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The early and Middle Bronze Age (1/2) in South and central Tyrrhenian Italy and their connections with the Avellino eruption: An overview

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1. Introduction

The aim of this paper is to present and discuss the status quaestionis regarding the chronology of the Early and Middle Bronze age in South and Central Tyrrhenian Italy (Fig. 1). In terms of ceramic relative chronology, the central region has always been linked to the northern Italian cultures and, through them, to the central European chronology. The relative chronological framework of the southern region, on the other hand, also relies on Aegean imported goods. Both regions share a common chronological scheme based on metal artefacts that, in turn, is linked to the European chronology. Unfortunately, the connections between ceramics and metal artefacts are often problematic. However, the recent discovery in southern Latium of the distal tephra of the so-called Avellino Vesuvian eruption, and the possible presence of other southern tephra from Vesuvius, opens up new opportunities for synchronising the different chronological sequences. In this paper I will first present the state of debate about the northern Italian chronology and about the Aegean connections in South Italy, discussing in turn the chronologies of Central and southern Italy. I will then present a Bayesian model for the chronology of the Avellino eruption and discuss its consequences for the Italian chronological framework at the beginning of the Bronze Age. All radiocarbon analyses were done with OxCal 4.3.2, IntCal13 (Bronk Ramsey, 2009a; Reimer et al., 2013).

2. The chronological framework, Northern Italy

The Bronze Age chronological scheme of Italy has been traditionally linked to the (post-) Reinecke chronological scheme of Central Europe (Reinecke, 1902, 1924); hence the Early Bronze Age has been considered to be approximately contemporary with the BzA and the beginning of the Middle Bronze Age (phases 1 and 2) to the BzB (Peroni, 1989; Carancini et al., 1996). Recently, Stockhammer et al. (2015), with the aid of 140 new radiocarbon dates from several necropolis south of Augsburg (Bavaria), proposed a date for BzA between 2150/2100 and 1700. These authors also suggested a different interpretation of the traditional chronological scheme at the beginning of the EBA (see for example David-Elbiali and David, 2009). Starting from a new absolute chronology of the bronze (also bone and boar tusk) pin sequence, they argued for a partial contemporaneity between BzA1a and BzA1b;

the last part of the latter would also be coincident with BzA2. This hypothesis has, however, already been questioned by Schwarz (2016). On the basis of the new radiocarbon dates and through a critical revision of the closed contexts with relevant bronze types, the author reaffirms the traditional sequence and proposes a revised absolute chronology: BzA1 from 2125 to 1875 BCE and BzA2 from 1875 to 1575 BCE (Fig. 2).

Recently, G. Leonardi and colleagues have discussed in detail the transition of CA/EBA in northern Italy (Leonardi et al., 2015). After an initial assessment of the current (relative) typo-chronology, they run a simple Bayesian model using a previously selected database of radiocarbon dates ranging between 4100 and 3500 BP from central northern Italy (the regions of Lombardy, Trentino, central-western Veneto and the plain of Emilia-Romagna). The phases, which in their model were designed to allow partial overlap, were grouped and ordered in Late Copper Age, Bell-Beaker Culture, Early Bronze Age and Polada Culture. The latter has been traditionally considered to coincide with the EBA in northern Italy (Peroni, 1971; Carancini et al., 1996; Bietti Sestieri, 2010). The model showed a partial overlap between the end of the CA (2438–2187 calBC) and the start of the EBA (2253–2146 calBC). Moreover, the start and end of the Bell Beaker phase were determined at respectively 2810–2475 calBC and 1981–1628 calBC (Fig. 3). These results led the authors to place the boundary between CA and EBA around 2200 and to hypothesise a possible partial coexistence between Bell Beaker and Polada settlements, especially before the spread of the pile-dwelling phenomenon which can be dated from 2070 to 2030 BCE calBC $\pm$ 10 y (first felling dates in the regional tree ring sequence GARDA 1; Fasani and Martinelli, 1996; Martinelli, 2005b, 2007; Billamboz and Martinelli, 2015). In other words, the period between the start of EBA and the appearance of pile-dwellings around Lake Garda was supposed to have been characterized both by the Bell Beaker Culture and by an initial stage of the Polada Culture (a.k.a. ‘proto-Polada’) already defined by R. Perini (1990) as Orizzonte Polada A-Serso I.

As for the end of the EBA, hence the beginning of the northern Italian Middle Bronze Age (MBA), competing hypotheses have been put forward by R. C. De Marinis (1999) and A. Vanzetti (1998, 2013). These authors also propose different relative sequences: De Marinis divides the MBA into MBA I, IIA, IIB and IIC (the latter later renamed MBA III in De Marinis and Salzani, 2005); Vanzetti adopts the tripartite scheme

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Fig. 3. Different proposals about the EBA and MBA chronology in Northern Italy. Dendro-sequences from Griggs et al. (2001); Martinelli, 2005b, with references.

MBA 1, MBA 2 and MBA 3 (Bernabò Brea and Cardarelli, 1997).

De Marinis, places the start of MBA I around 1600 BCE (Fig. 3) dating the last phase of the EBA (EBaII) to the 18th and 17th centuries BCE, on the basis of four tree-ring sequences from Fivè-area 4 (Martinelli, 1996), Laghetto del Frassino I (Martinelli and Kromer, 1999) and La Quercia I and II (Fasani and Martinelli, 1996; Aspes et al., 1998). He further argues that, at the transition EBA/MBA, some new types of pins with perforated obliquely globular head appear in Europe, which have also been found in Lavagnone and Fivè 4. These pins, constituting H. J. Hundt (1958) nordschweizerische Nadelgruppe, are dated to the beginning of the MBA and have been found also in Bodman-Schachen I C (Königer, 1989); dated by dendrochronology to the period 1611 - 1591 BCE (Königer, 2006).

Following a different chain of arguments, A. Vanzetti proposes an earlier start of MBA 1, during the 17th century BCE, contemporary with the central European BzA2c phase (Vanzetti, 1998, 2013). He observes that pins with obliquely and transversely perforated globular heads have also been found in unstratified contexts from Rapperswil-Jona SG-Technikum (Schmidheiny, 2010) together with a pottery assemblage similar to Bodman-Schachen IB (wood-cutting phase, 1644–1640 BCE; Königer, 2006) and Meilen-Schellen (wood-cutting phase, 1647–1641 BCE; Conscience, 2005). Vanzetti further adduces the wiggle-matched dendro-dates from post E621 at Castellaro del Vhò di Piadena. This post went out of use at the beginning of the MBA 3 and has been dated between 1660 and 1577 BCE $\pm$ 35 y (Martinelli, 2001, 2005b); since the cambial ring was absent, the wood-cutting date of the post should be 6–16 years younger. Thus, the MBA 2 had already started at 1571–1561 $\pm$ 35 y which makes a pre- 1600 starting date for the MBA 1 more plausible. Finally, Vanzetti analyses a series of radiocarbon dates from selected Terramare contexts with a safe relative chronology. A cumulative graph of the tripartite scheme shows the transition between EBA and MBA between 1670 and 1650 (1 σ) and the MBA 2 between 1580 and 1480/1460 (1 σ).

3. The chronological framework: the Aegean connections

On the basis of Aegean potsherds found in southern Italian settlements dated from the MBA onwards, synchronic connections between the two regions have been proposed (Bettelli, 2002; Alberti and Bettelli, 2005; Jung, 2005, 2006; 2013; Jones et al., 2014). The Italian Proto-appenninico 1, which in terms of relative chronology equals MBA 1 (at least in Campania), can be partially synchronized with the Late Helladic

(LH) I, as shown in Vivara Punta di Mezzogiorno where fragments of LH I Vaphio cups have been found in the Strati Superiori (Panichelli and Re, 1994; Jung, 2006). However, some of these have a slipped interior, which is considered no earlier than LH II (Jung, 2013). LH IIA and LH II/III potsherds were found in Vivara Punta d'Alaca in Proto-appenninico 2 contexts (Re, 1994; Jones et al., 2014). Since the Proto-appenninico 2 equals MBA 2, this would support the idea of a transition between MBA 1 and 2 in the LH IIA (Jung, 2013). By contrast, the start of the MBA 1 cannot be cross-linked with Aegean pottery since we do not have contexts that provide a clear and exclusive association. The presence of the typical MBA 3 Apennine decoration in the Milazzese contexts of the Aeolian Islands, together with LH IIIA potsherds (Bernabò Brea and Cavalier, 1980; Martinelli, 2005a), would constrain the end of the MBA 2 to no later than LH IIB. However, the presence of possible LH IIIA1 potsherds in the Protoappenninico layers of Vivara Punta d'Alaca (Merkouri, 2005) and Rocavecchia (Guglielmino et al., 2010) may indicate a later boundary between MBA 2 and 3 (Jones et al., 2014). The latter hypothesis has been disputed by R. Jung who observes that the relevant potsherds were found in mixed contexts and that they also have parallels in LH IIB Greek layers (Jung, 2006, Jung, 2016).

4. Central Tyrrhenian Italy (Tuscany and Lazio): the Early Bronze Age

In Central Tyrrhenian Italy - the regions of Tuscany and Lazio - the history of the EBA could (also) be seen as a gradual emancipation from the bell-beaker style towards new and local pottery types. The local development of the style can be clearly followed in the Tuscan settlements of Lastruccia and Termini Est (Sarti, 2000a), dated from the Copper Age (CA) to the MBA (Fig. 4). Lastruccia has been excavated in three parts (1, 2 and 3). In Lastruccia 1 five settlement horizons (orizzonti) were found, separated by alluvial layers. The Lastruccia 1, Orizzonte N (Sarti and Leonini, 2000), the Lastruccia 2A, Strati C2-3 (Filippi, 2000) and the Lastruccia 3, Strati 8 (Balducci et al., 2000), are all characterized by a later stage in the development of the bell-beaker decoration style, applied to local vessel types, called 'Epicampaniforme'. Both L. Sarti and M. Pacciarelli have already considered this to be the first EBA phase (Sarti, 1996, 2000a; Pacciarelli, 2001), mainly because of the appearance of new vessel types like globular and sharply angled bowls but also because the shape of the asymmetrical handles (anse a gomito) changes: in the Bell-Beaker style they are flat-topped,

Fig. 4. Lastruccia and Termini Est. The chronological scheme proposed by L. Sarti and the partly different interpretation by M. Pacciarelli. The Strato 3b has been interpreted differently in Sarti, 2000a and 2000b. The references in the table refer only to the ceramic assemblages. In the Pacciarelli chronological scheme the EBA is divided into two sub-phases (data from Sarti, 2000a, 2000b; Pacciarelli, 2001) (Arrighi, 2000).

now they become concave with an ellipsoid section, sometimes with a little projection at the end (Fig. 5). The context also shows many parallels with other pottery assemblages traditionally ascribed to the so-called EBA Asciano facies (Peroni, 1971): Romita di Asciano Strati 7–8

(Fig. 5; Peroni, 1963), Borgo Panigale (Catarsi Dall’Aglio, 1976) and Tanaccia di Brisighella (Farolfi, 1976). It is important to note that, according to some authors, the noticeable parallels with the Polada Culture in these assemblages do not point to reciprocal influences but rather to a common genesis from the Bell Beaker phenomena (Sarti and Leonini, 2007). In Lazio, at the southern periphery of Rome, a significant number of Copper Age settlements have been recently excavated. The abundant new data (radiocarbon dates and potsherds), together with a partial reassessment of the old data, have led scholars to propose a detailed ceramic sequence (Anzidei and Carboni, 2009, 2013; Anzidei et al., 2012). According to the authors, the late Copper Age in central Tyrrhenian Italy is characterized by a seamless succession of two facies: Laterza and Ortucchio (which they propose to call Dragged Comb facies). The latter is supposed to have originated from the former under the influence of the Bell Beaker phenomena. In the new typochronology of Ortucchio, the authors assign the entire EBA1 phase of Lastruccia and Termine Est to the late CA. They propose that the first part of the EBA was characterized by the Mezzano facies (to be discussed later), with its parallels in the spreading pile-dwelling phenomenon of the classical Northern Italy Polada Culture. According to this scenario, the Proto-Polada (Perini’s phase Polada A-Serso I) would be roughly coincident with the Epicampaniforme, forming the last part of the CA.

5. Central Tyrrhenian Italy (Tuscany and Lazio): the Middle Bronze Age (and the last part of EBA, according to some authors)

In 1973 a scuba survey was carried out in the Mezzano lake, where in the previous year some potsherds were collected (Franco, 1975). Abundant archaeological materials, including about 120 entire vessels, three bronze axes, a bronze pin and samples from 50 wooden piles,

Fig. 5. A selection of potsherds from Lastruccia, orizzonte N (from Sarti, 1996), Lastruccia 2A, strato C2-3 (from Filippi, 2000), Lastruccia 3, strato 8 (from Balducci et al., 2000), and Romita di Asciano, strati 7–8 (from Peroni, 1963).

Fig. 6. The bronze axes, the pin and a selection of potsherds from Lago di Mezzano, M1, (from Franco, 1982).

were collected from two areas (Mezzano 1 and 2). The quality and quantity of these finds made the context fundamental in the definition of the EBA, in spite of the lack of stratigraphy (Fig. 6). The parallels of Mezzano 1 with the Capo Graziano phase and the presence of the typical asymmetrical handles led the author to date this context to the EBA and possibly to the MBA (Franco, 1982). This interpretation was later confirmed by Carancini et al. (1996; see also Pacciarelli, 2001), who placed Mezzano 1 at the end of the EBA (EBA 2) and the beginning of the MBA (MBA 1A), among others on the basis of the presence of the EBA bronze pin with disc head and the bronze axes which can be dated to EBA and MBA 1 (Pellegrini, 1993; Carancini and Peroni, 1999). The presence of the so called “vasi a collo” (necked vessels) in the same context constitutes a link with the Polada 2 phase (Pacciarelli, 2001). Layer 3 of Santa Maria in Belverde in Tuscany has been considered partially coeval with Mezzano 1 and dated to EBA 2 (Fig. 7; Cuda and Sarti, 1992, 1996). Here, large bowls with thickened rim, carinated bowls with vertical handle projecting over the rim (attingitoi), which can be also compared with some Palma Campania pots), and carinated cups similar to the globular ones typical of the Polada Culture, constitute some of the differences with the previous EBA 1 phase. The transition between EBA and MBA in Tuscany has been widely discussed (Balducci et al., 2007), and partly relies on some - sometimes only recently excavated - stratigraphic sequences from Santa Maria in Belverde, Riparo del Capriolo and Buca del Leccio (Fig. 8; Cuda and Sarti, 1992; Cuda et al., 2001). In the light of those data, the MBA 1A has been considered a transition phase still characterized by EBA types, but with the presence of new vessel types which will fully develop in the

next phase (MBA 1B, Grotta Nuova facies); for example: bowls with in-turned rims, little carinated bowls, tongue-shaped grips with vertical holes, and horizontal grooved decorations just above the carina (Fig. 7). All of these sites have been considered as belonging to the Belverde-Beato Benincasa facies (Carancini et al., 1996; also Belverde-Mezzano in Pacciarelli, 2001), dated to EBA 2/MBA 1A. A slightly different opinion has been put forward by D. Cocchi Genick in her detailed analysis of the Grotta Nuova facies (Cocchi Genick, 2002). She reminds us that all the early stratigraphic sequences discussed above come from the Cetona Mountain, an extremely important cult place in the Bronze Age, and mostly from caves. By means of a new, detailed typology, she establishes that most of the vessels from those sequences have only been found in caves, and sometimes in underwater sites (Cocchi Genick, 2001, 2002). She concludes that those types must be considered as symbolic pots, which would have determined their long and unchanged life-span from the EBA to the MBA. In this light, she interprets the Belverde-Mezzano sites as belonging to the Grotta Nuova facies, with a slightly different chronology (Fig. 8). But irrespective of these differences in the interpretation of the origin of the Grotta Nuova facies, there is a wide agreement about its presence in Central Italy in the MBA 1 and 2 (Cardarelli, 1979; Guidi, 1981; Cocchi Genick, 1995, 2002; Carancini et al., 1996). The facies was identified as early as 1979 by R. Poggiani Keller in the Grotta Nuova cave (Poggiani Keller, 1978; Negroni Catacchio, 1992), and as more data became available (Sarti, 1980; Cocchi Genick, 1984, 1986; 1987; Cocchi Genick and Poggiani Keller, 1984) its development was firmly placed at the beginning of the MBA (Cocchi Genick et al., 1992; Cocchi Genick, 1995, 2002). The

Fig. 7. Selection of potsherds from Santa Maria in Belverde (from Cuda and Sarti, 1996). and Riparo del Capriolo (from Cuda and Sarti, 1992; Cuda et al., 2001).

earliest phase of the Grotta Nuova facies can be recognized in Dicomano (Fig. 9) (Sarti, 1980), Riparo Grande SU 4 (Cocchi Genick, 1992), and perhaps in Salcastrino delle Lole (Moroni Lanfredini, 1996, 2006), and is characterized by bowls with in-turned rims, collared bowls, spool-shaped handles, and raised handles with roll-shaped edges. In phase 2A the axe-shaped handles, common in the first phase, disappear and evolve into more elaborate shapes, externally curved and with raised margins; handles with double rings appear for the first time. In the final phase of the Grotta Nuova (MBA 2B) new decoration styles appear which will later develop into the characteristic Appenninico style. This phase has been recognized in Riparo Grande SU 3 (Cocchi Genick, 1992), Termine Est 2 Strato 3BC (Modeo et al., 2000), and Spallette di S. Margherita (Fig. 9; Cardarelli, 1979). The latter is also one of the southernmost sites belonging to the Grotta Nuova facies; as far as we know, that puts its southern boundary just south of Rome, possibly in the Pontine Plain.

6. Southern Italy (Campania and Apulia): the early and Middle Bronze Age

In Apulia and Campania, the first part of the EBA constitutes one of the most complex chronological issues. It has long been considered characterized by the last phase of the Laterza facies (also Laterza - Cellino San Marco, with the latter as the more recent period), which mostly develops in the CA (Peroni, 1971, 1996; Carancini et al., 1996; Pacciarelli, 2001; Recchia and Ruggini, 2009). This was mainly based on the association with typical Dalmatian Cetina pottery, like in the Tagli X and VIII/IX of the Laterza necropolis tomb 3 (Biancofiore, 1967; Marović, 1975; Ellinger and Radina, 1991), which was considered coeval with the first phases of the Italian EBA (Peroni, 1989). However, the chronology of the Cetina facies is still debated and competing hypotheses have been put forward. P. Della Casa considered it a Late Copper Age 3 facies, close to the Bell Beakers, and dated it around the middle of the 3rd millennium BCE (Della Casa, 1995). Kaiser and Forenbaher hypothesise two phases: an earlier one dated from 2500 to

Fig. 8. Different hypotheses about the EBA and MBA in Tuscany.

2250 BCE and a later one from 2250 to 1800 BCE (Kaiser and Forenbaher, 1999). A detailed discussion of the Cetina chronology has recently been published by R. Jung and B. Weninger (2015). They begin by pointing out that in Greece Cetina potsherds have been found, with few exceptions, in EHIII contexts. The chronology of EHIII is debated. Alternative hypotheses include timespans from 2200/2150 to 2000 BCE (Maran, 1998, 2007; Rahmstorf, 2006; Kouka, 2009) and from 2350 to 2150 (Rutter, 1983; Davis, 2013). Jung and Weninger, through a reassess of the radiocarbon dated sequences of Troy and Aegina, propose a starting date around 2300 calBC and an ending date before 2100 calBC.

Unfortunately few radiocarbon dates, all from charcoal, are available for contexts with Cetina potsherds (Table 1). In Croatia, three dates associated with Cetina 1 (also called Protocetina: Govedarica, 1989; Maran, 2007) come from the Grapčeva (Forenbaher and Kaiser, 2000) and Pupičina Cave (Forenbaher et al., 2013). They span from 2887 to 2149 calBC (1σ). In Aegina City IV, pottery phase D, a single potsherd shows typical Cetina decoration but unfortunately the four associated radiocarbon dates are all unreliable because they are affected by a probably large old-wood effect (Wild et al., 2010; Jung and Weninger, 2015). Finally, Jung and Weninger note that classic Cetina decorations are attested in Lerna IV.1 and Lerna IV.2. The former yielded two radiocarbon dates spanning from 2462 to 1985 calBC (1σ). In Campania, a charcoal from a hearth in the settlement of Fosso Aimone (Talamo, 2008; Passariello et al., 2010a), apparently a “pure” Cetina settlement, gave 3868 ± 75 BP (DSH 123, 2470–2210 calBC, 1σ).

These data would also support the hypothesis, put forward by many scholars, that in Campania the Cetina facies could have been contemporaneous to the more recent Laterza contexts, such as the Grotta Cappuccini di Galatone and the Cellino San Marco tomb (Lo Porto, 1963a), in the final portion of the CA (Cataldo, 1996; Petitti et al., 2010; Pacciarelli and Talamo, 2011; Pacciarelli et al., 2015; Arcuri et al., 2016; with various nuances).

Now, this leaves open the question of what constitutes the EBA in South Italy.

In 1972, during building activities near Palma Campania, a large number of whole pots (Fig. 10) were found buried under the Pomici di Avellino (AV) tephra, originating from the Vesuvius volcano (Albore Livadie and D’Amore, 1980). Since then, several more settlements have been found just below the AV pumice fall in Campania, some of them very well preserved, and all characterized by typical vessels such as hourglass-shaped stands and carinated bowls with raised ribbon handles (Talamo, 1996; Soriano, 2007; Soriano and Albore Livadie, 2016). In Oliva Torricella this typical pottery was found together with Cetina potsherds (Albore Livadie, 2011), and therefore a start of the facies in the EBA 1 has been proposed (Soriano and Albore Livadie, 2016). In S. Marcellino di Frignano 17 bronze axes were found inside a Palma Campania jar (Fig. 11; Albore Livadie et al., in prep; Albore Livadie, 1996). The development of the Italian bronze axe has been studied in detail by G. Carancini and R. Peroni (Carancini, 1992, 1996; Carancini and Peroni, 1999). In their EBA chronological sequence, which is

Fig. 9. A selection of potsherds from Grotta Nuova (from Poggiani Keller, 1978) and Spallette di S. Margherita (from Cardarelli, 1979).

Table 1
Radiocarbon dates from contexts with finds related to the Cetina group.

Code	14C age	STD	Calibrated age (1σ)	Sample	Context (su = stratigraphic unit)	Reference
Beta 103477	3880	120	2559–2149	Charcoal	Grapčeva Cave, SU 1200	Forenbaher and Kaiser, 2000
Beta 103478	4190	50	2887–2681	Charcoal	Grapčeva Cave, SU 1220	Forenbaher and Kaiser, 2000
OxA 18180	3963	27	2561–2464	Charcoal	Pupičina Cave	Forenbaher et al., 2013
VERA 3863HS	4049	27	2620–2495	Charcoal	Aegina City IV, furnace 1, pottery phase D	Wild et al., 2010
VERA 3861HS	4096	27	2836–2579	Charcoal	Aegina City IV, furnace 2, pottery phase D	Wild et al., 2010
VERA 3864HS	4128	27	2858–2631	Charcoal	Aegina City IV, furnace 1, pottery phase D	Wild et al., 2010
P 300	3870	61	2462–2287	Charcoal	Lerna IV.1, above burnt debris of "House of Tiles"	Ralph and Stuckenrath, 1962
P 299	3750	97	2333–1985	Charcoal	Lerna IV.1, Bothros B-8 (pit)	Ralph and Stuckenrath, 1962
DSH 123	3868	75	2470–2210	Charcoal	Fosso Aimone, hearth, SU 300	Passariello et al., 2010a

Fig. 10. A selection of potsherds from Palma Campania (from Albore Livadie and D'Amore, 1980).

mainly based on hoards, they identified four periods called ‘orizzonti’. In that sequence the 17 axes have all been included in the third orizzonte, but one (Fig. 11, red dot) could be a little later, at the transition with the fourth orizzonte (Carancini and Peroni, 1999). According to the authors, the third orizzonte is partially coeval with the transalpine Salez-Neyruz-Stufe (Abels, 1972) and, in particular, with the Salez hoard. The Salez-Neyruz-Stufe has been dated to BzA1. The fourth orizzonte is considered coeval with the BzA2 Langquaid-Stufe. Thus we can reasonably consider the S. Marcellino hoard at least partially coeval with the transition between European BZA1b and BzA2a which, in terms of Italian chronology, corresponds to an advanced stage of the EBA. In Avella (Vallone Serroncello, Fig. 11), another bronze axe belonging to the third orizzonte has been found together with a typical Palma Campania bowl with a raised ribbon handle (a “tazza-attigitoio”). Since, as said before, in the final stage of their development the

Palma Campania settlements and necropolis were buried under the AV eruption products, the already discussed association with the axes has been used by C. Albore Livadie as a *terminus post quem* for the eruption. She suggested that the latter could have happened at the end of the third orizzonte, also pointing to the otherwise unexplained absence, in Campania, of axes belonging to the fourth orizzonte.

After the eruption some parts of the Campanian plain were resettled rather quickly (Passariello et al., 2009). Indeed, the settlements of La Starza di Ariano Irpino (Albore Livadie, 1992) and Nola, Via Cimitile (Albore Livadie, 2007) all show pottery types that are very similar to those below the eruption level. However, we can also identify some new vessel types in these settlements. In La Starza, for example, a long occupation sequence starts just above the AV tephra. In the lower layers (2C6 and 2C5, Fig. 12), the pottery assemblage is still characterized by typical Palma Campania pots, but this time associated with raised

Fig. 11. Bronze axes from S. Marcellino di Frignano and Vallone Serroncello (from Albore Livadie et al., in prep., with no scale).

Fig. 12. A selection of potsherds from La Starza di Ariano Irpino (from Soriano and Albore Livadie, 2016; with no scale).

Fig. 13. The published potsherds from Vivara, Punta di Mezzogiorno (from Damiani et al., 1984).

handles with axe-shaped extensions, and sometimes with holes, which are considered typical of the succeeding Protoappenninico facies (Soriano and Albore Livadie, 2016). On the other hand, in the Tufariello settlement (Holloway, 1975) and the Pompei Sant'Abbondio necropolis (Mastroroberto, 1998) early Protoappenninico types are associated with EBA metal artefacts (Carancini, 1992, 1996; Pacciarelli, 2001). The coexistence of Palma Campania and Protoappenninico has also been indicated in the San Paolo Belsito settlement (Albore Livadie et al., 2007), in the Pratola Serra settlement that is buried below the AV tephra (Talamo, 1992, 1998), and in the sequence of Vivara Island (Fig. 13; Punta di Mezzogiorno, Strati Inferiori, Damiani et al., 1984, 1985). According to many authors, those associations would indicate a transition phase between Palma Campania and Protoappenninico, to be placed at the end of the EBA (EBA2B; Levi et al., 2005; Albore Livadie, 2007; Passariello et al., 2009; Soriano and Albore Livadie, 2016). The further development of the latter facies, first identified in Apulia in the sixties (Lo Porto, 1963a, 1963b; 1964), can be followed on Vivara island where an early phase (Protoappenninico 1) has been proposed for the findings in the settlement of Punta di Mezzogiorno. As said before, the Strati Inferiori (lower strata) still show strong influences from Palma Campania; the contiguous Strati Superiori (upper strata) show more developed types associated with LHI and LHIIA Aegean potsherds. On the same island, in the Punta d'Alaca settlement (Fig. 14), a later phase (Protoappenninico 2, MBA 2) has been recognized in the lower strata (fondo) of the Fossa Alfa and in potsherds from the floor of Struttura 1 and Struttura 2 (Damiani et al., 1984; Cardarelli and di Gennaro, 1996; Pacciarelli, 2001; Damiani and di Gennaro, 2003; 2016). A similar sequence was found in the settlement of San Paolo Belsito where the two Protoappenninico phases are intercalated by two other Vesuvian eruptions (the so-called AP1 and AP2).

In Apulia the situation is quite different, fairly complicated, and made worse by the lack of well excavated and radiocarbon-dated contexts at the transition between CA and EBA. Until recently, the absence of a clear Palma Campania phase led some authors to hypothesise the end of the facies Laterza-Cellino San Marco in the EBA, and the

appearance of the Protoappenninico immediately after (Talamo and Ruggini, 2005; Cazzella, 2009; Recchia and Ruggini, 2009; T. Scarano in Pacciarelli et al., 2015). The early start of the Protoappenninico was mainly based on the presence of the typical pottery in the EBA Campanian context already discussed. Other evidence, this time from Apulia, would have come from the hypogea of Casal Sabini 1 and Pisciuolo 2, where Protoappenninico vessels were found together with Cetina-type jugs and potsherds (Fig. 15, Cataldo, 1996). Cazzella et al. (2017), summarising all the data available so far, recently put forward a slightly different hypothesis. It must be noted that in 2012 a Palma Campania settlement was discovered at Posta Rivolta (Tunzi et al., 2012, 2017), in northern Apulia. The authors, admitting that all the available radiocarbon dates are older than 2300 BCE, still hypothesise a possible end of Laterza-Cellino San Marco in the EBA. Next, they identify a northern facies, which they consider strictly linked to Palma Campania, and a southern one that was first identified in the settlement of Cavallino (Pancrazzi, 1979; Orlando, 1997). The latter facies is characterized, among others, by axe-shaped handles with triangular holes, asymmetrical handles, rims decorated with parallel grooves, and tongue-shaped grips (Fig. 16; Recchia and Ruggini, 2009). In the next phase the whole of Apulia is supposed to have been characterized by the classic Protoappenninico, but at the end of the latter they again suggest a differentiation between the northern and central-southern parts. The northern part would have been characterized by the so-called Early Appenninico, which has been distinguished on the basis of data coming from Coppa Nevigata (Fig. 17) Gruppo C and Gruppo D (Cazzella and Moscoloni, 1987). These groups are composed of different layers put together both because of stratigraphic reasons and stylistic similarities. The Early Appenninico is characterized by the appearance of a new decoration style that will later develop into the Appenninico. The central-southern area, on the other hand, would have been characterized by the Punta Le Terrare facies, named after the homonymous settlement. It must be noted that the Early Appenninico, in the sense of Cazzella and Moscoloni, corresponds to the last part of Protoappenninico 2, in the sense of Damiani and Pacciarelli.

Fig. 14. Selection of potsherds from Vivara Punta d'Alaca, struttura 1 – SW (from [Damiani et al., 1984](#); [Damiani and di Gennaro, 2003](#)).

Fig. 15. Selection of potsherds from the Casal Sabini tomb 1 and the Pesciulo hypogeum 2 (from [Cataldo, 1996](#)).

Fig. 16. Selection of potsherds from Cavallino (from Pancrazzi, 1979).

Fig. 17. Selection of potsherds from Coppa Nevigata Gruppo C and Gruppo D (from Cazzella and Moscoloni, 1987).

7. The chronology of the Avellino eruption

7.1. Status quaestionis

The chronology of the Pomici di Avellino has been extensively discussed and an excellent summary has already been published by Vanzetti concerning the data available up to 2013 (Vanzetti, 1998; Saccoccio et al., 2013). One of the best estimates of the AV date comes from the settlement of Nola Croce del Papa, where nine pregnant goats, killed by the eruption, were found inside an animal pen. An average of three radiocarbon dates (DSH 145, DSH 103, DSH 146) gave

3550 ± 20 BP (1934–1881 calBC, 1 σ , 1952–1778 calBC, 2 σ ; Passariello et al., 2009). Very recently R. Jung, using the same dates but a different technique (Gaussian Monte Carlo wiggle-matching, Bronk Ramsey et al., 2001) proposed an even narrower calibrated date of 1908 ± 12 calBC (Jung, 2017). These dates are consistent with the non-Bayesian graph published by Saccoccio et al. (2013), which indicates a date around 3850 cal BP (1900 calBC) (Fig. 18).

The AV tephra has also been identified and dated in distal areas in Central and South Italy (Fig. 19). An older date for the eruption has been put forward using the sequence from the Lago Grande di Monticchio (Watts, 1996; Wulf et al., 2004, 2008), where the TM-4 tephra

Fig. 18. The probabilities of the calibrated radiocarbon data below Agnano Monte Spina (AMS) between Agnano Monte Spina and Pomici di Avellino (AV) and over the AV (from Saccoccio et al., 2013).

Fig. 19. Distal distribution of products of the Pomice di Avellino eruption during the magmatic Plinian phase (red) and the final phreatomagmatic phase (blue) and the dates of the distal tephra discussed in the text (red stars) (data from Sulpizio et al., 2008). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

has been correlated with the AV eruption. An *Abies* seed collected above the TM-4 has been radiocarbon dated to 3920 ± 50 (Ind 2, 2475–2310 calBC, 1σ), consistent with the varve-supported age for the TM-4 of 4310 ± 220 y. BP (2580–2140 BCE). This older date is also in good agreement with the radiocarbon date obtained from a sediment just above the AV layer in the Lago di Mezzano: 3820 ± 40 (Ua, 20639, 2339–2200 calBC, 1σ , Zanchetta et al., 2011). However, from the same lake, another radiocarbon measurement from a sediment just below the AV tephra (Ramrath et al., 1999) gave a younger date of 3630 ± 30 (Ind 4, 2030–1948 calBC, 1σ). It has therefore been suggested that all the samples from the lake could have been affected by a significant reservoir effect (Zanchetta et al., 2011) and their dates should be used with caution.

In 2011, following the discovery of the distal AV tephra in the Pontine Plain, an alternative estimation of the date for the AV eruption was proposed (Sevink et al., 2011). Samples were collected both above and below the distal tephra in two different locations: Migliara 44.5 (GrA 46200, GrA 46203 and GrA 46206, all peat) and Campo Inferiore (GrA 45003, GrA 45007, GrA 45042, GrN 32454, all wood, GrA 45134,

leaves). Two different Bayesian models were run, one for each location, and the results were combined (Fig. 20) in a single estimation of 1995 ± 10 calBC (Fig. 21). The latter has already been questioned by R. Jung (2013), who observed that in Migliara 44.5 the radiocarbon dates above the tephra (GrA 46206 and GrA 46203) are older than the one below, and also suggested the presence of a relevant old-wood effect in Campo Inferiore, which would have biased the result.

Finally, a totally different methodology has been applied by L. Vigliotti (2006): using the secular variation of the geomagnetic field and an age-depth model he estimated the date of the AV tephra in the sediment of the Lago di Nemi at 4077 y. BP (2127 y. BCE).

7.2. A new proposal

To better estimate the date we can consider the long list of all the radiocarbon dates connected to the eruption (Table 2). In order to build a Bayesian model, the ambiguous or poor samples mentioned above have been excluded, as well as any samples obtained from paleosols, since their radiocarbon age is often subject to substantial age offsets or

Fig. 20. The Bayesian models for the data collected at Campo Inferiore and Migliara 44.5 (from Sevink et al., 2011).

reservoir effects (Southon et al., 1999). The varve-supported ages have not been used.

If we look at the remaining samples from below the AV tephra, we may note that the majority were collected from archaeological sites destroyed by the eruption. In the settlement of Nola Croce del Papa, samples were obtained from a wooden structure (DSA 214) and from goats (DSH 103, DSH 145, DSH 146) and sheep (DSA 177) killed by the catastrophic event; the woman in San Paolo Belsito, Vigna died during the eruption as well (Ind 3). Unfortunately, we have no further stratigraphic information about the sample from San Paolo Belsito (DSH 161, animal bone). In Migliara 44.5 (GrA 46200, peat) and in Campo

Inferiore samples were collected just below the tephra (GrA 45003, GrA 45007 and GrA 45042, all wood, GrA 45134, leaves), but the trunks from both Campo Inferiore and Sarno Foce (Rome 1775, Rome 1776) could be older than the eruption. Other samples come from the settlements of Palma Campania (DSH 138, charcoal from hearth), Frattaminore (NA 277, charcoal) and Pratola Serra (NA 331, animal bones). Finally, four samples have been collected from the tephra or the underlying paleosols (Beta 231272, Teledyne ind 2 and Na 299, all charcoal, GrA 68587, twig). In the light of those data, I have modeled the distribution of the radiocarbon dates below the eruption in an exponential fashion, an approach commonly employed for destruction layers (Bronk Ramsey, 2009a); that is, I have assumed that the samples are predominantly concentrated close to the time of the eruption itself, with a diminishing number spreading further back in time. After the eruption, we assume an unknown time lag before the human re-occupation, thus a uniform distribution over time has been employed. Some settlements, like Nola Via Cimitile and La Starza, show a ceramic assemblage which is very similar to the one usually found below the tephra. On the other hand, the pottery from San Paolo Belsito is clearly different and can be ascribed to the MBA. We can therefore use the dates from Nola Via Cimitile (ITG138, ITGDSA121, samples unknown) as a terminus ante quem for the eruption. In addition, we can use the dates from a human skull (DSA 159, DSH 143) found inside a pit excavated in the tephra not far from the hut of Nola, Via Cimitile. The combination (R_Combine) gives 3467 ± 22 . Unfortunately, the sequence of La Starza has not been published yet, so we cannot ascertain which of the published radiocarbon dates belong to the more ancient levels. Finally, I used the dates from Campo Inferiore (GrA46210 and GrN 32454, all wood), but not those from above the tephra in Migliara 44.5 since they are older than the date below, which casts some doubt

Fig. 21. The combined data for the AV tephra in Sevink et al. (2011).

Table 2
The EBA and MBA (1/2) radiocarbon dates from Central (Tuscany and Lazio) and South Italy (Campania and Apulia). Bold, used in this paper to run a Bayesian model about the Avellino eruption. Italics, ambiguous or poor samples connected to the AV eruption, not used in the model. Ind: not specified. ?: unknown.

Code	14C age	STD	Sample	Context (su = stratigraphic unit)	Reference	Tephra connection
Beta 106576	3850	80	Charcoal	Lastruccia 2B, strato B, suborizzonte B1, drenaggio	Sarti, 2000b	
Beta 106577	3510	70	Charcoal from hearth	Lastruccia 2A, strato C1	Sarti, 2000b	
Beta 106578	3840	60	Charcoal	Lastruccia 2A, strato C2-3, suborizzonte C2, piano di frequentazione	Sarti, 2000b	
Beta 106579	3630	80	Charcoal	Lastruccia 3, strato 3, focolare e piano di frequentazione	Sarti, 2000b	
Beta 106580	3880	80	Charcoal	Lastruccia 3, strato 6, suborizzonte 6B, drenaggio	Sarti, 2000b	
Beta 106582	3780	70	Charcoal	Lastruccia 3, strato 8, dal tetto dello strato	Sarti, 2000b	
Beta 106583	3200	70	Charcoal	Termine Est 2, strato 3B-C, suborizzonte 3B, piano di frequentazione	Sarti, 2000b	
Beta 106584	3680	70	Charcoal	Termine Est 2, strato 3E, piano di frequentazione	Sarti, 2000b	
Beta 124040	3240	40	?	Gagnano	Moroni Lanfredini, 1999	
Beta 171118	3320	80	?	San Marco	Moroni and Benvenuti, 2010	In AV
Beta 231272	3530	40	Charcoal	Lagno Grado, in the Avellino punice fall	Zanchetta et al., 2011	
Beta 84136	3760	80	Charcoal	Lastruccia 1, strato N	Sarti, 1996	
Beta 84137	3620	80	Charcoal	Lastruccia 1, strato E	Sarti, 1996	
Beta 84138	3850	80	Charcoal	Lastruccia 1, strato S	Sarti, 1996	
Beta 92591	3670	50	?	Termine Est 1	Sarti, 2000b	
Beta 94385	4190	70	Charcoal	Lastruccia 1, strato S	Sarti, 1996	
BM 2413	2620	50	Charcoal	Vivara Punta di Mezzogiorno, Area A, struttura d1	Ambers et al., 1989	
BO 228	4010	90	Charcoal	Coppa Navigata, Gruppo A (hut)	Cazzella and Moscoloni, 1994	
BO 229	3540	60	Charred seeds	Coppa Navigata, Gruppo A (hut)	Cazzella and Moscoloni, 1994	
BO 230	3520	70	Seeds	Coppa Navigata, Gruppo A (hut)	Cazzella and Moscoloni, 1994	
CAMS 12612	3920	50	Abies seeds	Lago Grande di Monticchio, above tephra unit TM-4	Watts, 1996	Above AV
DSA 155	3538	103	?	Oliva Torricella	Arcuri et al., 2016	
DSA 159	3248	67	Human skull	Nola, Via Cimitile, SU 24	Albore Livadie, 2007	Above AV
DSA 177	3451	60	Animal bones	Nola, Croce del Papa. Sheep killed by the eruption	Albore Livadie, 2007	Below AV
DSA 214	3436	71	Wood	Nola, Croce del Papa, struttura 5 (hut), SU 1A1	Vecchio and Albore Livadie, 2002	Below AV
DSA 250	3628	69	Human bone	San Paolo Belsito, Monticello - La Starza, Tomb 5	Albore Livadie, 2007	
DSA 251	3969	61	Human bone	San Paolo Belsito, Monticello - La Starza, Tomb 8	Albore Livadie, 2007	
DSA 257	3681	87	Human bone	San Paolo Belsito, Monticello - La Starza, Tomb 9	Albore Livadie, 2007	
DSA 331	3293	69	Charred seeds or charcoal	La Starza di Ariano Irpino	Albore Livadie, 2007	Above AV
DSA 338	3466	43	Charred seeds or charcoal	La Starza di Ariano Irpino	Albore Livadie, 2007	Above AV
DSA 48H	3283	23	?	San Paolo Belsito, Montesano	Albore Livadie, 2007	Between AP1 and AP2
DSA 49H	3253	24	?	San Paolo Belsito, Montesano	Albore Livadie, 2007	Between AP1 and AP2
DSA 51H	3399	26	?	San Paolo Belsito, Montesano	Albore Livadie, 2007	Between AV and AP1
DSA 52	3142	27	?	San Paolo Belsito, Montesano	Albore Livadie, 2007	Between AP1 and AP2?
DSA 552	3403	29	Charred seeds or charcoal	La Starza di Ariano Irpino	Albore Livadie, 2007	Above AV
DSH 103	3560	20	Goat bone	Nola, Croce del Papa	Passariello et al., 2009	Below AV
DSH 105	3361	20	Animal bone	San Paolo Belsito, Montesano, SU 150 Q/F0	Passariello et al., 2010b	Above AP1
DSH 138	3666	52	Charcoal from hearth	Palma Campania, SU 27	Passariello et al., 2009	Below AV
DSH 142	3465	19	Charcoal	San Paolo Belsito, Montesano, SU 6	Passariello et al., 2009	Between AV and AP1
DSH 143	3492	23	Human skull	Nola, Via Cimitile, SU 24	Passariello et al., 2009	Above AV
DSH 145	3558	20	Goat bone	Nola, Croce del Papa	Passariello et al., 2009	Below AV
DSH 146	3533	22	Goat bone	Nola, Croce del Papa	Passariello et al., 2009	Below AV
DSH 153	3513	20	Animal bone	San Paolo Belsito, Montesano, SU 30	Passariello et al., 2010b	Between AV and AP1
DSH 154	3380	23	Animal bone	San Paolo Belsito, Montesano, SU 85 Q/E/F0	Passariello et al., 2010b	Above AP2
DSH 156	3426	48	Animal bone	San Paolo Belsito, Montesano, SU 25	Passariello et al., 2009	Between AV and AP1
DSH 159	3399	37	Animal bone	San Paolo Belsito, Montesano, SU 150 Q/G1	Passariello et al., 2010b	Above AP1
DSH 160	3368	47	Animal bone	San Paolo Belsito, Montesano, SU 150 Q/F0	Passariello et al., 2010b	Above AP1
DSH 161	3597	22	Animal bone	San Paolo Belsito, Montesano, SU 45	Passariello et al., 2010b	Below AV
DSH 296	3727	32	?	Oliva Torricella	Arcuri et al., 2016	
DSH 53	3368	19	Charcoal	Piazzale Tecchio, SU 264	Passariello et al., 2010b	Above AP1
DSH 76	3466	20	Charcoal	La Starza di Ariano Irpino, SU 633L	Passariello et al., 2009	Above AV
DSH 77	3423	25	Charcoal	La Starza di Ariano Irpino, SU 203b/QB5	Passariello et al., 2009	Above AV
DSH 78	3470	24	Charcoal	La Starza di Ariano Irpino, SU 629/QC3	Passariello et al., 2009	Above AV

(continued on next page)

Table 2 (continued)

Code	14C age	STD	Sample	Context (su = stratigraphic unit)	Reference	Tephra connection
F 103	3280	80	Charcoal from hearth	Dicomano	Azzi and Gulisano, 1979; Sarti, 1980	
F 104	3220	80	Charcoal from hearth	Dicomano	Azzi and Gulisano, 1979; Sarti, 1980	
F 74	3270	80	Charcoal from hearth	Dicomano	Azzi and Gulisano, 1979; Sarti, 1980	
GI77469	4100	100	Charcoal	Grotta del Fontino, taglio 5	Vigliardi, 1996	
GrA 45003	3565	20	Wood (small trunk or thick branch)	Campo Inferiore	Sevink et al., 2011	Below AV
GrA 45007	3690	15	Wood (large trunk, core)	Campo Inferiore	Sevink et al., 2011	Below AV
GrA 45042	3715	15	Wood (large trunk, rings 2-5)	Campo Inferiore	Sevink et al., 2011	Below AV
GrA 45134	3585	20	Alnus leaves	Campo Inferiore	Sevink et al., 2011	Below AV
GrA 46200	3565	25	Peat	Migliara 44.5	Sevink et al., 2011	Below AV
GrA 46203	3685	25	Peat	Migliara 44.5	Sevink et al., 2011	Above AV
GrA 46206	3635	25	Peat	Migliara 44.5	Sevink et al., 2011	Above AV
GrA 46210	3610	30	Wood	Campo Inferiore	Sevink et al., 2011	Above AV
GrA 68587	3535	35	Wood, Quercus twig	Femmina Morta (Fondi)	Doorenbosch and Field, in prep.	Below AV
GrN 14544	3600	60	Charcoal	Riparo del Lauro, Strato 3	Cocchi Genick, 1987	
GrN 16090	3210	35	?	Riparo Grande, US 3	Cocchi Genick 1992; Cocchi Genick, 1998b	
GrN 32454	3635	40	Wood	Campo Inferiore	Sevink et al., 2011	Above AV
Ind 1	3225	140	?	San Paolo Belsito, Montesano	Albore Livadie et al., 2007	Above AP2?
Ind 2	3410	90	?	Val di Rose, strato C2	Sarti and Martini, 1993	
Ind 3	3560	110	Human bone (woman, died during the eruption)	San Paolo Belsito, Vigna	Albore Livadie et al., 1997	Below AV
Ind 4	3630	30	Bulk sediment	Lago di Mezzano	Ramrath et al., 1999	Below AV
Ind 5	3630	90	Charcoal	Termine Est 1, strato 3B	Sarti, 2000b	
Ind 6	3440	70	Charcoal from post hole	Poggio Fornello US8	Paribeni Rovai and Aranguren 1996	
Ind 7	3720	40	?	Gricignano US Navy Support Site, hearth above Flegrea 3	Albore Livadie, 2007	Between Flegrea 3 and AV
Ind 8	3500	90	Charcoal from hearth	Isola di Coltano, US 17	Pasquinnucci and Menchelli, 1997	
ITG 138	3373	82	?	Nola, Via Cimitile, SU 28	Albore Livadie and Vecchio, 2005	Above AV
ITG DSA 121	3252	95	?	Nola, Via Cimitile, SU 20	Albore Livadie and Vecchio, 2005	Above AV
LTL 3482A	3614	45	?	Casetta Mistici, EBA level	Anzidei and Carboni, 2013	
LTL2409A	3567	50	?	Casetta Mistici, EBA level	Anzidei and Carboni, 2013	
Ly 3034	3960	200	?	Querciola	Sarti and Vigliardi, 1988; Sarti, 1997	
Ly 3035	4130	150	?	Querciola, struttura A	Sarti and Vigliardi, 1988; Sarti, 1997	
NA 258	4020	230	Charred trunk (beam?)	La Starza di Ariano Irpino, SU 224a	Terrasi et al., 1999	Above AV
NA 277	3400	190	Charcoal	Frattaminore, prop. D'Ambrosio, SU 28	Terrasi et al., 1999	Below AV
NA 293	3250	170	Charcoal	La Starza di Ariano Irpino, US A	Terrasi et al., 1999	Above AV
NA 294	3060	100	Charcoal	La Starza di Ariano Irpino, US B	Terrasi et al., 1999	Above AV
NA 299	3480	100	Charcoal	Lagno Cavone, below Avellino, paleosol	Terrasi et al., 1999	Below AV
NA 301	3520	160	Combustion residues from small plants	Ottaviano, Zabatta, weighted mean from 2 samples: paleosol below Avellino and from Avellino pumices	Terrasi et al., 1999	In and below AV
NA 327	3500	150	Charcoal	La Starza di Ariano Irpino, US 164	Terrasi et al., 1999	Above AV
NA 331	3450	230	Animal bones, from hearth	Pratola Serra, hut A, from an hearth	Terrasi et al., 1999	Below AV
R 830A	3510	50	Humics from paleosol	Pomigliano D'Arco, paleosol under Avellino	Alessio et al., 1973	Below AV
R 830B	3610	50	Humics from paleosol	Pomigliano D'Arco, paleosol under Avellino	Alessio et al., 1973	Below AV
R 973a	3230	50	Quercus sp. fragments of pile ca 30cm	Mezzano 1, 7-9m	Alessio et al., 1975; Franco, 1982	
R 974a	3220	50	Wood fragments of pile	Mezzano 1, 7-9m	Alessio et al., 1975; Franco, 1982	
R 984a	3320	60	Quercus sp. fragments of pile ca 14cm	Mezzano 1, 7-9m	Alessio et al., 1975; Franco, 1982	

(continued on next page)

Table 2 (continued)

Code	14C age	STD	Sample	Context (su = stratigraphic unit)	Reference	Tephra connection
R 987	3200	50	Alnus sp. fragments of pile ca 14cm	Mezzano 1, 7-9m	Alessio et al., 1975; Franco, 1982	
RDDI 1343	3430	50	Twig charcoal in pyroclastic surge	Ottaviano quarry	Southon et al., 1999	In AV
Rome 1059	3270	70	Charcoal	Coppa Navigata, D4G 21b (phase B). Stratigraphically below Cgamma3 (Rome 342)	Cazzella and Moscoloni, 1999	
Rome 1060	3160	50	Charcoal	Coppa Navigata, D4AV 2z	Cazzella and Moscoloni, 1999	
Rome 1061	3230	60	Charcoal	Coppa Navigata, D4AV 2	Cazzella and Moscoloni, 1999	
Rome 1062	3200	60	Charcoal	Coppa Navigata, D4H 11 (phase B). Stratigraphically below Cgamma3 (Rome 342)	Cazzella and Moscoloni, 1999	
Rome 1063	3120	55	Charred seeds	Coppa Navigata, D4AV 3a	Cazzella and Moscoloni, 1999	
Rome 1236	3310	55	Charcoal	Coppa Navigata, D4AL 3II	Cazzella et al., 2001	
Rome 1237	3345	55	Charcoal	Coppa Navigata, D4AL 3I	Cazzella et al., 2001	
Rome 1238	3310	55	Seeds	Coppa Navigata, D4F 21a	Cazzella et al., 2001	
Rome 1239	3320	55	Seeds and charcoal	Coppa Navigata, D4D 41h	Cazzella et al., 2001	
Rome 1240	3400	60	Charcoal	Coppa Navigata, D3G 5	Cazzella et al., 2001	
Rome 1241	3450	60	Charcoal	Coppa Navigata, D4G 11la	Cazzella et al., 2001	
Rome 1242	3370	60	Charred seeds	Coppa Navigata, D3L 41b	Cazzella et al., 2001	
Rome 1243	3300	55	Charcoal	Coppa Navigata, D3O 5	Cazzella et al., 2001	
Rome 1347	3675	60	Carbonized wood	Acerra, Spiniello, well	Albore Livadie, 2007	Below AV
Rome 1775	3660	45	Charred tree trunk	Sarno Foce, hut 1, posthole 2	Marzocchella et al., 1999	Below AV
Rome 1776	3615	45	Charred tree trunk	Sarno Foce, hut 1, posthole 3	Marzocchella et al., 1999	Below AV
Rome 339	3200	60	Bone	Coppa Navigata, Calfa3, former gruppo B	Cazzella and Moscoloni, 1994	
Rome 341	3020	60	Bone	Coppa Navigata, E4, Gruppo D	Cazzella and Moscoloni, 1994	
Rome 342	3260	70	Animal bones	Coppa Navigata, Cgamma3 (Calderoni et alii 2012), (phase B). Stratigraphically above "struttura quadrangolare", 1998 excavation (Cazzella, Moscoloni 1999)	Cazzella and Moscoloni, 1994	
Rome 344	3265	65	Bone	Coppa Navigata, F5, gruppo di strati C	Cazzella and Moscoloni, 1994	
Rome 743	3505	60	?	Riparo delle Fedi, taglio 5 sup	Cocchi Genick, 1998a	
St 1343	3800	80	Charcoal	Luni sul Mignone, Tre Erci, Capanna IV, strato 8	Östenberg, 1967	
St 2042	3955	200	Bone	Luni sul Mignone, Tre Erci, Capanna IV, strato 8	Östenberg, 1967	
St 2043	4025	100	Bone	Luni sul Mignone, Tre Erci, Capanna IV, strato 7 inferiore	Östenberg, 1967	
St2044	3005	75	Bone	Luni sul Mignone, Casa Sud, Trincea 12, strato 6	Östenberg, 1967	
Teledyne ind 2	3548	129	Small diameter charcoal	Somma Vesuviana, AV, interbedded in the products of eruption or in the underlying paleosols	Rolandi et al., 1998	In AV
Teledyne ind 3	3240	10	Organic material	Ottaviano, "In prehistoric vase interbedded in the Avellino pumice fall deposit"	Rolandi et al., 1998	In AV
Ua 20639	3820	40	Bulk sediment	Lago di Mezzano, core LMZ-A (5.83-5.84m)	Zanchetta et al., 2011	Above AV
UD 277	3420	100	Charcoal	Giovinazzo, Via Marco Polo	Radina and Battisti, 1988	
UD 278	3770	100	Charcoal	Giovinazzo, Piazza S. Salvatore, taglio 20 (livello D, saggio A	Cataldo et al., 1990	
USGS ind 1	3480	30	?	San Paolo Belito, Montesano	Albore Livadie, 2007	In AP1
UIC 1338	3420	50	?	Salcastino delle Lole, livello superiore	Moreni Lanfredini, 1996, 2006	
UIC 1339	3940	80	?	Salcastino delle Lole, livello inferiore	Moreni Lanfredini, 1996, 2006	
UIC 1340	3560	80	?	Salcastino delle Lole, livello superiore	Moreni Lanfredini, 1996, 2006

Fig. 22. Bayesian model with the selected radiocarbon dates connected to the AV eruption.

on their reliability.

As for the analysis, a general outlier model has been applied, which assumes a 5% prior probability of each date being an outlier (Bronk Ramsey, 2009b).

Fig. 23. Final calibrated radiocarbon dating for the Avellino eruption.

The result (Fig. 22) places the AV eruption between 1929 and 1858 calBC, 2σ , or 1916–1886 calBC, 1σ (Fig. 23). The estimate is just younger than that of Sevink et al. (2011) and is consistent with the results of Passariello et al. (2009) and Jung (2017). In any case, all the results indicate that the estimations from Monticchio and Mezzano probably need a revision, as already noted by Sevink et al. (2011).

8. Discussion

8.1. An important gap between Centre and South

Fig. 1 shows only the archaeological sites with relevance to the chronological problem at hand, so it is rather unrepresentative of the overall situation and distribution of settlements and necropoleis. However, the geographical gap between the South Italian sites in Campania and Apulia, and the northern ones in Lazio and Tuscany, does not simply reflect the research history: it also shows the boundary between two different cultural sequences (Fig. 2). The correlation between the two, based on similarities between relatively few potsherds and even less bronze objects, has always been problematic. The situation is made even worse by the low number and quality (in terms of samples) of the radiocarbon dates available for both Central and Southern Italy, even if this is now rapidly improving (Martinelli, 2005a; Albore Livadie, 2007; Calderoni et al., 2012; Alberti, 2015). Thus, strengthening the correlations between the two areas would also refine the synchronization of Aegean and European chronologies. Here tephrochronology provides a particularly valuable opportunity to address the issue, for two main reasons.

First, and obviously, the presence and preservation of the same tephra in different locations allows precise synchronization. For example, the AV tephra constituted a terminus post quem for the layers above in the stratigraphic sequence of Tratturo Caniò in the Pontine Plain (Fig. 24; Feiken et al., 2012). But it is not only the intact tephra that can constitute a reliable terminus post quem: in Coppa Nevigata, for example, the earliest layers have been found in a hut just below the massive MBA fortification. Potsherds from those layers (Gruppo A, Cazzella and Moscoloni, 1987) have been dated at the beginning of the Protoapenninico. The discovery, in 1999, of the AV pumice in their temper allowed the entire sequence of Coppa Nevigata (and partially the Protoapenninico) to be placed after the eruption (Levi et al., 2005). Moreover, volcanic minerals can also be found in soils. Excavations in the La Sassa cave, Southern Lazio, starting in 2015 in the framework of the Avellino Project, led to the discovery of a Copper Age necropolis covered by EBA/MBA layers (unpublished). Volcanic materials, not uniformly distributed in the sequence, have already been detected in soil samples collected from all the layers. Analyses are

Fig. 24. Tratturo Caniò, south-eastern section of the excavation trench. The AV tephra is labelled 7000 (from Feiken et al., 2012).

Fig. 25. The chronological connections that can be established by means of the AV tephra.

underway to determine their origins.

Secondly, the availability of several radiocarbon dates from different places may, with the aid of Bayesian statistical analysis, constrain the chronology of the tephra with high precision. The AV dates recently proposed have a timespan of 20/30 years. Of course it is always possible to compare absolute chronologies, but high resolution dates make the process very effective.

8.2. The synchronization with the European chronology

Coming back to the original problem, synchronising the AV eruption (as it is dated in this paper: 1907–1881 calBC, 1σ) with the European framework is not difficult (Fig. 25). The eruption would have occurred at the end of the Singen cemetery (Hohentwiel, Germany) which, according to Stockhammer et al. (2015), has to be placed around 1900. In the revised chronology of Schwarz (2016), it would have occurred at the end of BZA1b. The eruption can also be connected to the famous princely graves of Leubingen (Sömmerda, Germany) and Helmsdorf (Hettstedt, Germany; Becker et al., 1989). The dendro-dates from these graves, 1942 ± 10 and 1840 ± 10 respectively, even if we take into consideration the absence of the outermost rings in the timbers involved, synchronize the eruption with the classic phase of the Únětice culture. In North Italy, the AV date can be effectively compared with

the dendro sequence Garda 1. The eruption would then have taken place just after the Lavagnone 3 and can be placed within the lifespan of La Quercia 1, therefore at the end of the local EBA IB or the beginning of EBA IC. As for the Bronze axe sequence, if the assumption of Albore Livadie is true, an AV date around 1900 would confirm the parallelism between the third orizzonte and the BzA1 and the transition to the fourth orizzonte approximately coincident with the eruption.

8.3. The synchronization with the Aegean chronology

We saw that the first Aegean imported goods in South Italy (Fig. 25), dated Late Helladic I and II, come from Vivara Punta di Mezzogiorno, Strati Superiori, which have no direct connection with the AV eruption. The LHI phase is dated by S. Manning between 1700/1675 and 1635/1600 (Manning et al., 2006; Manning, 2012), hence 1700 can be considered a terminus post quem for the Vivara, Strati Superiori which, moreover, have been dated to the Protoappenninico 1B (MBA 1B; Pacciarelli, 2001; Damiani et al., 1984). In particular, both A. Cazzella (Cazzella and Moscoloni, 1994) and Albore Livadie already suggested a partial contemporaneity between the post-AV layers from La Starza di Ariano Irpino ("from the second to the fourth level of huts"; Albore Livadie et al., 1996) and the Punta di Mezzogiorno, Strati Inferiori. The Gruppo A in Coppa Nevigata, as already discussed, must also postdate

Fig. 26. The calibrated radiocarbon dates available so far in Central Italy and the date of the Avellino tephra.

the eruption and has been ascribed to the Protoappenninico 1. Three radiocarbon dates come from the Gruppo A, two of which were obtained on charred seeds (BO 229, 3540 ± 60 , 1950–1772 calBC, 1σ and

BO 230, 3520 ± 70 , 1936–1752, 1σ) and the third from a charcoal which belonged to a post (*Quercus*) (BO 228, 4010 ± 90 , 2838–2350 calBC, 1σ). Since the latter is clearly an outlier, we can use the

Fig. 27. The calibrated radiocarbon dates available so far in Apulia and the date of the Avellino tephra.

combination of BO 229 and BO 230 (3532 ± 46 , 1928–1775 calBC, 1σ) as a good estimation for the hut age. However, this date has been questioned because the distance to the succeeding Gruppo B phase in Coppa Nevigata, radiocarbon dated to after 1600, seems excessive (Cazzella and Moscoloni, 1994; Vanzetti, 1998). Now, the Protoappenninico 1 has also been recognized at San Paolo Belsito, where it is bracketed between the AV and AP1 eruptions. According to R. Jung, the timespan of that phase should be around 80/90 years, with a latest possible ending at about 1759 y. BCE (Jung, 2017), and this would fit with the very early radiocarbon dates from Coppa Nevigata. Since in San Paolo Belsito the subsequent levels, between AP1 and AP2, have been considered Protoappenninico 2A (Albore Livadie, 2007), there is a gap of about 60 years between the end of the Protoappenninico 1 at San Paolo Belsito and the start of the same phase at Vivara. As already R. Jung pointed out, the same mismatch also applies for the start of Protoappenninico 2 (MBA 2; Jung, 2017). However, in another paper, C. Albore Livadie considered the archaeological levels between AP1 and AP2 as Protoappenninico 1/2A (Albore Livadie et al., 2007). The occurrence of Protoappenninico 1 in these levels would be a possible explanation for the chronological hiatus, assuming that the few radiocarbon dates published so far come from the oldest phase. Finally, we should not forget that the extremely low number of (published) potsherds and radiocarbon dates from these contexts makes any attempt at synchronization quite weak.

8.4. The synchronization with Centre and South Italy

In Figs. 26–28 all EBA/MBA radiocarbon dates available to date have been plotted together with the latest estimation of the AV eruption date. An in-depth discussion of the radiocarbon dates is beyond the

scope of this paper, but some general observations can nonetheless be made. The scarcity of radiocarbon dates is evident. It is also evident that most of them, with the exception of Lastruccia, San Paolo Belsito and Coppa Nevigata, are not inserted into a long stratigraphic sequence. Moreover, quite often only a few associated potsherds have been published to date. Even in Coppa Nevigata, which holds the longest sequence of radiocarbon dates (in fact, almost all the radiocarbon dates in Apulia) the associated pottery types are not always known. In Campania the situation is far better since many radiocarbon dates come from settlements hit by the Vesuvian eruptions, so the general sequence is better established. In Central Italy, the only long radiocarbon sequence comes from Lastruccia but since no radiocarbon dates cross the AV date the entire EBA phase of Lastruccia (Epicampaniforme and the first part of Berverde-Mezzano) should fall before the eruption.

9. Conclusion

From this general overview, some points can be made.

- The Avellino eruption has been extensively studied. Even if some problems remain to be solved, the high precision dates put forward for the eruption converge around 1900 BCE;
- The combination of the tephrochronology and Bayesian analysis offers an excellent opportunity to reassess the Italian chronology and to refine the established links with the European and Aegean chronological frameworks. Very precise correlations with the European chronology and (less precise) correlations with the Aegean scheme should be possible;
- The potential of the method has not yet been fully exploited. The chronologies of Central and South Italy, relying on stylistic parallels,

Fig. 28. The calibrated radiocarbon dates available so far in Campania and the date of the Avellino tephra.

leave an important gap between the two regions. Unfortunately, at the moment, the scarcity of radiocarbon dates from well excavated contexts, as well as the generally poor quality of the available dates,

prevent the construction of reliable radiocarbon-based chronologies that could be used as an independent check on these typochronologies.

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