need good fertile soils, and only einkorn and millet can give good yields in less fertile soils and poorer growing conditions. Thus, in a situation like that of the Terramara, in which archaeobotanical data suggested that farmers probably used little fertilizer, and possibly had few legumes, a long-term cultivation might have led to a depletion of the soil.

Actually, at the Terramara, there is a significant fall in cereal pollen (top of Profile 1, fig. 3), dated at around 1300 B.C.-Phase X, i.e. slightly before the decline became evident in the archaeological record. This cereal field decline was synchronous with those of woods (fewer *Quercus* and other woody plants) and the increase of fallows (more *Centaurea nigra* type, *Cirsium, Polygonum aviculare* type). Cereal macroremains also seem to decrease in Phase X, but the general poor state of preservation prevents this being established with certainty (concentrations and percentages in Tab. 2).

In the Terramara di Montale's economy, the fall in cereals and wood would have meant a fall in the major resources from the area of influence, causing an environmental crisis in the settlement. Such a crisis, due to overexploitation of the soils and woods, resulted in land which was less suitable for cultivation than before and a wood which could not be renewed quickly (Mercuri *et al*. 2006).

Conclusions

The importance of cereal fields in the cultural landscape of the Terramara di Montale is a key topic to understand the economy of the Terramara because its inhabitants based their subsistence largely on cereals. These were mainly common/durum wheat (*Triticum aestivum/durum*), emmer (*T. dicoccum*) and einkorn (*T. monococcum*), followed by hulled barley (*Hordeum vulgare*), broomcorn millet (*Panicum miliaceum*), oat (*Avena* sp.) and rye (*Secale cereale*).

Pollen data suggested that cereal fields covered approximately 75 ha near-site. Barley, einkorn and millet fields may have been prevalently distributed in the western/south-western near-site areas. About one third of the open areas in the Terramara's area of influence were devoted to fields and the other part to shrubby pastures. The alternation of field and pastures were found to have been a major typology of land use. Besides crop-pasture alternation, ignicoltura (using fire to clear) was adopted at the establishment of the settlement, and fire was probably also used in subsequent times to manage the land. Crop rotation and animal dung were also used to enrich soils, thus assuring good yields. These practices provided a sufficient renewal of the territory for some years, but probably not for the entire life of the Terramara. In fact, cereal fields followed the history of the site: before the onset of the settlement, they were already present in the territory; then they rapidly expanded when people settled on the site; fields became a main feature of the cultural landscape; when the Terramara declined, either the extension of fields decreased or they were, more probably, abandoned. The near-site pollen diagram showed that the declining trend of cereal fields observed in the on-site diagram continued till early Roman times (figs. 3,5), but the area's vocation for cereal fields did not stop until some time after the Mediaeval Age.

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