THE EFFECTS OF THE AVELLINO PUMICE ERUPTION ON THE POPULATION OF THE EARLY BRONZE AGE CAMPANIAN PLAIN (SOUTHERN ITALY)

Quaternary International (2018), https://doi.org/10.1016/j.quaint.2018.03.035

Claude Albore Livadie
Emeritus research Director, CNRS, MMSH, Centre Camille Jullian, Archéologie Méditerranéenne et Africaine - UMR 7299 (AMU - CNRS) 5 rue du Château de l'Horloge, 13094 Aix en Provence, France. Email address: *alborelivadie@gmail.com*

Mark Pearce
Professor of Mediterranean Prehistory, Department of Classics and Archaeology, University of Nottingham, Nottingham NG7 2RD, UK. Email address: *mark.pearce@nottingham.ac.uk*

Matteo Delle Donne
Research fellow, Department of Asian, African and Mediterranean Studies - University of Naples "L'Orientale", Piazza S. Domenico Maggiore, 12, 80134 Naples, Italy.
ISMEO - International Association of Mediterranean and Oriental Studies, Corso Vittorio Emanuele II, 244, 00186 Rome, Italy. Email address*: matteodelledonne@email.it*

Natascia Pizzano
Istituto per le Tecnologie Applicate ai Beni Culturali - CNR, Area della Ricerca 1, Montelibretti – Roma, Italy. Email address: *natascia.pizzano@itabc.cnr.it*

Abstract
Palma Campania, the type-site of the Early Bronze Age Palma Campania culture, was covered by the products of the Avellino Pumice eruption, and was thus preserved in a similar way to the Roman sites in Campania covered by the AD 79 eruption. The devastating effects of this Plinian eruption led to the belief that it had killed a large part of the local population and/or caused large-scale emigration and landscape desertification. However, new sites have been found that were established shortly after the eruption and geoarchaeological studies of areas close to the Somma-Vesuvius volcano (Boscoreale, Boscotrecase, Torre Annunziata/Oplontis, Pompeii) and also further away (the Benevento area, Irpinia and the Salerno area) have shown continuity of occupation after the Avellino Pumice eruption and during the later, Middle Bronze Age, AP1 and AP2 eruptions. Palynological analysis also shows great similarity between the environments before and after the Avellino Pumice eruption. The pottery evidence is typologically very similar before and after the eruption, which suggests that the people who resettled the Campanian plain after the eruption were closely related to those living there previously, whose material culture is that of the Palma Campania culture. Radiocarbon dates also suggest a rapid recolonisation of some sites. In this paper we shall show that although the pyroclastic products of the Avellino Pumice eruption certainly had a major impact on the landscape (soils, flora, water resources) and may have killed off a percentage of the population in some areas, this eruption was not the main cause of the socio-economic and political transformations that occurred in this area during the Middle Bronze Age, which we believe to have been mainly caused by the cumulative effect of the later AP1 and AP2 eruptions.

1. |The effects of the Plinian Avellino Pumice eruption

The Plinian eruption known as the Avellino Pumice eruption (*1950-1820 cal BC* at 95.4%) devastated a large part of the Piana Campana, an area which was densely inhabited by Early Bronze Age farmers and herders (Fig.1). There had been increasing forest clearance in the area since at least the late Neolithic (end of the fifth millennium BC), leading to the creation of an

open landscape largely characterised by cereal cultivation (Marzocchella, 1998, 2002; Saccoccio et al., 2013).

The Plinian Avellino Pumice event caused a severe and long-lasting environmental crisis in the areas most affected by the eruption. Many aspects of daily village life were gravely damaged if not completely obliterated, as the eruptive products often sealed human settlements and infrastructures, particularly in those areas directly affected by huge pyroclastic flows. The volcanic products (pumice, ash and pyroclastic surge material) and post-depositional events (lahars, flooding, alluvial fans, landslides, etc.) brought major environmental changes in these areas. However, we shall see that, even though the settlers left their homes during the eruption and escaped, a range of evidence points to a relatively rapid resettlement of some areas affected by the eruption. Where possible, the site of the settlement and the cultivated fields abandoned during the volcanic event or a nearby area were resettled. Certain areas were only very slightly affected or not at all by the catastrophic event, like the area south of the volcano where the Palma Campania culture continued without interruption, or the islands of the Gulf of Naples, which were practically untouched. It seems that only a small temporal gap occurred between the abandonment of the settlements and their resettlement after the volcanic catastrophe; this is confirmed by radiocarbon dates and continuity in pottery forms and decoration, which show similar cultural traditions. We may therefore suggest that the people who left the area affected by the eruption, settling elsewhere for a while, returned to resettle the land of their ancestors.

The Avellino Pumice eruption can be dated through a combination of ^{14}C dates and pottery seriation, especially from the sites of Nola and San Paolo Belsito.
Sevink et al. (2011) use a Bayesian model, based on stratigraphic priors, to propose what they claim is a ‘robust’ date for the Avellino Pumice eruption. This is based on radiocarbon determinations on peat, wood and leaves from a former lake at the distal locations of Migliara and Campo Inferiore, in the Agro Pontino, southern Lazio (Fig.2). Their modelled date for the Avellino Pumice eruption is *2010-1958 cal BC* (at 95.4%) but close examination of their plot (Sevink et al., 2012, fig.7) and rerunning the model using OxCal 4.3 (Bronk Ramsey, 2009) suggests that there is a poor fit, with a very low agreement index (i.e. statistical reliability). Passariello and colleagues (2009), on the other hand, obtained three dates from a sheep (not goat, as originally described) killed by the eruption at the proximal site of Nola-Croce del Papa which, when combined using the OxCal 4.3 ‘Combine command, give a modelled calibrated date of *1950-1820 cal BC* (at 95.4%; Bronk Ramsey 2009). As can be seen from Figure 2, the calibrated dates for the organic material found below the tephra at Migliara and Campo Inferiore do not contradict this date and more recent work (Passariello et al., in press), which also presents a new date on dog bone from Nola-Croce del Papa, supports the date proposed by Passariello et al. (2009). It should be noted, however, that the modelled date proposed by Sevink et al. does not overlap with the modelled date based for the sheep killed by the eruption, despite their claims that the two dates are consistent (Sevink et al. 2012: 1045).We prefer the date of *1950-1820 cal BC* (at 95.4%) for the eruption.
It is widely believed that the Avellino Pumice eruption caused a significant interruption in human settlement in the Piana Campana, especially since the economy was primarily based on local resources. On the basis of radiocarbon dates available at the time, it was previously estimated that at least 230 years passed before the resettlement of distal areas and more than 1000 years before proximal areas could be resettled (Albore Livadie et al., 1998a).
The areas most affected by the eruption are the northern and north eastern parts of the Piana Campana, stretching towards the Beneventano, Irpinia and the Capitanata. Pyroclastic products related to the Avellino Pumice eruption reached the boundary of Daunia, in Puglia region, documenting that there was an east-northeast elliptical dispersal axis of fallout deposits (Fig.1). Grey pumices, used as temper in the Proto-Apennine (phase A) pottery at Coppa Nevigata, were probably collected along the main waterways (Caldara and Simone, 2012). The accumulation of

small lenses of deposits in riverbeds in Puglia was a distal effect of the eruption at a distance of over 150 km from the volcano caldera (Levi and Cioni, 1998; Levi et al., 1999). At Pompeii, however, which is close to the Somma-Vesuvius volcano, only a few ash lenses may be related to the Avellino Pumice eruption, while the effects of later pyroclastic events appear to have been more significant. Rather than the result of the Avellino Pumice eruption, it is reasonable to suppose that the evidence found at *Insulae* V, 1 and V, 6 by Nillson and colleagues (Nillson and Robinson, 2005; Nillson 2008) and at the cemetery of Sant'Abbondio (Mastroroberto, 1998, 146, n. 18, fig. 6.6) documents a later pyroclastic eruption which according to deep cores also impacted the coastal area and Civita Giuliana (Di Maio, Scala, Albore Livadie. in press). The evidence from the *Casa dei Postumii* is also probably due to this later eruption.
Pyroclastic surges also affected the areas located to the northwest of the volcano. In those areas, the network of roads and fields, which have been documented archaeologically, was obliterated and investigations have confirmed the massive effect of the volcanic eruption on local human settlement (Saccoccio et al., 2013).
Archaeological excavations carried out in the area northwest of the Somma-Vesuvius volcano have clearly documented how the water supply network of wells, springs, rivers and channels was severely modified as a result of the Avellino Pumice eruption (Di Vito et al., 2009). Such effects of the induced hydrogeological crisis were also particularly significant in the Calore Beneventano hydrographic system; for example, the valley floor of the River Jenga, which drains the east side of the Taburno Camposauro Massif, was flooded by volcaniclastic material, which interrupted the watercourse and deeply impacted the human settlement at Santa Maria la Peccerella (Bisogno et al., 1998, p. 213, phase f, fig. a, p.214).
At Nola, the Croce del Papa settlement area was initially covered by a white and mostly grey pumice fallout level more than 1.5 metres thick (Albore Livadie and Vecchio 1999; Albore Livadie and Vecchio, 2002, Albore Livadie et al., 2005). Within a few hours, a number of pyroclastic flows and surges followed by lahar streams reached the site (Fig. 3). The same process probably occurred at sites such as Saviano in the nearby plain.
The eruption also affected the coastal area where evidence of a tsunami is recorded, causing major damage in the Gulf of Naples (Milia et al., 2009). Tsunamite deposits have been found during archaeological excavations in Naples harbour and evidence from the Duomo underground station indicates that the eruption interrupted a long sequence of paralic sediments with few pottery sherds (Giampaola and Boenzi, 2013 41). In the period following the eruption, there is sporadic resettlement of the coastal area, documented by the presence of postholes relating to enclosures or fences (Amato et al., 2009: 28).
The Early Bronze Age settlement at Afragola was entirely covered by the Avellino Pumice tephra, which led to the area being abandoned until the Late Bronze Age (Nava et al., 2007). However, the situation differs at nearby Gricignano, where graves and an arable field system have been identified right on top of the eruption surge, demonstrating resettlement of the area after the eruption (Marzocchella, 1998; 2002). This is not an isolated example: the return of people to their destroyed settlements shortly after the eruption is documented at several sites, and is best known at Nola and San Paolo Belsito.

2. The resettlement of the landscape: Nola and San Paolo Belsito

Recent data allow us to reconsider the previous assumption that it took a long time before the Piana Campana was resettled. Surprisingly, there was a rapid resettlement, no more than a few decades after the Avellino Pumice event, even in proximal areas heavily impacted by the eruption.
This resettlement is well documented at Nola-via Cimitile (Albore Livadie et al., 2001, fig. 6, 125), and at San Paolo Belsito, where a hut showing at least one reconstruction phase was found on a poorly humic level that formed after the eruption (Albore Livadie et al., 2007a) (Fig. 4). Settlement pattern stability is documented both in proximal (the western and southern slopes of the Somma-Vesuvius and the Piana del Sarno) and distal areas (Salerno area) after the Avellino

eruptive event. This is evidenced at Pompeii (Nillson and Robinson, 2005; Nillson 2008), Oplontis (Torre Annunziata) (Di Maio 2014) (Fig. 5), Boscoreale, and Boscotrecase (Stefani et al., 2001; Fergola et al., 2011) where arable fields were cultivated even after the eruption. Ploughed fields at Ponte Valentino in the Calore valley, east of Benevento, were found to have been sealed by 10 centimetres of pumice but agricultural recovery in this more distal area was also almost immediate (Bisogno et al., 1998). Further south, at Battipaglia-Castelluccia, continuous occupation from the Early to the Recent Bronze Age was recorded, and does not seem to have been affected by the eruption (Scarano, 2011). The Avellino Pumice eruption appears to have had no effect on the settlement on Vivara or the other islands in the Gulf of Naples.

The task of assessing the effects of the Avellino Pumice eruption on human presence in the Piana Campana is particularly hard. The only available data to date is provided by material culture remains (mainly pottery) and the funerary record. Thus it is useful to focus on aspects related to everyday life, such as farming and husbandry, in order to evaluate the changes that may have occurred in the aftermath of the eruption.

3. The economic and environmental context before the eruption

In this section we give a short account of findings at two sites at Nola, Croce del Papa and Piazza d'Armi. These data can be compared with our current understanding of the settlement pattern after the Avellino Pumice eruption – in particular the sites of Sant'Abbondio, Capua-Strepparo and Capua-Cento Moggie (graves), Ariano Irpino-La Starza, Vivara-Punta Capitello and Vivara-Punta di Mezzogiorno. There are no reliable radiocarbon dates for Vivara-Punta di Mezzogiorno but the pottery, which shows parallels with the Palma Campania culture can be assigned to a period shortly after the eruption (Cazzella, 1999).

Nola-Croce del Papa

The settlement of Croce del Papa was partially excavated in 2001-2002 by Claude Albore Livadie on behalf of the local heritage authority, the *Soprintendenza Archeologica di Napoli e Caserta*. Three huts were investigated as well as a small portion of an apsidal feature pertaining to another hut located 70 metres from hut 4. Thanks to its unique state of conservation, the area (a farmyard with various pens for domestic animals) provided clear information on the everyday activities performed there (Albore Livadie et al., 2005, 2011).

The exceptional nature of the discovery is due to the dynamics of the eruption: a few hours after it began, when the site was already covered by more than one metre of pumice and fine ash sediment, which had settled on the roofs of the huts, the settlement was reached by pyroclastic flows that penetrated inside the huts, filling them and creating a cast of the wood and wattle and daub structures. The flow completely filled the contents and the internal structures such as clay storage-bins and ovens. Perfectly preserved impressions of the organic materials were produced by the slow fossilisation process, so that for example the straw thatch of the huts was reproduced in detail, thanks to the particularly fine grain of the sediments. This has given us an extraordinarily detailed understanding of the archaeobotanical evidence and of the forms of the huts and their construction techniques as well as of the internal layout of the settlement. The site was then completely sealed by the deposition of a number of volcaniclastic/alluvial layers.
Hut 4 contained a large number of pieces of meat (Fig.7), whereas hut 3 contained a high number of ears of wheat, most of which were found in the main room with a hearth (Fig. 8a). The ears of wheat had been stored in a large pot, which was overturned when the pyroclastic flow entered the hut. In the same room there was a large storage bin, which unfortunately was not excavated (Fig. 8b).

The archaeobotanical investigation focused on charred carpological remains, which are direct evidence that could be collected during the excavation, and also on indirect evidence like the

plant impressions in the ashy mud resulting from the pyroclastic flow of the phreatomagmatic phase that characterised the last hours of the eruption (Fig. 6a, 6b) (Costantini et al., 2007).
330 l of soil samples were floated in order to extract the carpological remains. 13,509 charred seed and fruit remains were collected and largely identified: 13,372 cereals (98.98%), including caryopses and spikelets; 32 fruit remains (0.24%); 58 weed remains (0.43%); 47 indeterminate seeds (0.35%). Among the cereals there is a large predominance of genus *Triticum* (wheat) (6194 remains, 46.32%), mainly *Triticum dicoccum* (emmer) and in smaller quantities *Triticum* cf. *spelta* (spelt) and *Triticum* cf. *durum/aestivum* (naked wheat), followed by *Hordeum* (barley) (3527 remains, 26.38%), *Triticum*/*Hordeum* (1092 remains, 8.17%), as well as *Panicum* (millet) (19 remains, 0.14%) and remains of *Cerealia* (2540 specimens, 18.99%). The fruit remains consist of *Corylus avellana* (hazelnut, 20 remains, 62.50%), *Vitis* sp. (grape, 3 remains, 9.38%), *Prunus* cf. *spinosa* (blackthorn, 3 remains, 9.38%), *Quercus* sp. (acorn, 1 remains, 3.13%), *Olea* sp. (olive, 1 remain, 3.13%) and *Amygdalus* cf. *communis* (almond, 4 remains, 12.50%).
The archaeobotanical documentation included also 89 imprints, mainly emmer and barley ears, spikelets and straw and one almond fruit, recovered in a layer of volcanic ash.

The faunal analysis showed a preponderance of sheep/goat (*Ovis aries* L. and *Capra hircus* L, MNI 36), pigs (*Sus scrofa* L, MNI 26) and, to a lesser extent, cattle (*Bos taurus* L., 17 MNI). There were only a few dog bones (*Canis familiaris* L., NMI 5). Birds, deer (*Cervus elaphus* L., NMI 9) and probably also boars (*Sus scrofa ferus*) were hunted. A fenced area covered by a canopy, with several vegetable fibre containers, contained a pen where at the moment of the eruption 13 subadult sheep were kept (*Ovis aries* L., with or without horns); almost all were pregnant (structure 8, contexts 44 and 18). Most were between 1 and 1.5 years old, while some were probably older (Pizzano, 2011; in press).

The faunal remains provided much information concerning food preservation and storage practices. Entire portions of disarticulated cattle and pig skeletons were found in the apses of the huts, which were used as storage areas. These portions were often hung on a cord passing through a hole in the hut posts or beams, which suggests that the meat was preserved by drying and/or smoking.

Nola-Piazza d'Armi
In 2008 a new settlement, Piazza d'Armi (the area of the former sports ground), was discovered in the modern town centre a few hundred metres from the Nola-Croce del Papa site. The botanical and faunal evidence is comparable to the data from the Nola-Croce del Papa settlement, evidencing life before the Avellino Pumice eruption.
The palaeosol at Piazza d'Armi was found only 3.5m below ground level, while at the nearby Croce del Papa settlement it is located at 6.20m in depth. This suggests that the site was located on a low rise in the ground which protected it from the direct effects of pyroclastic flows (Albore Livadie and Castaldo, 2009).
A thick grey pumice layer covers a former ground surface, which is particularly rich in potsherds and fragments of bone and charcoal. There were two large parallel cart tracks left by the repeated passage of vehicles. Similar cart tracks have been found at the site of Palma Campania-Pirucchi (Albore Livadie 1998; 2008).
Beneath this context, an older occupation surface was discovered, showing two different phases: a disused workshop area overlain by a structure which may be a dwelling. Series of postholes of different sizes, either aligned or showing no logical arrangement, relate to enclosures and fences or to structures for stalling livestock (Fig.9).

The pottery from this context is still being studied and is typical of the typological repertoire of the Palma Campania culture: bowls with flat everted rims or a slightly convex profile, carinated cups/dippers with ribbon handle and rounded base, jars with fingertip-impressed 'button'

decoration, lids of milk boiling pots, small jars with notched rims. The decoration, sequences of scratched or incised angular motifs and flat or fingertip-impressed cordons, has parallels in the ceramic repertoire of the sites located in the area of the plain, such as Palma Campania-Balle, Nola-Croce del Papa and Ottaviano-Alveo Zennillo). The archaeobotanical and archaeozoological data also confirm the presence of all the usual plant and animal species.

A preliminary archaeobotanical analysis of some soil samples from the site documents the presence of the principal cereal species cultivated throughout the Italian Bronze Age, such as emmer (*Triticum dicoccum*) and barley (*Hordeum vulgare*). As at Nola-Croce del Papa, it was possible to reconstruct the cereal-growing techniques used by the inhabitants of the settlement. This is testified by the presence of entire or partially fragmented wheat caryopses as well as by spike remains that show how the last step of cereal processing was carried out. The charred remains show that the diet was complemented by wild fruits, such as cornelian cherries (*Cornus mas*) and acorns (*Quercus* sp.) (Delle Donne, in press).

The most significant faunal assemblage examined (Natascia Pizzano, unpublished report in the archive of the *Soprintendenza Archeologica di Napoli e Caserta*), comes from the occupation surface beneath the Avellino Pumice eruption (context 12) at Piazza d'Armi. 644 bone remains were examined and the usual domestic species were found. Cattle is the dominant species in all sectors of the excavation, documented by whole disarticulated portions and/or bones with butchery cut-marks; both adult and young sheep/goats were found in almost all the investigated layers as were pigs of different ages and sex. A small bird and a red deer were also identified. A bone fragment from a pit (context 348) might be dog (*Canis familaris* L.).

We shall now provide a critical review of the data concerning the last phase of the Palma Campania culture, and especially the transition to the Proto-Apennine period (beginning of the Middle Bronze Age), in order to understand continuity and transformation within sites during the recovery from the eruption.

4. After the event: elements of continuity

Some sites attest resettlement after the eruption with elements of continuity with the previous settlement. Cultural continuity can be argued to demonstrate the continuity of human groups, with a very brief or no hiatus at all in the economic and social development of a settlement.

Ariano Irpino-La Starza

The La Starza settlement at Ariano Irpino is located about 70 Km NE of the Somma-Vesuvius volcano. There is a group of different sized huts built directly on a layer of fallen pumice. Excavation and palaeoenvironmental data show a fast recovery of vegetation after the eruption, with an open landscape (maple and hop hornbeam) dominated by holm oak (Coubray, 1999). Moreover, the typology of the pottery, which shows parallels with the material uncovered under the Avellino Pumice eruption in the Piana Campana, contradicts the hypothesis of a slow resettlement, i.e. after several generations, of the area as initially suggested by radiocarbon dating (Albore Livadie et al., 1998a).

A number of radiocarbon dates are available for the site and are reported in Table 1; they indicate that the site was rapidly settled. One of the oldest huts excavated (context 205) had an oval plan, oriented northeast-southwest, with an internal oval clay hearth, set into a floor of cobbles and potsherds laid flat. A second hut (context 203) had an elliptical plan and was also oriented northeast-southwest; it had a beaten clay floor. A clay hearth inside another hut (2C6) covered a pit containing the skeleton of a six-year-old child (Petrone, 1999). The settlement was defended by a limestone wall and ditch, which ran along the edge of the north terrace.

A preliminary archaeobotanical study was carried out on plant remains recovered from the layers that overlie the Avellino Pumice eruption layers (Delle Donne, in press). More than 100 plant remains were retrieved from the examined samples collected in all the areas where human activities were performed. 27% of plant remains may be classified as cereals (mainly *Triticum dicoccum* and *Hordeum vulgare*), 34% as legumes (*Vicia faba*) and 39% as fruits (mainly *Quercus* sp. acorns). The high degree of fragmentation and the presence of deformed seed and fruit remains suggests that most of the material analysed was charred as a result of a short-term, direct exposure to a very intense fire.

Faunal analysis carried out on the very same stratigraphic layers at the settlement of La Starza (Albarella, 1999; Ascierto, 2004/2005) documents a mixed diet characterised by a range of animals. Species present were dog (NMI 3), sheep/goat (NMI 12), pig (NMI 8) and *brachyceros* cattle (NMI 8), that became very important as beasts of burden for the cultivation of cereals and other products. Cattle, sheep and goats, slaughtered as adults, were raised for meat and probably for wool, milk and its derived products, as well as for labour in the case of the cattle. Pigs were slaughtered at a young age. Domestic dog bones with butchery cut marks were found: like the cattle, adult dogs were slaughtered, probably when they had no further use other than food. Hunting seems to have been rare and is documented by the presence of red deer (NMI 2), roe deer (NMI 2) and boar (NMI 1).

Nola-Via Cimitile

At Nola, in Via Cimitile (about 700 metres from Piazza d'Armi), two small test trenches (7 and 8) were opened between October and December 1999.

Trench 7 uncovered a very small part of a hut with an enclosure, constructed on the pumice deposit of the Avellino Pumice eruption, at the top of which was the ash layer formed during the phreatomagmatic phase of the eruption. Only the floor of the apsidal part of the structure could be excavated, uncovering abundant ceramic material and charcoal (context 9). Charcoal from this occupation context (context 28) radiocarbon dated: DSH-138: 3492±23 BP -1890-1740 cal BC (95.4%). A 10cm deep pit had been excavated in the pumice and the hardened ash overlying it, between the hut and the enclosure fence; in it was a fragment of an adult human skull (context 24- 26/11/99), embedded in the grey pumice. Radiocarbon determination gave the following date: DSH-143: 3492 ± 23 BP, 1690 -1400 cal BC (95.4%).

A range of pottery mixed with reworked pumice was found in Trench 8. Finds from contexts 20 and 21 included fragments of cups and/or dippers with ribbon handles and umbilical bases, a sherd of a pedestal-bowl with a flat everted rim and a ribbon handle joining the rim to the point of maximum width of the pot, and fragments of large bowls, pots with an internal ledge, carinated vessels, flat everted rims, rounded-rim cups and jars with notches or fingertip impressions on the rim.

The faunal assemblage was studied by Natascia Pizzano who identified cattle (*Bos Taurus*), sheep/goat (*Ovis vel capra*), pig (*Sus scrofa*) and dog (*Canis familiaris*). Gaetano Di Pasquale identified two charcoal samples (trench 8, context 20 and context 28) as belonging to the group of deciduous oaks (*Quercus pubescens, Q.robur, Q.petraea* and *Q. cerris*). He has commented (pers. comm.) that even though oak was not found in the preliminary anthracological analysis of the material from Nola-Croce del Papa, it is highly likely to be present.

The excavation suggests that the original hut plan was a structure with apsidal ending, typical of the horse-shoe shaped huts of the Palma Campania culture. The enclosure shows parallels with those found at Gricignano (Marzocchella, 1998), Afragola (Laforgia et al., 2009), Nola-Piazza d'Armi and Nola-Croce del Papa. The hut probably had a maximum width of 5 metres, like hut 4 at Nola-Croce del Papa (Fig. 10).

Capua-Strepparo and Cento Moggie

There were several phases of occupation in the area of Strepparo and Cento Moggie in Capua, spanning from the Early Bronze Age to the end of the Middle Bronze Age (Apennine phase: Minoia and Raposo, 1996). This is the only locality so far known in the Caserta district where there is evidence for any continuity of occupation before and after the Avellino Pumice eruption, although there is a change of use from settlement to funerary area. Although no markers of the Avellino Pumice eruption were found, material within the hut and pits may be dated to a time shortly before the eruption, as clearly attested by the presence of typical Palma Campania culture features (ribbon handle cups, a cooking tray (*spiana*), hourglass-shaped supports, jars, etc.). Another structure, probably also a hut, was identified to the north of this hut. Preliminary analysis suggests that this hut dates to the beginning of the Middle Bronze Age. It contained hemispheric bowls and hourglass-shaped supports, which suggest parallels with the material uncovered at Vivara-Punta Capitello (Damiani et al., 1984).
A small number of burials have been excavated in the nearby cemetery. The skeletons lay on either their right or left side, with slightly bent legs. The bodies were oriented east-west with the skull to the west, or southeast-northwest with the head facing south. The grave assemblages have very close formal parallels with the grave goods found at Sant'Abbondio and therefore might be dated to a very late phase of the Early Bronze Age, close to the transition to the Middle Bronze Age (Proto-Apennine phase).
Further, more detailed study will allow the possible contemporaneity of the burials and the probable hut to be assessed.

Pompeii-Sant'Abbondio
A small settlement belonging to the Palma Campania culture was excavated at Pompeii between 1993 and 1997, on the small volcanic hill of Sant'Abbondio which controls the lower course of the Sarno river. There was a double line of east-west oriented postholes in the lava substratum. The lack of palaeo-surfaces suggests that the structure had only a single, very brief phase of use (Mastroroberto, 1998). The area then became a cemetery; most of the tombs date to the beginning of the Middle Bronze Age (Proto-Apennine phase), but some burials show late Early Bronze Age features. Generally, the burials are trench graves, sometimes with a step at the side. The bodies are crouched, lying on their side and oriented north-south with the head facing west, towards sunset; other are oriented east-west. There are also graves with burials in a supine position. Grave goods are relatively poor, although some of the graves with weapons have richer assemblages, including bronze weapons (dagger blades), pottery (cups, pedestal-vases), bronze personal items (pins and awls) and flint artefacts (daggers and arrows).
Children (less than 5-6 years) are buried in large pots (*enchytrismos*) and there is also the burial of a two or three-year-old child inside a tuff sarcophagus (T.22/93), which may have had a lid. A layer of tephra covering the funerary area was interpreted as documenting the Avellino Pumice eruption (Mastroroberto, 1998, 146, n. 18, fig. 6) but it is more likely this layer can be correlated with the one uncovered during the Swedish excavations in the *Regio* I in Pompeii (see above) and documents a later pyroclastic eruption.

The Sant'Abbondio cemetery, the groups of burials at Capua-Strepparo and Cento Moggie, Gricignano and San Paolo Belsito as well as the cemeteries of Oliva Torricella, Picarielli, and Ostaglio in the Salerno area provide some of the rare funerary evidence for the Early Bronze Age in Campania. Unfortunately, it is rather difficult to discuss the evidence in depth because little documentation is available (Albore Livadie and Marzocchella, 1999), but some considerations are possible. The practice of offering pots and food with the burial (funerary feasting?) is recurrent, as is the breaking of pots. It is generally believed that through time there was a gradual shift from a marked crouching of the legs to the supine position. The majority of the burials are trench graves, but tumuli are recorded, at both Gricignano and San Paolo Belsito. *Enchytrismos* burials seem to characterise children under the age of 5-6 years. After this age, they were buried in the same way as adults. Graves may be lined with stones and cobbles (in particular in the cemeteries

from the Salerno area) and may have different orientations. Mastroroberto's (1998, p. 139, n. 9) suggestion that grave orientation depends on the gender of the deceased needs verifying.

5. Radiocarbon chronology

Calibrated radiocarbon dates from sites resettled after the Avellino Pumice eruption provide strong confirmation of the short interval that elapsed before people returned to their former homes. Figure 10 shows individual calibration plots for the three dates for the sheep killed by the eruption at Nola-Croce del Papa and a plot for the combined date (calculated using the OxCal 4.3 'Combine' command; Bronk Ramsey 2009) compared to sites to the northeast of the volcano, at Nola-Via Cimitile, Nola-San Paolo Belsito and Nola-Masseria Rossa in the Piana Campana, and at Ariano Irpino-La Starza in the hills, showing that resettlement at these locations was rapid, taking place very soon after the eruption.

6. Discussion

There are very few differences in the environmental data for before and after the eruption (Fig.12). A programme of pollen sampling at sites predating the eruption (Avella, Gricignano, Palma Campania, San Paolo Belsito, Schiava di Tufino and Visciano) indicated a very open landscape with pastures, water meadows and small woods of *Quercus* sp. (oak) and *Alnus* (elm) or *Corylus* (hazel) (Vivent and Albore Livadie, 2001, fig. 5a-5b). Intensive exploitation of the plain is attested by Dominique Vivent's study at the excavations at the Gricignano US Navy base that showed the predominance of Non Arboreal Pollen (NAP). In their discussion of Vivent's data, Saccoccio et al. (2013) commented that tree pollen values are generally lower before the Avellino Pumice eruption, whereas in the plain they increase after the eruption, probably due to the relocation of settlements to more easily defendable locations. They add that after the later AP1 episode, the arboreal pollen increases, reaching 28% and confirming a relative abandonment of the plain, matched by an increased settlement of the hills (Saccoccio, et al., 2013:90).

Before the eruption, cereal cultivation was characterized by emmer (*Triticum dicoccum*) and barley (*Hordeum vulgare* L.). Archaeobotanical investigation at Nola-Croce del Papa, has provided us with exceptionally detailed information concerning prehistoric agricultural practices, mainly regarding cereal threshing and storage. It has been possible to investigate day-to-day practices, performed inside the houses or in the areas nearby. According to the data, emmer and barley, after harvesting and a first processing, were stored as ears, without stems, in large ceramic bins which were sited in the main room of the hut; cereals were then threshed, maybe in quantities needed for daily use, on a large fenced threshing floor, as attested by the large number of chaff remains, in particular glume bases and forks, retrieved from soil samples collected in this area. The presence of millet (*Panicum* sp.) at Nola-Croce del Papa and at Oliva Torricella (in the Salerno area) (Delle Donne 2011) attests the early cultivation of this minor cereal, then documented in other areas, as shown by the evidence from Middle Bronze Age layers of Capua, Strepparo and Cento Moggie (Castiglioni, Rottoli 1996).
Cereal cultivation seems to be complemented by the systematic and efficient cultivation of legumes, with a clear predominance of the broad bean (*Vicia faba* L.) which was recognised at the Early Bronze Age site of Oliva Torricella (Delle Donne, 2011), in the Proto-Apennine levels at Ariano Irpino-La Starza and at Vivara (Costantini et al., 2001), where it was associated with *Pisum* sp., *Lens* sp. and *Lathyrus* sp.
The gathering of wild fruits is well attested in the carpological record of Campanian sites such as Afragola (Laforgia et al., 2009; Laforgia et al., 2015), Capua (Castiglioni, Rottoli 1996), Pratola Serra (Ciaraldi, 1999; 1998-2000), Pompeii-Swedish excavation (Nillson and Robinson, 2005; Nillson 2008), Nola-Piazza d'Armi and Nola-Croce del Papa. Here almonds (*Amygdalus communis*), blackthorn sloes (*Prunus* cf. *spinosa*), acorns (*Quercus* sp.), hazelnuts (*Corylus avellana*), olives (*Olea* sp.) and grapevine (*Vitis* sp.) were found. At Nola-Piazza d'Armi cornelian cherry stones (*Cornus mas* L.) were also attested.

Archaeobotanical data for the phase before the eruption from Nola-Croce del Papa and Nola-Piazza d'Armi and for the phase following the eruption from Ariano Irpino-La Starza (Costantini et al., 2007; Coubray, 1999; Delle Donne, in press), together with data for other sites in the region (Afragola, Pratola Serra, Pompeii) can help us understand agricultural techniques and crop management. It seems that agricultural production was not very different before and after the eruption, but we need to consider the different archaeobotanical strategies adopted at the different sites; even though it was noted that cereals became less common at Pratola Serra after the eruption and wild fruits increased (Ciaraldi, 1999; 1998-2000). When the landscape was resettled, the cultivation of cereals began again and the wild resources present were exploited as much as possible. Little can be said about environmental recovery at La Starza (Coubray, 1999), but Albarella (1999) notes that husbandry continued to be based on the same animal species, even if hunting may have become more significant as compared to the previous period.

Pottery from the layers following the eruption is typologically similar to the previous period. We find cups with ribbon handles and wide concave bowls typical of the Palma Campania culture, but there are some differences, indicative of the short time span before resettlement.
For example, incised and fretted decoration was abandoned. Less complex forms with more linear profiles and more rigid shapes seem to be attested (Soriano and Albore Livadie, 2017).

There do not seem to be great changes in funerary ritual, though there is a gradual shift from crouched inhumation with flexed arms and legs to supine inhumation. There is also a shift in the composition of the grave furniture as bronze artefacts and weapons become more common. The Sant'Abbondio graveyard, still unpublished 20 years after its discovery, might also provide valuable information concerning social change. Burials 8 and 22 clearly stand out from the others because of their rich assemblages (bronze weapons and pots). Albore Livadie and Marzocchella (1999) have argued that after the Avellino Pumice eruption there begin to be clearer indications of a stratified society, as indicated by the burial of a young man with a dagger in a large trench grave at Gricignano.
The continuity of settlement attested at the site of Sant'Abbondio, not far from ancient mouth of the river Sarno, is a clear indicator of maritime trade, which probably also involved sites such as Naples-Piazzale Tecchio (Albore Livadie et al., 2007b) and the island of Vivara.

As has been seen, the radiocarbon evidence confirms that resettlement was relatively rapid after the eruption.

Final remarks
At the symposium in honour of Luigi Bernabò Brea, Albore Livadie and Marzocchella (2003) remarked on the scarcity of settlements (no more than 30) during the period following the eruption as compared to those belonging to the period A before the eruption and the Apennine phase. They considered this discontinuity to attest to a real demographic drop caused by the devastating effects of the volcanic event on the population and more in general on the environment.
Even if only a few settlements may be dated to the phase immediately following the eruption (to the list published in 2003 we can only add the sites of Naples-Piazzale Tecchio and Pompeii), it is clear that they are often located close to previously settled areas (Nola, San Paolo Belsito, Pompeii, etc.). It should be added that like the AD 79 eruption that preserved Roman Pompeii, the pyroclastic material of the Avellino Pumice preserved the underlying settlements it covered, while later sites do not have the same preservation conditions. This is likely to have skewed the statistics regarding post-eruption sites.
At Pompeii, there is evidence for layers which may be assigned to the Palma Campania culture (perhaps three well-defined strata under the volcanic ash) (Boman and Nilsson, 2006/2007;

Nilsson, 2008; Nilsson and Robinson, 2005). Three further layers were uncovered above the ash, underlining settlement continuity at site.
At Oplontis, Torre Annunziata, the stratigraphy recorded within the garden of the so-called *Villa A*, known as Poppaea's Villa (Di Maio 2014: 703-706), attests pedomarkers of deep ploughing (about 10 cm) on top of a palaeosol. The furrows and ridges of this ploughing are similar to those investigated at Boscoreale and Boscotrecase, which can be ascribed to an undefined moment between the Neolithic and Early Bronze Age (layer 5b) on the basis of tephrostratigraphy. An undated pyroclastic layer (6), fully preserved only inside the furrows, seals these ploughed fields under a 10 cm thick layer (Di Maio, 2014, 706, Tav.4.1, Fig. 4.14) (Fig. 5). The recovery of agricultural practices thus seems to be have been immediate and led to the discovery of a new 'productive' horizon which essentially reworked pyroclastic sands and gravels in an ashy and slightly humic matrix, but was not as fertile as the soil that was cultivated before the eruption. The presence of some pumice that originated during the Avellino Pumice eruption, reworked and embedded in this horizon (7), allows us to ascribe the ploughed palaeosurface to the end of the Early Bronze Age and the Palma Campania culture. Two further pyroclastic layers (8 and 10) are again followed by the immediate reprise of prehistoric agricultural practices. At San Marzano sul Sarno and in the area of Castel San Giorgio, continuity in human occupation is also widely attested by traces of ploughing under the sub-Plinian AP1 and AP2 eruptions, whose impact, although less than the Avellino Pumice episode, was still significant (Figs.13,14).

7. Conclusions

The Avellino Pumice eruption certainly had a dramatic impact on the people living in the Campania region, especially in certain areas. Nonetheless, there is now evidence of the recovery of many sites after the catastrophe. These sites, fewer in number and perhaps occupying less territory compared to the period before the eruption, do not show significant changes as regards their way of life and agricultural and husbandry practices. It seems likely that it was the same Palma Campania culture groups that returned to the territory where they belonged, as suggested by the archaeological, palaeobotanical, and archaeozoological evidence. Despite the effects of the Plinian Avellino Pumice eruption, the inhabitants were able to resettle the area close to the volcano a short time after the event, but a few generations later, two sub-Plinian events, the AP1 and AP2 eruptions, critically affected the human populations living in the eastern Piana Campana.

It seems that the period when the second Middle Bronze Age eruption (AP2) took place is the least well documented in archaeological terms. Radiocarbon dating (DSH-154: 3380 ±23 BP: Albore Livadie, 2007a; Passariello et al., 2009) indicates that AP2 occurred at 1750-1620 cal. BC (at 95.4%) during Middle Bronze Age 1/2 when a new archaeological culture, the Proto-Apennine, is attested. It is may be suggested that the material culture change also reflects the presence of new human groups in the area, which was previously characterised by the Palma Campania culture. The indirect effects of a Plinian eruption, in addition to not one but two sub-Plinian episodes, might have had serious consequences for the survival of the local population, even years after the first catastrophe (most recently, Di Maio et al. 2012: 41). The effects on the climate of an eruption have been clearly shown by recent studies (Zanchetta et al., 2012). During the eruption, enormous amounts of sulphur dioxide are released. The dioxide is oxidised becoming sulphuric acid in the troposphere and in the stratosphere. It is likely that the droplets that are formed would interact with the sunlight, causing a drop in temperature.
Nilsson (2009) suggested that an initial decrease in human population after the Avellino Pumice eruption, and as a consequence of the number of settlements, might be due to problems exploiting the landscape for agriculture and husbandry, but also, we argue, in restoring the communication network, the irrigation and drainage network (streams, springs and wells), the agrarian infrastructure and visual and cultural landmarks.
But the real crisis in human activity in the area of the volcano is not only due to the effects of the Avellino eruption. A more intense and long-lasting period of environmental crisis was caused by

the coupled effects of the Avellino Pumice and the following prehistoric eruptions (AP1 and AP2). Consequently, we must redate the climax of the crisis to a few generations after the traditional transition between the end of the Early Bronze Age and the beginning of the Middle Bronze Age 1/2.
It is possible to offer further considerations concerning the settlement pattern that characterised the Middle Bronze Age, which likely indicates a situation of greater insecurity (hilltop settlements with defensive infrastructures). But due to the lack of extensive excavations in the region, it is difficult to fully assess the incidence of strategically located sites in this period. The fortified sites of Ariano Irpino-La Starza (Albore Livadie, 1992) and Buccino-Tufariello (Holloway et al., 1975) seem so far to be exceptional. Indeed, Albore Livadie and Marzocchella (2003, 130, n. 29) have already expressed doubts concerning the usual interpretation of the wall surrounding Buccino-Tufariello as a defensive structure and Holloway himself suggested an alternative hypothesis: that the walls were necessary to support structures above them (Holloway et al., 1975, 33). The lack of adequate data suggests that interpretation can go no further at present.

Bibliographic references

Albarella, U., 1999. The animal economy after the eruption of Avellino pumice: the case of the La Starza (Avellino, southern Italy). In: Albore Livadie, C. (Ed.), L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico), Atti del Seminario internazionale, 15-17 Luglio 1994, CUEBC, (Territorio storico e ambiente, 2), Bari, pp. 317-330.

Albore Livadie, C., 1992. Nuovi scavi alla Starza di Ariano Irpino. In: Cocchi Genick, D. (Ed.), L'età del Bronzo in Italia nei secoli dal XVI al XIV sec. a.C. Atti del Congresso, Viareggio 1989, Rassegna di Archeologia, 10, Firenze, pp. 481-491.

Albore Livadie, C.,1998. L'area a nord est del Somma Vesuvio: sequenze eruttive e ritrovamenti archeologici. In: Guzzo, P.G., and Peroni, R. (Eds), Archeologia e Vulcanologia in Campania, Pompei, 21 Dicembre 1996, Arte Tipografica, Napoli, pp. 48-67.

Albore Livadie, C., 1999. Territorio e insediamenti nell'agro Nolano durante il Bronzo antico (facies di Palma Campania): Nota preliminare. In: Albore Livadie, C. (Ed.), L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico), Atti del Seminario internazionale, 15-17 Luglio 1994, CUEBC, (Territorio storico e ambiente, 2), Bari, pp. 203-245.

Albore Livadie, C., 2007. L'età del Bronzo antico e medio nella Campania nord−occidentale. In: Atti della "XL Riunione Scientifica", Istituto Italiano di Preistoria e Protostoria, Strategie di insediamento fra Lazio e Campania in età preistorica e protostorica, Firenze, vol. II. pp. 179-203.

Albore Livadie, C., 2008. "Sites et campagnes de l'âge du Bronze sous les cendres du Vésuve". In: Guilaine, J. (Ed.), *Villes, villages, campagnes de l'Age du Bronze*, Seminario del Collège de France, Paris, Edition Errance, Collection des Hespérides, pp. 126-141.

Albore Livadie, C., and Castaldo, N., 2009. Nola (Napoli) - L'insediamento del Bronzo antico in Piazza d'Armi, Notiziario. Rivista di Scienze Preistoriche, Firenze, LIX, pp.386-387.

Albore Livadie, C., and Marzocchella, A., 2003. La struttura degli abitati del Bronzo antico e medio nelle Eolie e nell'Italia meridionale. In: Albore Livadie, C., Cazzella., A., Marzocchella, A., Pacciarelli, M., 2003. La struttura degli abitati del Bronzo antico e medio nelle Eolie e nell'Italia meridionale. Atti XXXV Riunione Scientifica IIPP, Le comunità della preistoria italiana. Studi e ricerche sul neolitico e le età dei metalli, Castello di Lipari, Chiesa di S. Caterina 2-7 Giugno 2000, Firenze, pp. 123-133.

Albore Livadie, C., and Marzocchella, A., 1999. Riflessioni sulla tipologia funeraria in Campania fra Bronzo antico e Bronzo medio San Severo, San Severo 27-29 Novembre 1998, 19° Convegno nazionale, Tavola rotonda: Ipogei della Daunia: Culti e riti funerari nella media età del Bronzo, Foggia, pp. 117-134.

Albore Livadie, C., and Vecchio, G. (Eds.), 2002. Nola. Quattromila anni fa. Il villaggio dell'Età del Bronzo antico distrutto dal Vesuvio. Soprintendenza per i Beni archeologici delle Province di Napoli e Caserta, Comune di Nola, Nola, 72 pp.

Albore Livadie, C., Campajola, L., D'Onofrio, A., Moniot, R. K., Roca, V., Romano, M., Russo, F, Terrasi, F., 1998. Evidence of the adverse impact of the "Avellino Pumices" eruption of Somma-Vesuvius on old Bronze age sites in the Campania region (Southern Italy), Quaternaire, vol.9, n.1, pp. 37-43.

Albore Livadie, C., Castaldo, N., Mastrolorenzo, G., Vecchio, G., 2001. Effetti delle eruzioni del Somma-Vesuvio sul territorio di Nola dall'età del Bronzo all'epoca romana tardiva. In: Tephras. Chronologie et archéologie, Brives-Charensac 24-29 Août 1998. Les dossiers de l' Archéo-Logis 1, Juvigné, E. and Raynal, J.-P. (Eds), Goudet, pp. 119-128.

Albore Livadie, C.; Vecchio, G.; Castaldo, E., Castaldo, N., Delle Donne, M., Minieri, L., Pizzano, N., 2005. Il villaggio di Nola, Croce di Papa (Napoli) nel quadro della facies culturale di Palma Campania (Bronzo antico), Pompei, Lit. Sicignano, 55 pp.

Albore Livadie, C., Vecchio, G., Castaldo, N., 2007a. L'età del Bronzo a San Paolo Belsito (Nola -Napoli). Atti XL Riunione Scientifica IIPP, Roma 2005, Firenze, pp. 869-872.

Albore Livadie, C., Vecchio, G., Castaldo, N., Pizzano, N., Pappalardo, M. T., Amato, V., di Vito, M., 2007b. L'insediamento protoappenninico di Fuorigrotta - Piazzale Tecchio. In: Strategie di insediamento fra Lazio e Campania in età preistorica e protostorica. Atti XL Riunione Scientifica IIPP, Roma 2005, Firenze, pp. 961-964.

Albore Livadie, C., Vecchio, G., Delle Donne, M., Pizzano, N., 2011. Un paysage fossilisé sous les cendres du Vésuve (Nola, Naples, Italie). In: Studer, J., David-Elbiali, M., Besse, M. (Eds), Paysage… Landschaft… Paesaggio. L'impact des activités humaines sur l'environnement du Paléolithique à la période romaine. Actes du colloque du Groupe de travail pour les recherches préhistoriques en Suisse, GPS/AGUS, Genève, 15 et 16 Mars 2007, (Cahiers d'archéologie romande, 120), Lausanne, pp. 159-174.

Amato, L., Guastaferro, C., Cinque, A., di Donato, V., Romano, P., Ruello, M.R., Perriello, Zampelli, S., Morhange, C., Russo Ermolli, E., Irollo, G., Carsana, V., Giampaola, D., 2009. Ricostruzioni morfoevolutive nel territorio di Napoli. L'evoluzione tardo pleistocenica-olocenica e le linee di riva di epoca storica. Méditerranée, 112, pp. 23-31.

Ascierto, A., 2005-2006. I livelli della "ripresa" dopo l'eruzione delle Pomici di Avellino a "La Starza" (Ariano Irpino – AV): indagine archeofaunistica. Advisor Claude Albore Livadie, coadvisor Natascia Pizzano. Università di Napoli "Suor Orsola Benincasa". Unpublished Master thesis.

Bisogno, G., Fariello, M., Di Maio, G., Sperandeo, G., 1998. Geoarcheologia e ambiente antico lungo la Media e Bassa Valle del Calore Beneventano. In: D'Amico, C., and Albore Livadie, C.

(Eds), Quarta Giornata delle Scienze della Terra e l'Archeometria, 20-21 Febbraio 1997. Il future della Memoria, 1, Istituto Universitario Suor Orsola Benincasa, Napoli, pp. 210-215.

Boman, H., and Nilsson, M., 2006-2007. The early street and the prehistoric finds in Vicolo delle Nozze d'Argento, Pompeii. Opuscula Romana 31/32, 2006/7, pp. 161-165.

Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51, 1, pp. 337-360.

Caldara M., and Simone, O., 2012. L'ambiente fisico nell'area dell'insediamento di Coppa Nevigata, in A. Cazzella, M. Moscoloni, G. Recchia, Coppa Nevigata e l'area umida alla foce del Candelaro, Foggia, pp. 339-359.

Castiglioni, E. and Rottoli, M., 1996. Capua (Caserta). Località Strepparo e Cento Moggie. Scavi nell'area Cira. Resti botanici da un pozzo dell'età del bronzo. Bollettino di Archeologia, Roma, 37-38, pp. 62-67.

Cazzella, A., 1999. La sequenza di Vivara-Punta di Mezzogiorno. In: Albore Livadie, C. (Ed.), L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico). Atti del Seminario internazionale, 15-17 Luglio 1994, CUEBC, (Territorio storico e ambiente, 2), Bari, pp. 149-156.

Ciaraldi, M., 1998-2000. The role of plant economy at Pratola Serra (Avellino, southern Italy) in the context of the Italian Bronze age. Origini, Roma, Nuova Serie, XXII, pp. 251-266.

Ciaraldi, M., 1999. The economy of plant resources of the early Bronze Age settlement of Pratola Serra (Avellino, southern Italy). In: Albore Livadie, C. (Ed.), L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico). Atti del Seminario internazionale, 15-17 Luglio 1994, CUEBC, (Territorio storico e ambiente, 2), Bari, pp. 287-298.

Costantini, L., Costantini Biasini, L., Giorgi, J. A., 2001. Archaeobotanical investigation in the Bronze age site of Vivara (Procida, Naples). In: Guarino, A. (Ed.), Proceedings 3rd International Congress on Science and technology for the Safeguard of cultural Heritage in the Mediterranean Basin, Vol 1, Alcalà de Henare (Spain), 9-14 July 2001, Alcalà de Henare, Servicio de Publicaciones de la Universidad de Alcala, pp. 165-174.

Costantini, L., Costantini Biasini, L., Delle Donne, M., 2007. L'agricoltura del villaggio protostorico di Nola, loc. Croce del Papa (NA). In: Strategie di insediamento fra Lazio e Campania in età preistorica e protostorica. Atti XL Riunione Scientifica IIPP, Roma 2005, Firenze, pp. 705-718.

Coubray, S., 1999. Résultats de l'analyse paléobotanique sur le site de la Starza (Avellino, Italie méridionale) au début du Bronze moyen. In: Albore Livadie, C. (Ed.), L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico), Atti del Seminario internazionale, 15-17 Luglio 1994, CUEBC, (Territorio storico e ambiente, 2), Bari, pp. 311–316.

Damiani, I., Pacciarelli, M., Saltini, A. 1984. Le 'facies' archeologiche dell'isola di Vivara e alcuni problemi relativi al Protoappenninico B. *AION* (archeol), IV, pp. 1-38.

Delle Donne, M., 2011. Analisi archeobotaniche preliminari, in C. Albore Livadie, La facies di Palma Campania. L'aspetto di Oliva Torricella. In: Campanelli, A. (Ed.), Dopo lo Tsunami. Salerno antica, Napoli, Arte'm, pp. 134-137.

Delle Donne, M., 2018. La protostoria agricola della Campania: nuovi dati archeobotanici. In: Albore Livadie, C., and Vecchio, G. (Eds.), Il villaggio di Croce del Papa (Nola): un insediamento del Bronzo antico sepolto dall'eruzione pliniana delle Pomici di Avellino. Centre Jean Bérard, Napoli in press.

Di Maio, G., 2014. Villa A. La sequenza stratigrafica del giardino settentrionale. In: Clarke, J. R., and Nayla K. Muntasser (Eds), Oplontis: Villa A ("Of Poppaea") at Torre Annunziata, Volume 1, The Ancient Setting and Modern Rediscovery. New York, ALCS E-Book, pp. 693-721, in part. pp. 703-706.

Di Maio, G., Cicirelli, C., Albore Livadie, C., 2012. Sintesi correlative di inquadramento geoarcheologico ed evoluzione del paesaggio antropico, in Geoarcheologia e ricostruzione del paesaggio archeologico. In: Cicirelli, C., and Albore Livadie, C. (Eds), Poggiomarino, L'Erma di Bretschneider, Roma, pp. 26-44, in part. 40-44.

Di Maio, G., Scala, S., Albore Livadie, C., 2018. Effetti delle eruzioni protostoriche del volcano Somma Vesuvio sugli insediamenti umani della piana del Sarno. Quaternaria Nova, Roma in press.

Di Vito, M. A., Zanella, E., Gurioli, L., Lanza, R., Sulpizio, R., Bishop, J., Tema, E., Boenzi, G., Laforgia, E., 2009. The Afragola settlement near Vesuvius, Italy: the destruction and abandonment of a Bronze Age village revealed by archaeology, volcanology and rock-magnetism. Earth and Planetary Science Letters, 277, 3-4, pp. 408-421.

Di Vito, M. A., de Vita, S., Piochi, M., 2013. Il Somma Vesuvio: storia eruttiva e impatto delle sue eruzioni sul territorio. In: Di Vito, M. A., and de Vita, S. (Eds.), Miscellanea INGV 18, Roma, pp. 14-21.

Fergola, L., Stefani, G., Albore Livadie, C., Esposito, E., Di Maio, G., 2001. Recenti indagini geoarcheologiche nei territori di Boscoreale e Boscotrecase. In: Guzzo, P.G. (Ed.), Pompei. Scienza e Società, 250° Anniversario degli Scavi di Pompei, Atti del Convegno, Milano, pp. 207-208.

Giampaola, D., and Boenzi, G., 2013. Interazione tra attività vulcanica e vita dell'uomo : evidenze archeologiche nell'area urbana di Napoli. In: Di Vito, M. A., and de Vita, S. (Eds.), Miscellanea INGV 18, Roma, pp. 38-44.

Holloway, R., Nabers, N. P., Lukesh, S. S., Eaton, E. R., Hartmann, N. B., Barker, G., McKerrall, H., Phippen, W. L., Leuci, G., 1975. Buccino, The Early Bronze Age Village of Tufariello. Journal of Field Archaeology, vol. 2, pp. 11-81.

Laforgia, E., Boenzi, G., Amato, L., Bishop, J., Di Vito M. A., Fattore, L., Stanzione, M., Viglio, F., 2009. The vesuvian "Pomici di Avellino" eruption and Early Bronze Age settlement in the middle Clanis valley. Méditerranée, 112, pp. 101-107.

Laforgia, E., Boenzi, G., Matarazzo, T., Stanzione, M., 2015. Ambiente e biodiversità nella piana campana: modalità di sfruttamento delle risorse vegetali in una comunità del Bronzo antico. Il villaggio del Bronzo antico di Afragola. In: Preistoria del cibo. L'ambiente fonte di risorse alimentari condizionamenti e impatto ambientale in funzione dell'acquisizione delle risorse alimentari, 50° Riunione Scientifica IIPP, Roma, pp. 1-12.

Levi, S. T., and Cioni, R.,1998. I piroclasti in alcune ceramiche pugliesi dell'età del Bronzo e l'area di dispersione originaria delle Pomici di Avellino: un indicatore cronologico, tecnologico e di scambio. In: Guzzo, P.G., and Peroni, R. (Eds.), Archeologia e Vulcanologia in Campania, Napoli, pp. 159-166.

Levi, S. T., Cazzella, A., Cioni R., 1999. Presenza di materiale pomiceo dell'eruzione vesuviana di Avellino nella ceramica dell'età del Bronzo di Coppa Nevigata (Fg). In: Albore Livadie, C. (Ed.), L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico), Atti del Seminario internazionale, 15-17 Luglio 1994, CUEBC, (Territorio storico e ambiente, 2), Bari, pp. 341-354.

Marzocchella, A., 1998. Tutela archeologica e preistoria nella pianura campana. In: Guzzo, P. G., and Peroni R. (Eds.), Archeologia e vulcanologia in Campania, Napoli, pp. 97-133.

Marzocchella, A., 2002. Europa tra preistoria e protostoria. Dai primi insediamenti al fenomeno urbano. Aspetti e forme dell'organizzazione del territorio. Il mondo dell'archeologia, Treccani, pp. 905-907.

Mastroroberto, M., 1998. La necropoli di S. Abbondio: una comunità dell'età del Bronzo a Pompei. In: Guzzo, P. G., and Peroni, R. (Eds.), Archeologia e vulcanologia in Campania, Napoli, pp. 135-149.

Milia, A., Raspini, A., Torrente, M.M., 2009. Evidence of slope instabilities and tsunami associated with the 3.5 ka Avellino eruption of Somma–Vesuvius volcano, Italy. In: Violante, C. (Ed.), Geohazard in Rocky Coastal Areas. The Geological Society, London, Special Publications, 322, pp. 105-119.

Minoia, M., and Raposo, B., 1996. Capua. Località Strepparo e Cento Moggie. Scavi nell'area del CIRA. Rinvenimento di sepolture e strutture del'età del bronzo. Boll. di Archeologia, 37-38, pp. 54-61.

Nava, M.L., Giampaola, D., Laforgia, E., Boenzi, G., 2007. Tra Clanis e il Sebeto: nuovi dati sull'occupazione della piana campana tra il Neolitico e l'età del Bronzo. In: Strategie di insediamento fra Lazio e Campania in età preistorica e protostorica. Atti XL Riunione Scientifica IIPP, Roma 2005, Firenze, pp. 101-126.

Nillson, M. and Robinson, M., 2005. Remains of prehistoric habitation beneath Pompeii V 1,13. Opuscula Romana 30, pp. 97-103.

Nilsson, M., 2008. Evidence of Palma Campania settlement at Pompeii. In: Guzzo, P.G. and Guidobaldi M. P. (Eds.), Nuove ricerche archeologiche nell'area vesuviana (scavi 2003-2006). Nuove ricerche archeologiche nell'area vesuviana (scavi 2003-2006), Colloquio Internazionale, Roma 1-3 Febbraio 2007, (Studi della Soprintendenza archeologica di Pompei, 25), L'Erma di Bretschneider, Roma, pp. 81-86.

Nilsson, M., 2009. The First of a Series of Disasters? Pompeii and the Aftermath of an Early Bronze Age Eruption. Archaeological Review from Cambridge, 24. 2. 2009, pp. 81-98.

Passariello, I., Albore Livadie, C., Talamo, P., Lubritto, C., D'Onofrio, A., Terrasi, F., 2009. ^{14}C Chronology of Avellino Pumices Eruption and timing of human reoccupation of the devastated region**,** Radiocarbon 51(2), pp. 803-816.

Passariello, I., Marzaioli F., Capano M., D'Onofrio A., De Cesare N., Terrasi F., 2018. Le datazioni assolute dell'eruzione. In: Albore Livadie, C., and Vecchio, G. (Eds.), Il villaggio di Croce del Papa (Nola): un insediamento del Bronzo antico sepolto dall'eruzione pliniana delle Pomici di Avellino. Centre Jean Bérard, Napoli in press.

Petrone, P.P., 1999. Osservazioni su resti ossei umani da contesti di abitato dell'età del bronzo medio iniziale in Campania. In: Albore Livadie, C. (Ed.), L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico). Atti del Seminario internazionale, 15-17 luglio 1994, CUEBC, (Territorio storico e ambiente, 2), Bari, pp. 331-340.

Pizzano, N., 2011. In: Albore Livadie, C., Vecchio, G., Delle Donne, M., Pizzano, N. Un paysage fossilisé sous les cendres du Vésuve (Nola, Naples, Italie). In: Studer, J., David-Elbiali, M., Besse, M. (Eds), Paysage… Landschaft… Paesaggio. L'impact des activités humaines sur l'environnement du Paléolithique à la période romaine. Actes du colloque du Groupe de travail pour les recherches préhistoriques en Suisse, GPS/AGUS, Genève, 15 et 16 Mars 2007, (Cahiers d'archéologie romande, 120), Lausanne, pp. 159-174.

Pizzano, N., 2018. Allevamento e caccia in una comunità protostorica. Nola - Croce del Papa. In: Albore Livadie, C., and Vecchio, G. (Eds.), Il villaggio di Croce del Papa (Nola): un insediamento del Bronzo antico sepolto dall'eruzione pliniana delle Pomici di Avellino. Centre Jean Bérard, Napoli in press.

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck, C.E., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Staff, R.A., Turney, C.S.M., van der Plicht, J., 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0-50,000 years cal BP. Radiocarbon 55, 4, pp. 1869–87.

Saccoccio, F., Marzocchella, A., Vanzetti, A., 2013. The field system of Gricignano d'Aversa (Southern Italy) and the agrarian impact in the Piana Campana, ca. 3900 cal BP. Quaternary International 303, pp. 82-92.

Scarano, G., 2011. "L'abitato di Castelluccia", in Campanelli, A. (Ed.), Dopo lo Tsunami. Salerno antica, Napoli, pp.126-133.

Sevink, J., Van Bergen, M.J., Van der Plicht, J., Feiken, H ., Anastasia, C., Huizinga, A., 2011. Robust date for the Bronze Age Avellino eruption (Somma-Vesuvius): 3945 ± 10 calBP (1995± 10 calBC). Quaternary Science Reviews, 30, pp. 1035-1046.

Soriano, E., Albore Livadie, C., 2017. La facies di Palma Campania e i suoi rapporti con le facies coeve dell'Italia medio-tirrenica e dell'Italia meridionale: considerazioni alla luce delle recenti scoperte, Dialoghi sull'Archeologia della Magna Grecia e del Mediterraneo, Paestum, pp. 101-111.

Stefani, G., Fergola, L., Albore Livadie, C., Di Maio, G., 2001. Le Somma-Vésuve et la region pompéienne durant la Préhistoire: premiers résultats géoarchéologiques à Boscoreale et à Boscotrecase. In: Tephras. Chronologie et archéologie, Brives-Charensac 24-29 Août 1998. Les dossiers de l' Archéo-Logis 1, Juvigné, E., and Raynal, J.-P. (Eds), Goudet, pp. 211-218.

Vivent, D., and Albore Livadie, C., 2001, Contributions de la palynologie à l'étude des comportements humains en contexte volcanique actif: exemple de l'âge du Bronze en Campanie

(Italie). In: Tephras. Chronologie et archéologie, Brives-Charensac 24-29 Août 1998. Les dossiers de l' Archéo-Logis 1, Juvigné, E., and Raynal, J.-P. (Eds.), Goudet, pp. 245-254.

Zanchetta, G., Giraudi, C., Sulpizio, R., Magny, M., Drysdale, Russell., N., Sadori, L., 2012. Constraining the onset of the Holocene "Neoglacial" over the central Italy using tephra layers. Quaternary Research, pp. 236-247.

Tables and pictures

Fig. 1. Map showing the location of sites mentioned in the text, with the fallout pattern for the Avellino Pumice eruption, pyroclastic density currents in red; fallout isopachs in blue and green (after Di Vito et al., 2009).

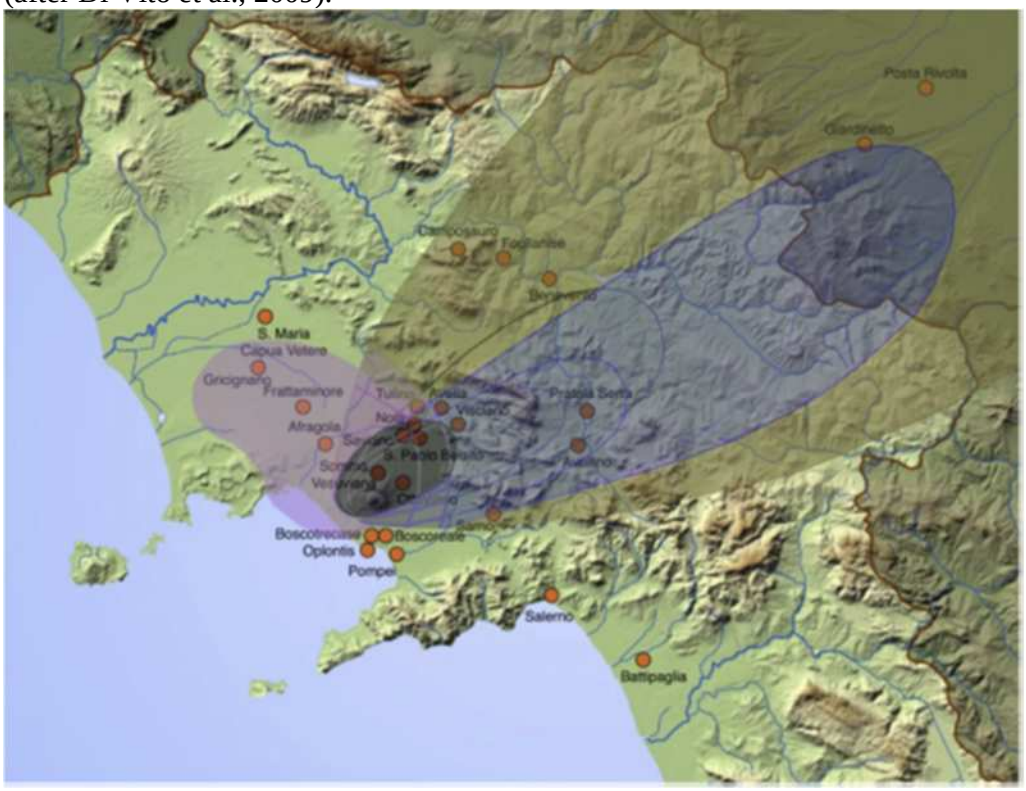

Fig. 2. Calibrated radiocarbon dates for samples below and above the Avellino Pumice tephra at the distal locations of Migliara and Campo Inferiore, in the Agro Pontino, southern Lazio (Sevink et al., 2011) compared with three calibrated dates from a sheep killed by the eruption at the proximal site of Nola-Croce del Papa, and the combined date (OxCal 4.3 'Combine' command: Bronk Ramsey, 2009; Reimer et al., 2013); all calibrations at 95.4%.

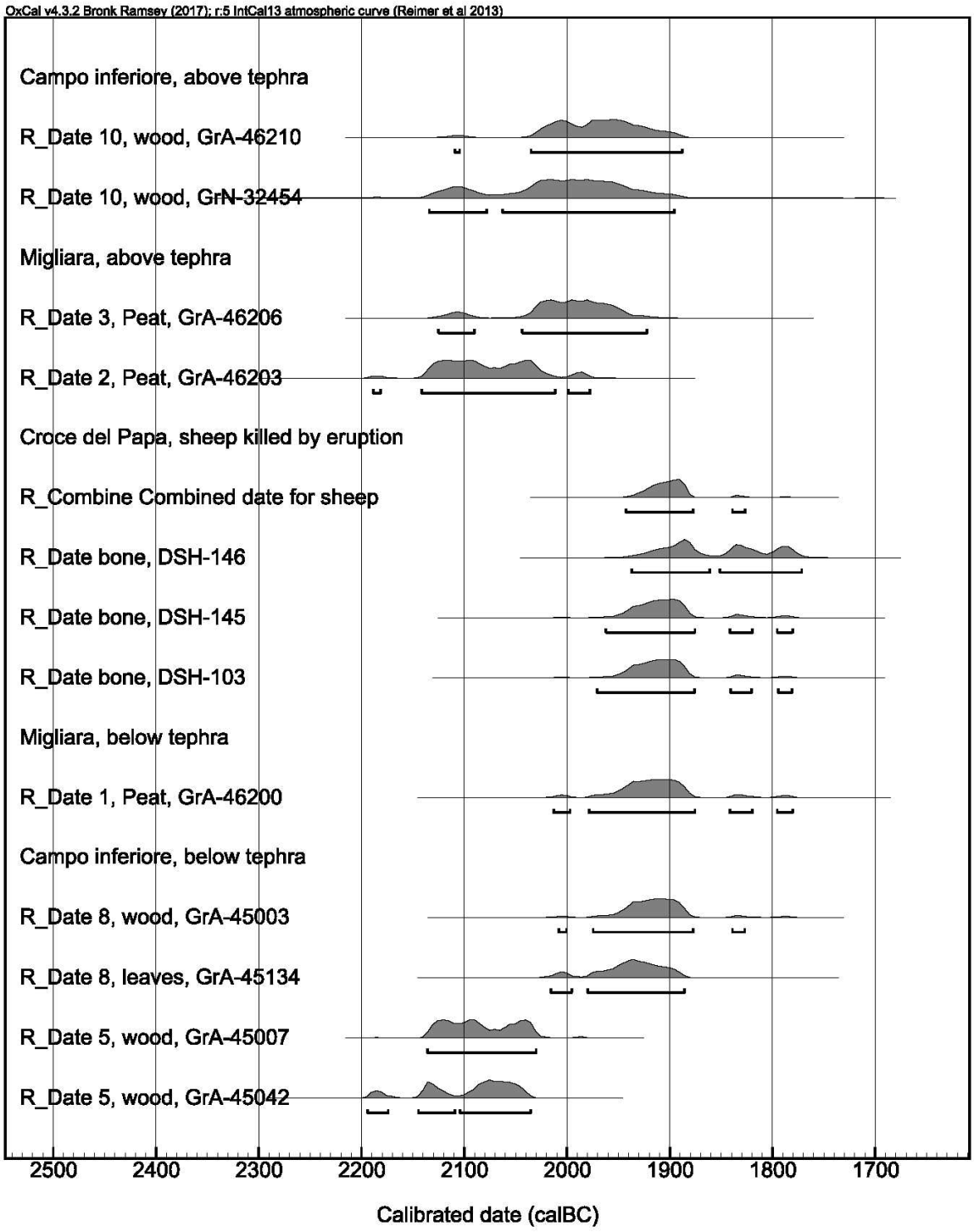

Fig. 3. Nola-Croce del Papa settlement. Hut 3 with its fill.

Fig. 4. San Paolo Belsito. A hut built on the Avellino Pumice eruption deposits.

Fig. 5. Oplontis. Stratigraphy of the garden of “Villa A”. (Source: Geomed. S.r.l. Scafati).

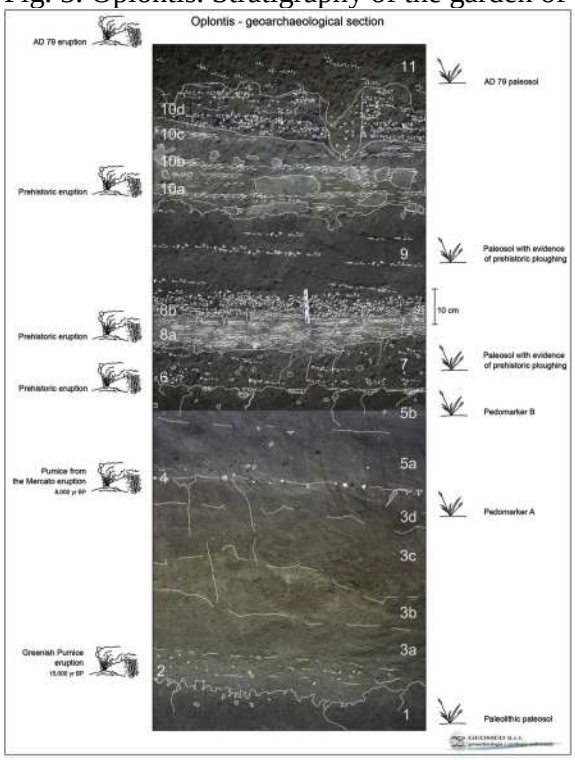

Fig. 6a. Nola-Croce del Papa settlement. Imprint of emmer (*Triticum dicoccum*) ear in volcanic ash.

Fig. 6b. Nola-Croce del Papa settlement. Imprint of barley (*Hordeum vulgare*) ear in volcanic ash.

Fig. 7. Nola-Croce del Papa settlement. Hut 4 during excavation.

Fig. 8a. Nola-Croce del Papa settlement. Hut 3.

Fig. 8b. Nola-Croce del Papa settlement. Storage bin from hut 3.

Fig. 9. Nola-Piazza d'Armi settlement.

Fig. 10. Individual calibration plots for the three dates for the sheep killed by the eruption at Nola-Croce del Papa and a plot for the combined date (OxCal 4.3 ‘Combine’ command; Bronk Ramsey 2009) compared to Nola-Via Cimitile, Nola-San Paolo Belsito, Nola-Masseria Rossa and Ariano Irpino-La Starza in the hills, showing that resettlement at these locations was rapid, taking place very soon after the eruption; all calibrations at 95.4% (Reimer et al., 2013).

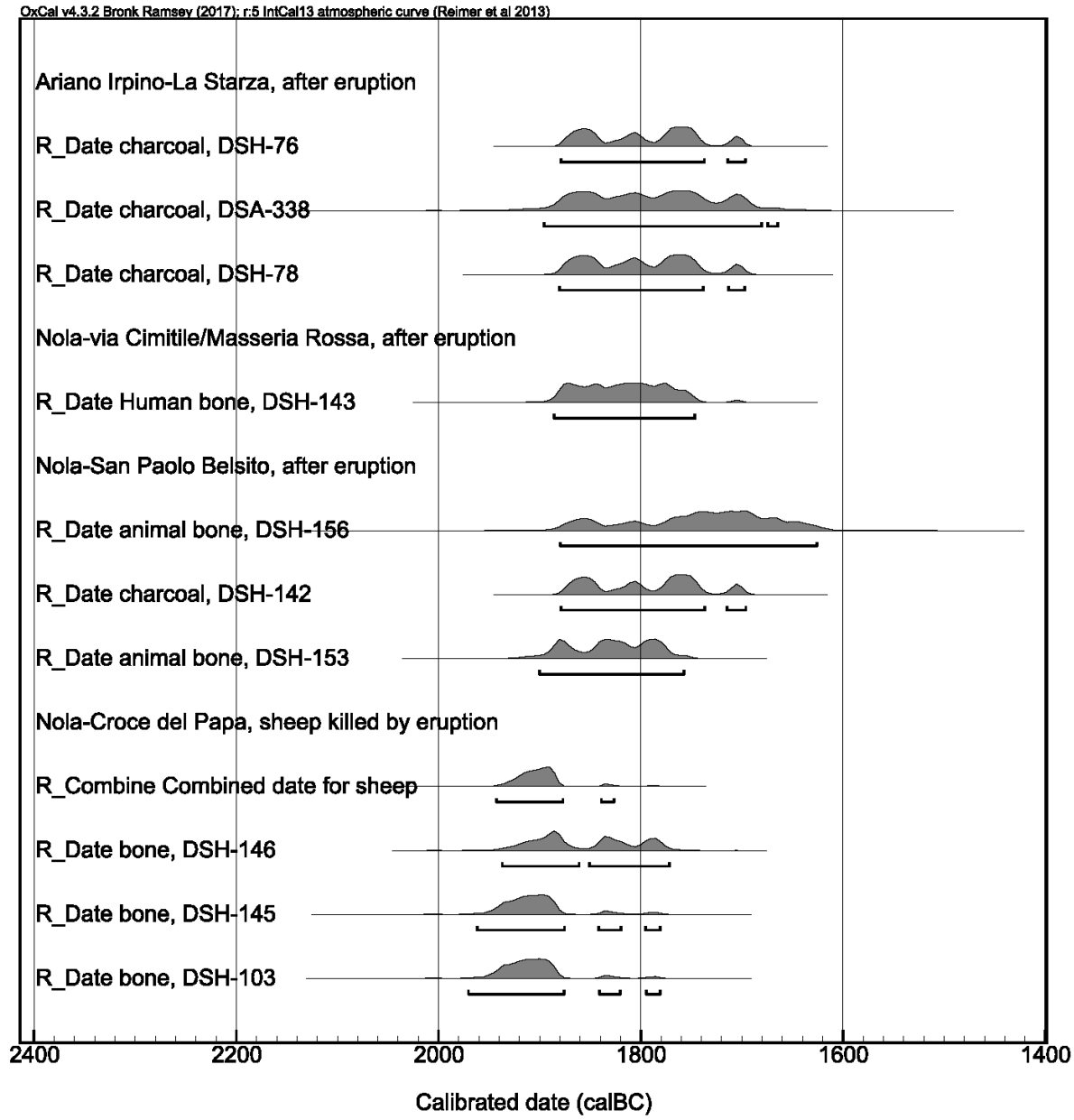

Fig. 11. Nola-Via Cimitile/Masseria Rossa. Hut and part of the enclosure.

Fig. 12. San Paolo Belsito. Pollen diagram (source: Vivent and Albore Livadie 2001: 249, fig.3a)

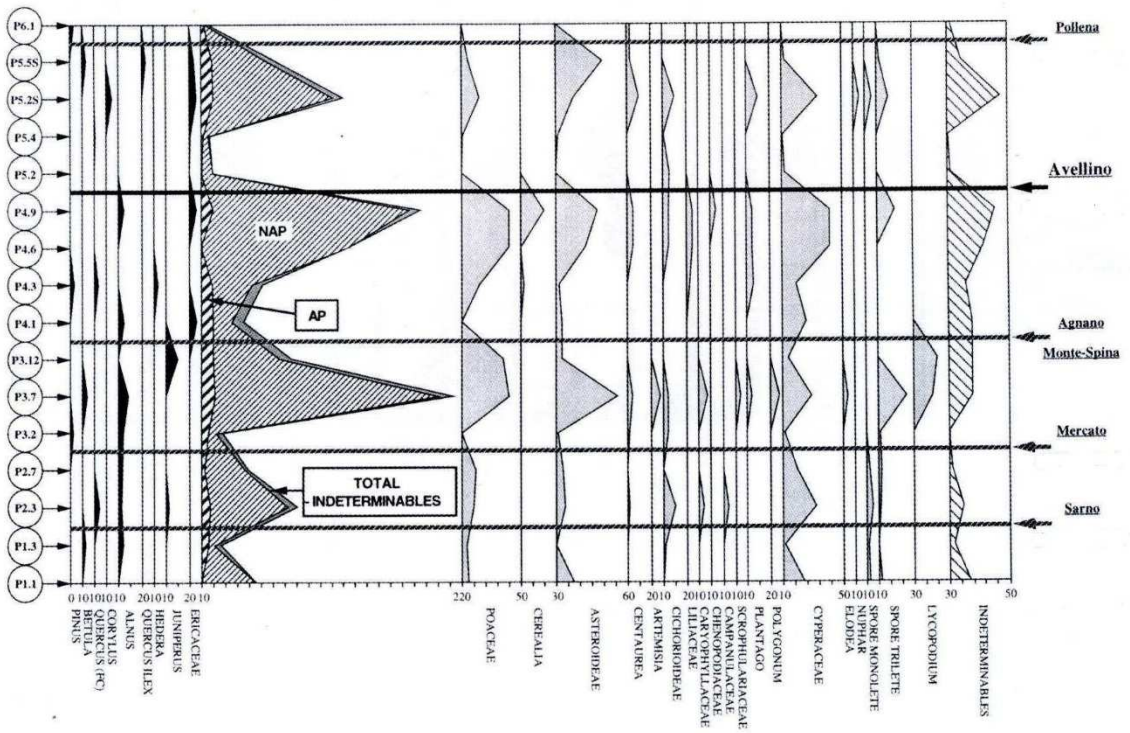

Fig. 13. Map showing the location of sites mentioned in the text, with the fallout pattern for the AP1 eruption (after Di Vito et al., 2013).

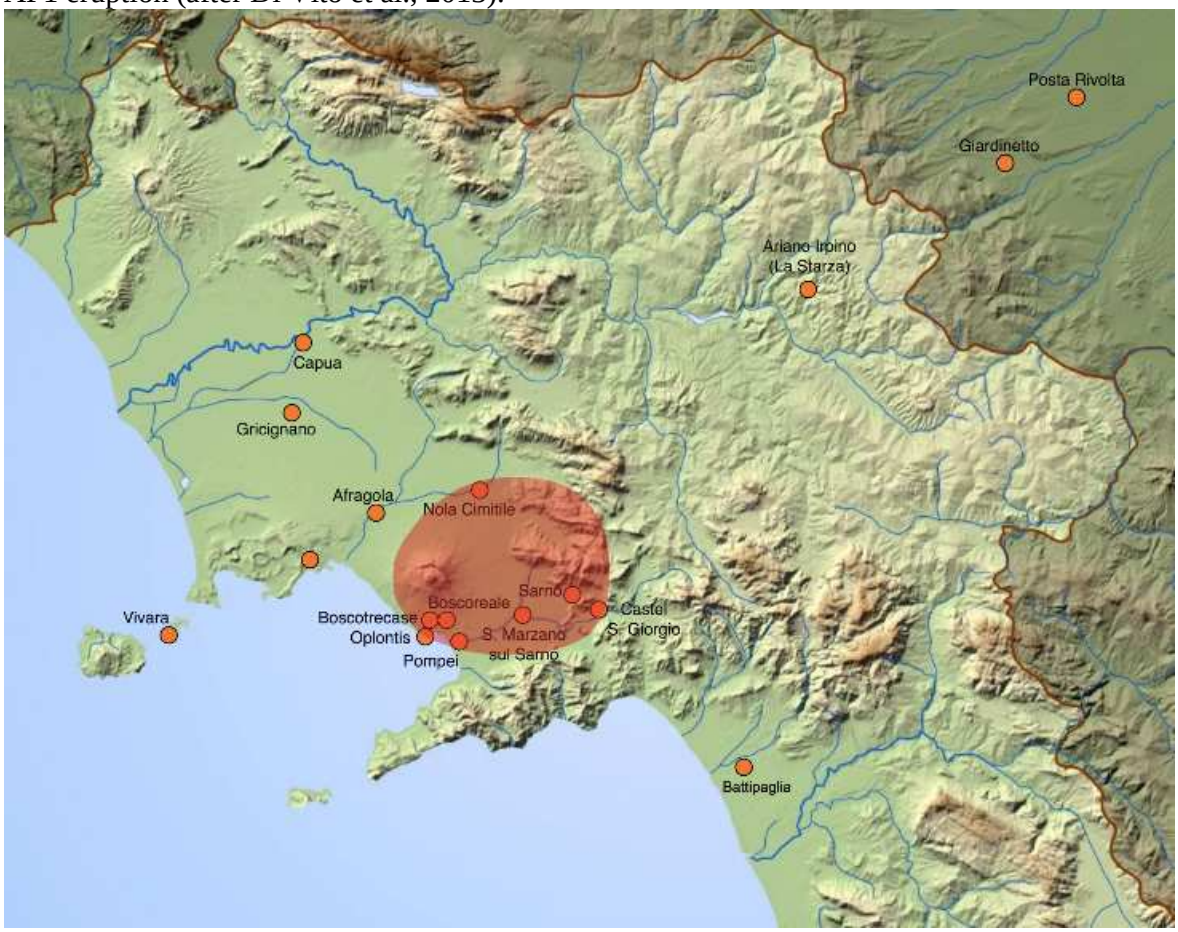

Fig. 14. Map showing the location of sites mentioned in the text, with the fallout pattern for the AP2 (after Di Vito et al., 2013).

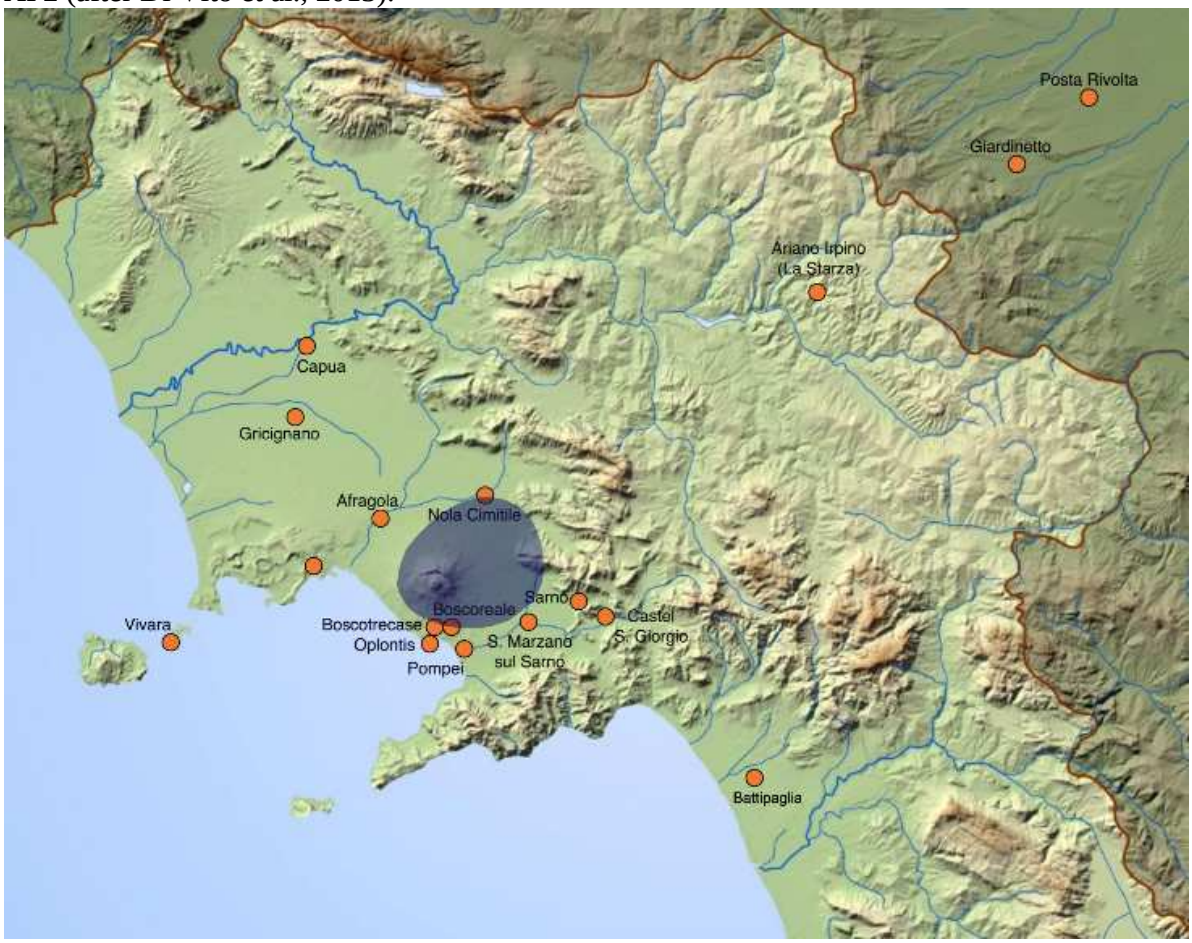

Table 1

Material	**Lab number**	**Determination BP**	**Cal BC at 95.4% confidence interval**	**Source or comments**
Ariano Irpino-La Starza, AP2 eruption				
Animal bone	DSH-154	3380 ± 23	1741-1623	Passariello et al. 2009: tab.3
Ariano Irpino-La Starza, after eruption				
Charcoal	DSH-77	3423 ± 25	1870-1643	Passariello et al. 2009: tab.3
Charcoal	DSH-76	3466 ± 20	1880-1697	Passariello et al. 2009: tab.3
Charcoal	DSA-338	3466 ± 43	1896-1665	Albore Livadie 2007: 193, note 20
Charcoal	DSH-78	3470 ± 24	1881-1698	Passariello et al. 2009: tab.3
Nola-via Cimitile (=Masseria Rossa), after eruption				
Human bone	DSH-143	3492 ± 23	1886-1747	Passariello et al. 2009: tab.3
Nola-San Paolo Belsito, after eruption				
Animal bone	DSH-156	3426 ± 48	1880-1627	Passariello et al. 2009: tab.3
Charcoal	DSH-142	3465 ± 19	1880-1697	Passariello et al. 2009: tab.3
Animal bone	DSH-153	3513 ± 20	1901-1758	Passariello et al. 2009: tab.3
Nola-Croce del Papa, sheep killed by eruption				
Combined date for bone	DSH-146, DSH-145, DSH-103		*1943-1827*	'Combine' command, OxCal 4.3.2; Bronk Ramsey 2009
Animal bone	DSH-146	3533 ± 22	1938-1772	Passariello et al. 2009: tab.3

Animal bone	DSH-145	3558 ± 20	1963-1781	Passariello et al. 2009: tab.3
Animal bone	DSH-103	3560 ± 20	1971-1782	Passariello et al. 2009: tab.3
Campo inferiore, above tephra				
Wood	GrA-46210	3610 ± 30	2110 -1889	Sevink et al. 2011: tab.1
Wood	GrN-32454	3635 ± 40	2135 -1896	Sevink et al. 2011: tab.1
Campo inferiore, below tephra				
Wood	GrA-45003, 45006, 45256, 45257	3565 ± 20	2009 -1828	Sevink et al. 2011: tab.1
Leaves	GrA-45134, 45265, 45266	3585 ± 20	2016 -1886	Sevink et al. 2011: tab.1
Wood	GrA-45007, 45008, 45259, 45260	3690 ± 15	2136 -2031	Sevink et al. 2011: tab.1
Wood	GrA-45042, 45032, 45254, 45255	3715 ± 15	2195 -2036	Sevink et al. 2011: tab.1
Migliara, above tephra				
Peat	GrA-46206, 46208	3635 ± 25	2135 -1896	Sevink et al. 2011: tab.1
Peat	GrA-46203, 46205	3685 ± 25	2198 -1953	Sevink et al. 2011: tab.1
Migliara, below tephra				
Peat	GrA-46200, 46201	3565 ± 25	2026 -1773	Sevink et al. 2011: tab.1