ISTITUTO ITALIANO DI PREISTORIA E PROTOSTORIA

RIVISTA DI SCIENZE PREISTORICHE

fondata da Paolo Graziosi

LXXI - 2021 - Firenze

Istituto Italiano di Preistoria e Protostoria

Rivista di Scienze Preistoriche

fondata da Paolo Graziosi

LXXI – 2021 – Firenze

Associato all'Unione Stampa

Rivista di Scienze Preistoriche - LXXI - 2021 - DOI 10.32097/1151 - pp. 47-89

ISTITUTO ITALIANO DI PREISTORIA E PROTOSTORIA

RIVISTA DI SCIENZE PREISTORICHE

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A new seriation and chronology for early Italian metalwork, 4500-2100 BC

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Ricevuto: 8 aprile 2021
Accettato: 22 ottobre 2021
Pubblicato on line: 28 marzo 2022

Keywords: Metalwork, Late/Final Neolithic, Eneolithic, Chronology, Typology, Italy

Parole chiave: Metalli, Neolitico Recente/Finale, Eneolitico, Cronologia, Tipologia, Italia

Supplementary data
https://www.openprehistory.org/wp-content/uploads/2022/03/21_06_iaia_e_dolfini_supplementary_data.pdf

Abstract - A new seriation and chronology for early Italian metalwork, 4500-2100 BC - The article discusses an original seriation and chronology for prehistoric Italian metalwork, c.4500-2100 BC, which these authors developed as part of the EU-funded TEMPI project, 2015-2017. The research is grounded in a critical reclassification of early copper-alloy axes, daggers and halberds; a reassessment of metal-rich burial assemblages from northern and peninsular Italy, organised into geographically and chronological coherent groupings; and an evaluation and Bayesian statistical modelling of radiocarbon dates from metal-rich burials, integrated by fresh AMS determinations and typological comparisons with selected non-Italian metalwork. Thus reassessed and modelled, the data have enabled these authors to suggest that early Italian metalwork could newly be organised into five discrete horizons charting the evolution of copper-alloy technology and object design over two and a half millennia. The research significantly contributes to a 50-year-long debate that has engaged some of the foremost specialists in later Italian prehistory and provides solid ground on which future research on early Italian metallurgy can build.

Riassunto – Una nuova seriazione e cronologia per i primi manufatti metallici italiani, 4500-2100 BC - L'articolo discute un nuovo schema cronologico e di seriazione dei manufatti in rame e lega di rame italiani datati tra il 4500 e il 2100 a.C. circa. La ricerca, che gli autori hanno sviluppato come parte del progetto europeo TEMPI (2015-2017), si basa su una revisione critica della classificazione delle più antiche asce, pugnali e alabarde; una rivalutazione dei complessi funerari con metalli dell'Italia settentrionale e peninsulare, organizzati in raggruppamenti coerenti geograficamente e cronologicamente; e un riesame e modellazione statistica bayesiana delle date al radiocarbonio da sepolture ricche di metalli, integrate da nuove determinazioni AMS e confronti tipologici con manufatti non italiani. Così rivalutati e configurati, i dati hanno consentito agli autori di suggerire che i manufatti in metallo neo-eneolitici possano essere posti in sequenza in cinque orizzonti distinti, che tracciano l'evoluzione della metallurgia preistorica italiana nell'arco di due millenni e mezzo. La ricerca contribuisce in maniera significativa a un dibattito iniziato 50 anni or sono, che ha coinvolto alcuni dei massimi specialisti della tarda preistoria italiana, e fornisce un terreno solido su cui sviluppare ricerche future sulla prima metallurgia italiana.

INTRODUCTION

Since the 19th century, metal objects have provided the principal building blocks for the chronology of later European prehistory. For example, the transition from the Neolithic to the Metal Ages was defined by the appearance of copper axes, while Montelius (1903), Fox (1923), and Reinecke (1965), among others, divided the Bronze Age into discrete phases by charting the evolution of diagnostic metal types. Early classification work was later reassessed by radiocarbon, which gave greater temporal depth to the European past, sometimes correcting the regional sequences previously outlined (Renfrew 1973; Roberts-Uckelmann-Brandherm 2013; Trigger 2006: 121-129).

In Italy, however, early metallurgical studies took a partly different pathway. On the one hand, the dominance of evolutionary thinking often led to assuming that technological change would rely on slow, incremental changes in object morphology and alloy composition (e.g. the evolution of flanges on metal axes; Dolfini and Giardino 2015: 146). On the other hand, the late application of radiocarbon compared to other regions of Europe long hindered the reappraisal of early metalwork chronology. By the late 20th century, this state of affairs had crystallised into an orthodox view maintaining that metalworking had developed in Italy significantly later than in most of south/central Europe (Dolfini 2013a).

Peroni (1971) first proposed a detailed chronology for early Italian metalwork, focusing on metal-rich Remedello and Rinaldone 'cultures', north-central Italy. Grounding his argument in typological and contextual considerations, he split the two 'cultures' (and their metalwork assemblages) into two phases, one Late Eneolithic (phase I) and the other Early Bronze Age (phase II). Bianco Peroni (1994) and Carancini (1993, 2001) adopted his chronology. The latter, in particular, subdivided Peroni's (1971, 1996) phases into finer-grained horizons characterised by distinctive types of axes, daggers and halberds, which he mostly assigned to the 3rd millennium BC.

Problems with this chronology began to show from the 1990s. Several discoveries (e.g. the Iceman and the copper mines at Libiola and Monte Loreto; Barfield 1994; Maggi, Pearce 2005) suggested that metals first circulated south of the Alps in the 4th millennium BC, with some authors proposing even earlier dates (Barfield 1996; Dolfini 2013b; Pearce 2007; Skeates 1993). In the last two decades, the widespread application of AMS precision dating has conclusively demonstrated that Rinaldone-style metalwork was cast and used in the west-central peninsula from the mid-4th millennium BC (early Eneolithic), following an experimentation phase in the late 5th and early 4th millennia BC (Late/Final Neolithic; Artioli *et alii* 2020; Carboni 2020; Conti-Persiani-Petitti 1997; Dolfini 2010, 2013a; 2014; Dolfini-Aranguren-Silvestrini 2011; Fedeli and Galiberti 2016). Similar chronologies were discussed for northern and southern Italy (Cocchi Genick 2013; de Marinis 1994, 1997, 2006, 2013; Miari-Bestetti-Rasia 2017; Passariello *et alii* 2010; Pearce 2007).

While this work has cumulatively proved that the orthodox chronology and seriation of early Italian metalwork is problematic, it is yet unclear what should replace it. Three key requirements must be fulfilled to reach a new consensus: (1): classification work informed by explicit criteria, which ought to account for any significant transformation underwent by the objects during their life histories; (2) a reassessment of radiocarbon dates from metal-rich burial sites (supplemented by targeted new dates, where necessary); and (3) a review of metal and non-metal burial assemblages enhanced by *comparanda* with other regions of Europe. This is what these authors set out to do as part of the EU-funded TEMPI project, 2015-17.

The article discusses some of the main project results. The next section outlines the research methodology. Subsequent sections discuss object classes and types, their associations, and their chronology as validated by radiocarbon dating and cross-cultural comparisons. The final section presents a novel sequence of early Italian metalwork comprising five horizons, *c*.4500-2100 BC. The sites discussed in the article are shown in fig. 1.

RESEARCH METHODOLOGY

The research is grounded in the following four-step approach: (1) classification of a large sample of early copper-alloy axes, daggers and halberds, enhanced by object morphometry and validated by metalwork wear analysis; (2) meaningful co-occurrences of metal and non-metal classes/types

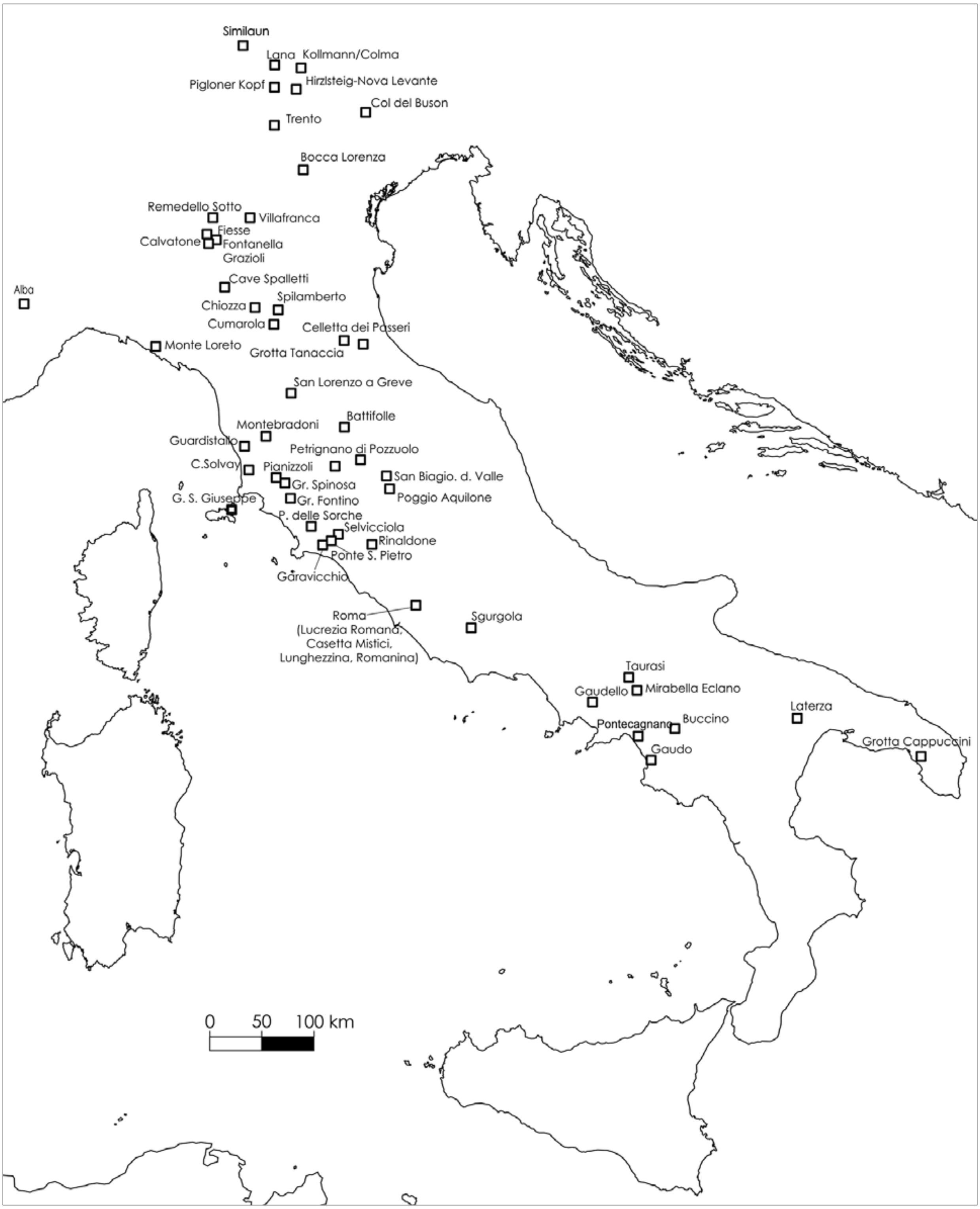


Fig. 1 - Map of the sites discussed in the article.
Carta dei siti menzionati nel testo.

in Eneolithic burials; (3) selected typological crosslinks with dated metals from outside Italy; and (4) a reassessment of radiocarbon dates from metal-rich burials, supplemented by fresh AMS dates.

Step 1: Object classification

The classificatory work stems from considering that the accepted typologies of early Italian metals are not grounded in explicit criteria and parameters, nor do they account for technological changes to ob-

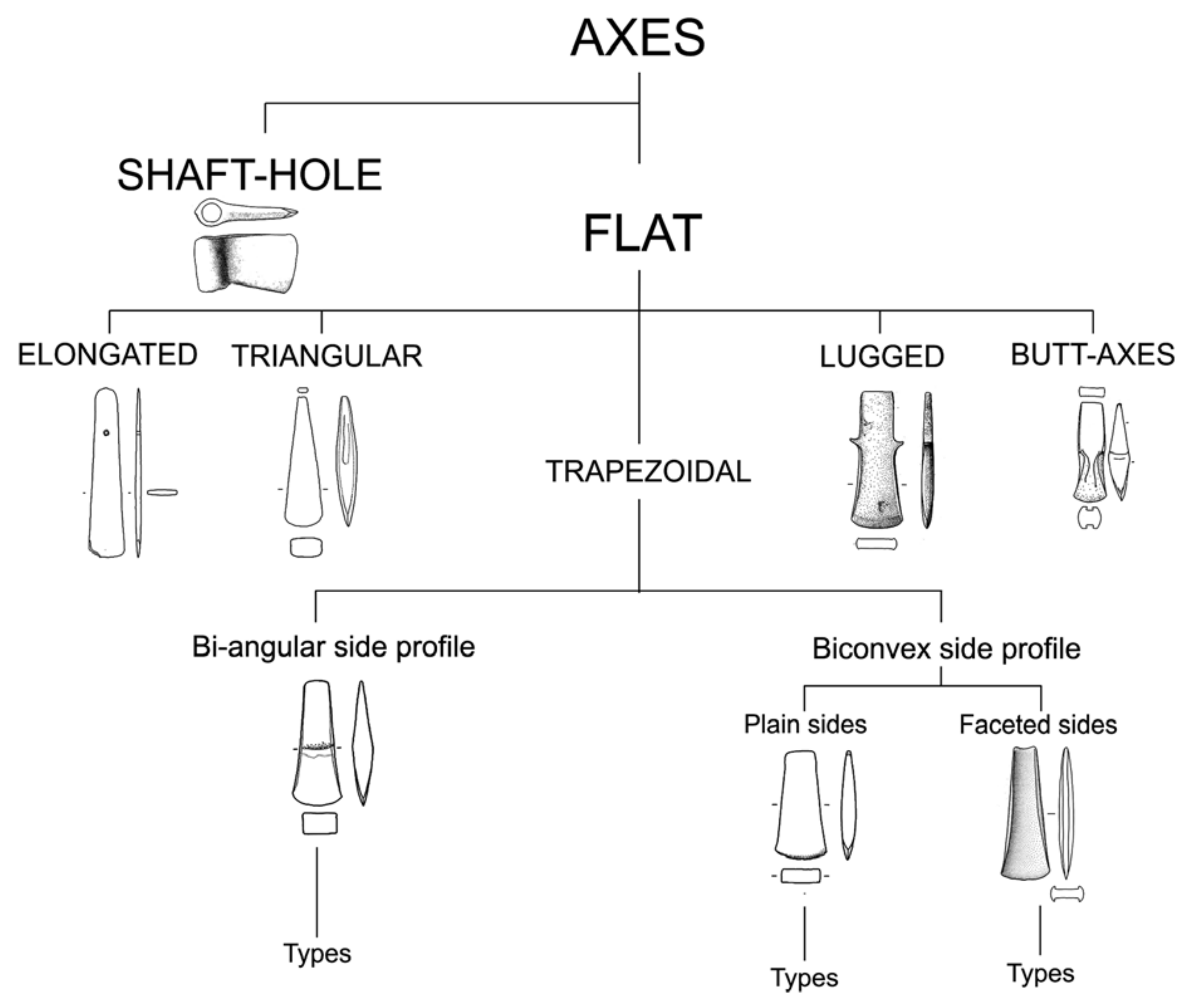


Fig. 2 - Axe classification scheme discussed in the article. The classification comprises three hierarchical tiers, top to bottom: (1) macro-classes (i.e. shaft-hole and flat axes); (2) classes (i.e. elongated, triangular, trapezoidal, lugged and butt-axes); and, limited to trapezoidal axes, (3) two subclasses (i.e. bi-angular and biconvex side profile). Further details are provided in the online supplementary material (see link at the bottom of the article). Drawings are not to scale (after Bianchin Citton 2013; Bietti Sestieri and Macnamara 2007; Carancini 1993; Carboni 2020; Dolfini 2004; Tecchiati 1992; and original drawings by A. Dolfini and C. Iaia).
Schema di classificazione delle asce discusso nel testo. La classificazione comprende tre livelli, dall'alto in basso: (1) macro-classi (cioè asce ad occhio e asce piatte); (2) classi (cioè asce allungate, triangolari, trapezoidali, a spuntoni laterali e a tallone); e, limitatamente alle asce trapezoidali, (3) due sottoclassi (cioè a profilo laterale biangolare o biconvesso). Ulteriori dettagli sono forniti nei supplementary data. Disegni non in scala (da Bianchin Citton 2013; Bietti Sestieri and Macnamara 2007; Carancini 1993; Carboni 2020; Dolfini 2004; Tecchiati 1992; e disegni originali di A. Dolfini e C. Iaia).

ject shapes and features after casting. This has led to problematic attributions, for example when blade reduction due to resharpening is not recognised as such (e.g. Bianco Peroni 1994, plate 10.127, where a Massa Marittima-type dagger is not classified within the type due to its heavily resharpened blade). Similar problems are raised by using technological features (e.g. margins raised or thickened by hammering) as chronologically salient classificatory parameters (de Marinis 1992: 397; Carancini 1993: 133). Of course, raised margins might be chronologically salient, but one ought to demonstrate it rather than assume it *a priori*. To counter such problems, these authors designed an object classification strategy based on simple qualitative variables (e.g. geometric differences in object outline) partly enhanced by quantitative morphometric analysis. The approach was inspired by Read (2007), who advocates the use of metric variables as an exploratory tool to achieve typologically significant qualitative distinctions.

Firstly, one of these authors (CI) assembled a database of 480 early copper-alloy axes, daggers

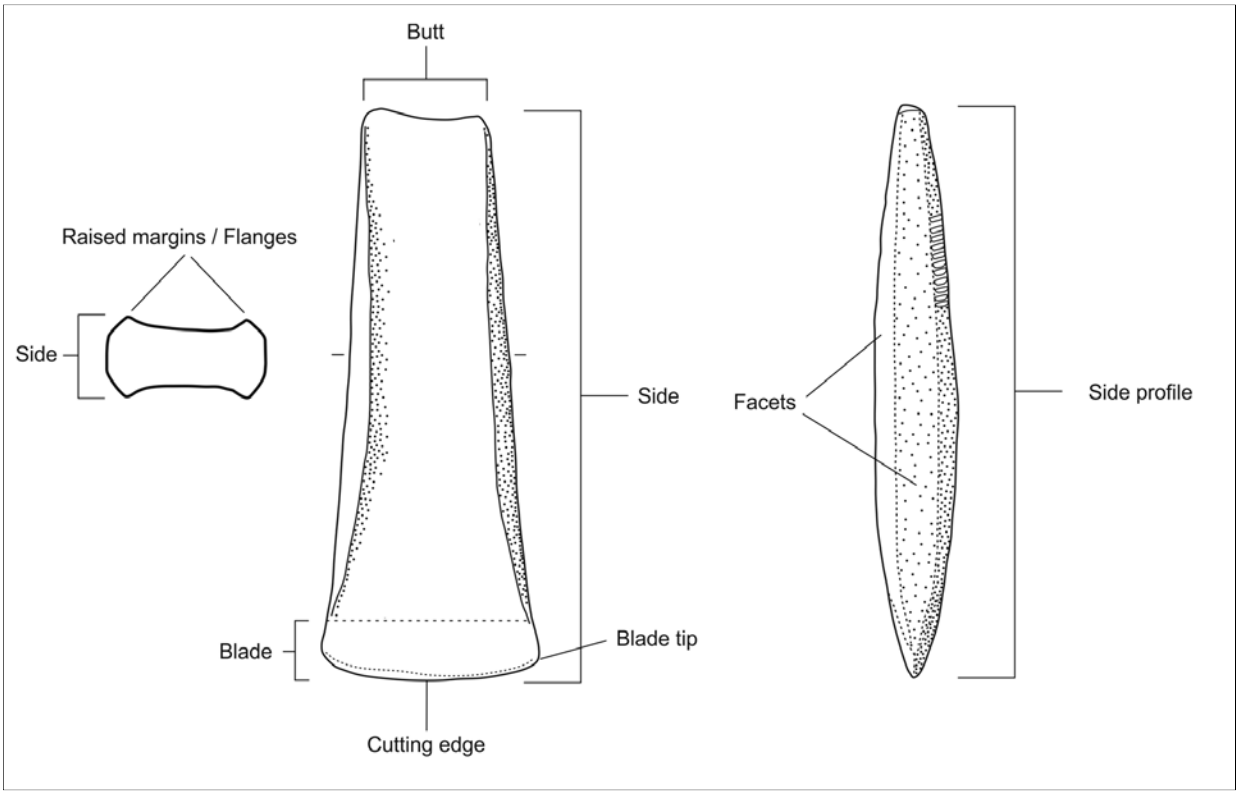


Fig. 3 - Nomenclature used by these authors to describe Italian copper-alloy axes.
Nomenclatura adottata dagli autori per descrivere le asce italiane in rame o in lega di rame.

Axe class	Description	Image
Elongated axe	An axe with a thin and slender outline	Fig. 2
Triangular axe	An axe with a near triangular outline	Fig. 2
Trapezoidal axe	An axe with a near trapezoidal outline	Fig. 2
Lugged axe	An axe with protruding spurs or ‘lugs’ on either side	Fig. 2
Butt axe	An axe with a body markedly divided into a butt and a blade	Fig. 2

Table 1 - Classes of Italian flat axes discussed in the article.
Classi di asce piatte italiane trattate nel testo.

and halberds from continental Italy, for which reliable drawings were available (some were newly made). He then split the database into axes and bladed implements (i.e. daggers and halberds) as the two object categories bear no morphological relationship with one another. Finally, he further split Eneolithic axes into geographical sets comprising northern and peninsular Italy, whereas Neolithic axes were classified as one group. He took this decision after several unsuccessful attempts at classifying the Eneolithic sample as a whole. Failure to group together metals from the two regions, and conversely success with a geographically split sample, is informative of deep morphological differences in the objects from the two areas, notwithstanding some common types. Likewise, success with grouping together all Neolithic axes reveals wide-ranging knowledge transfer dynamics from c.4500-3650 BC, as discussed below.

All axes were newly categorised into two macro-classes: (1) flat axes and (2) shaft-hole axes (fig. 2). This broad distinction is grounded in a technological problem (i.e. how to haft an axe blade) to which two mutually exclusive solutions can be devised. No further differences could be discerned in the sample of shaft-hole axes, except for specific types, which were defined through crosslinks with objects from central and eastern Europe. The nomenclature used for describing the axes (partly inspired by Needham 2017: 4-8) is outlined in fig. 3.

Flat axes were split into five classes (table 1) based on near-irreducible geometric differences

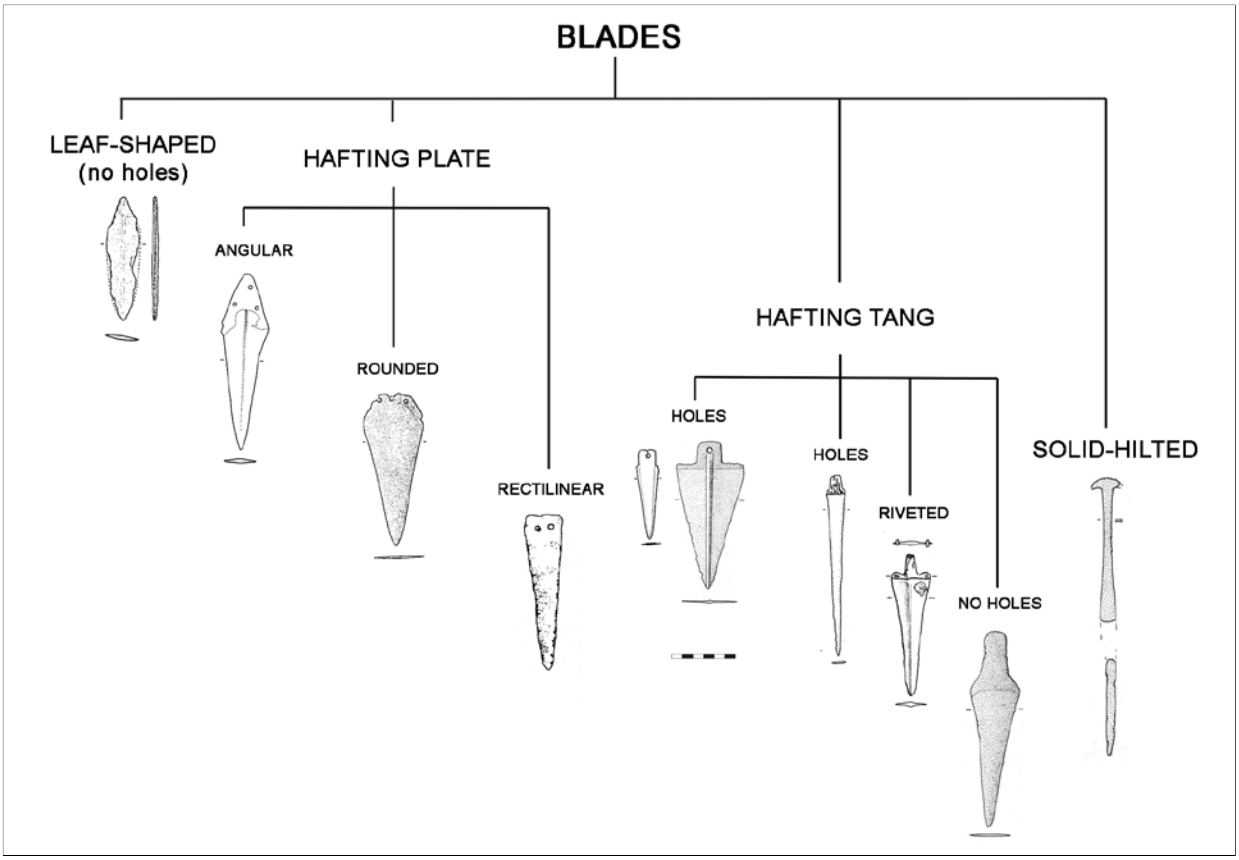


Fig. 4 - Classification scheme of daggers and halberds discussed in the article. Unlike axes, daggers and halberds were split into four classes (i.e. leaf-shaped blade, blade with a hafting plate, blade with a hafting tang, and solid-hilted daggers). The classes were further split into (and sometimes coincide with) types. Further details are provided in the online supplementary material (see link at the bottom of the article). Drawings are not to scale (after Bianco Peroni 1994; Bailo Modesti and Salerno 1998; Carboni 2020; Ingravallo 2002; Petitti-Persiani-Pallecchi 2011, and Zanini 2002).
Schema di classificazione di pugnali e alabarde discusso nel testo. Diversamente dalle asce, pugnali e alabarde sono stati suddivisi in quattro classi (cioè lama foliata, lama con piastra di immanicatura, lama con codolo di immanicatura, e pugnali con elsa fusa). Le classi sono state ulteriormente articolate (e talvolta coincidono con) in tipi. Ulteriori dettagli sono forniti nei supplementary data. Disegni non in scala (da Bianco Peroni 1994; Bailo Modesti e Salerno 1998; Carboni 2020; Ingravallo 2002; Petitti-Persiani-Pallecchi 2011; Zanini 2002)

Dagger/halberd class	**Description**	**Image**
Leaf-shaped blade	A blade with a leaf-shaped outline and no rivet holes	Fig. 4
Blade with a hafting plate (with rivet holes)	A blade with the hafting plate featuring 1+ rivet holes	Fig. 4
Blade with a hafting tang (with or without rivet holes)	A blade with a hafting tang with or without rivet holes; the tang may occasionally be riveted to the heel	Fig. 4
Solid-hilted daggers	A dagger with a cast hilt indistinct from the blade	Fig. 4

Table 2 - Classes of Italian daggers and halberds discussed in the article. The classes defined here were further divided into types, which often coincide with types empirically defined by other authors.
Classi di pugnali e alabarde italiani trattati nel testo. Le classi qui definite sono state ulteriormente articolate in tipi, i quali spesso coincidono con i tipi definiti da altri autori su base empirica.

in their outlines and side profiles (Read 2007: 150). This means that metalworkers would have found it near impossible (or extremely impractical) to change an object template into another after casting, or to hammer the same cast blank into different classes of objects. Trapezoidal axes were further divided into subclasses based on their side profiles, i.e. bi-angular vs bi-convex. In northern Italy, a further subdivision is detected, i.e. plain sides vs faceted sides (the latter fea-

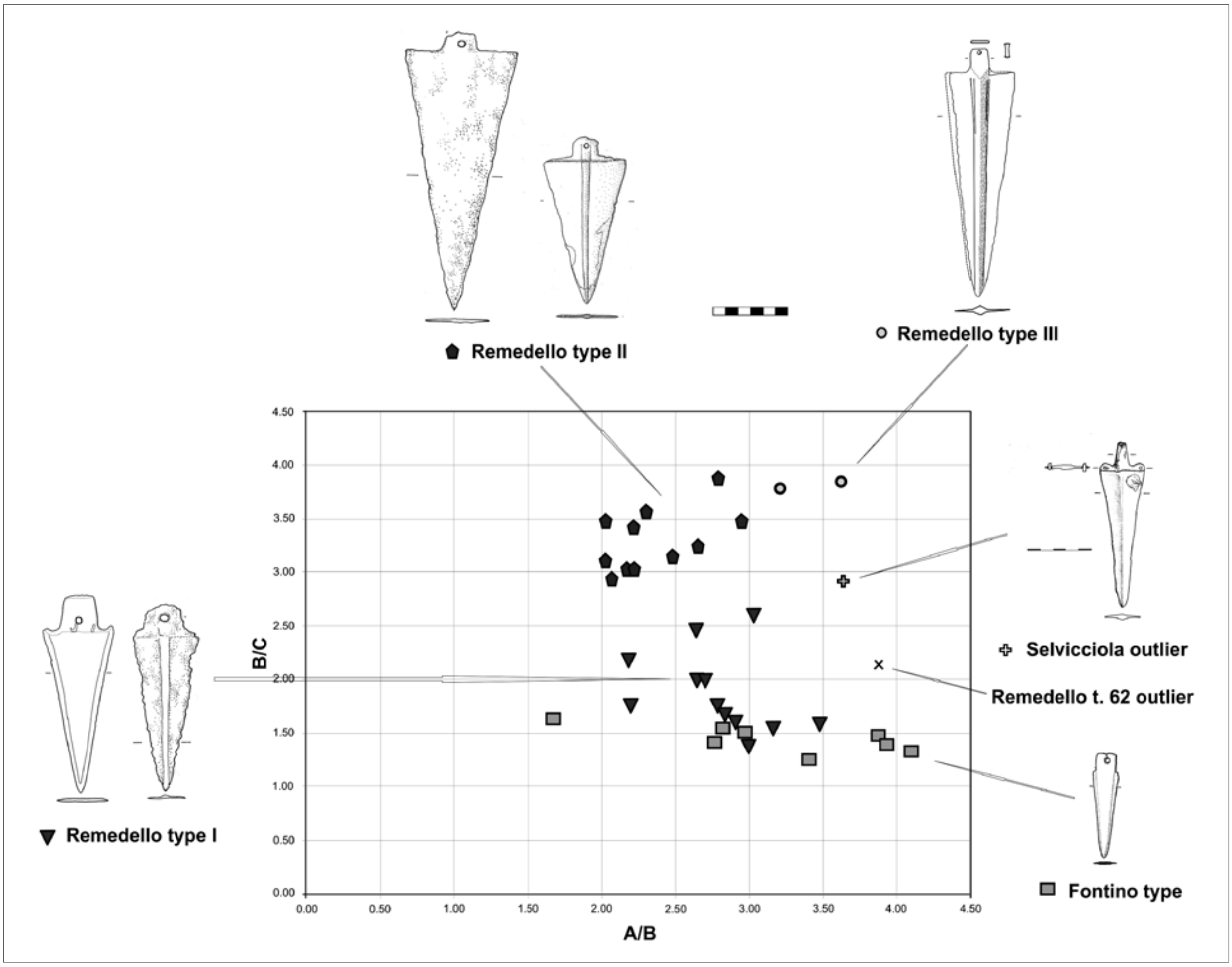


Fig. 5 - Scatterplot showing how types were defined for Remedello-group daggers. A/B: dagger total length vs maximum width ratio; B/C: dagger maximum width vs tang width ratio. Scale 1:3 (drawings after de Marinis 2013; Miari *et alii* 2017; Petitti-Persiani-Pallecchi 2011; Zanini 2002; and original drawings by C. Iaia).

Scatterplot che illustra come sono stati definiti i tipi per i pugnali del Gruppo Remedello. A/B: rapporto tra la lunghezza totale e larghezza massima del pugnale; B/C: rapporto tra la larghezza massima del pugnale e la larghezza del codolo. Scala 1:3 (disegni da de Marinis 2013; Miari et alii 2017; Petitti-Persiani-Pallecchi 2011; Zanini 2002, e disegni originali di C. Iaia).

ture is due to hammering). Types define a lower classification level to classes and subclasses. They are identified by distinctive features and/or morphological parameters including the divergence and curvature of an axe's outline and side profile; continuities and discontinuities in outline; and butt shape. Variants define the range of variability within each type.

Daggers and halberds were categorised into four classes based on the shape and features of their hafting plates/tangs (table 2, fig. 4). The classes were then divided into (and sometimes coincide with) types as defined by a combination of blade outline, hafting features, and morphometric parameters. Unlike the axe classification discussed above, which frequently differs from accepted typologies, the dagger and halberd types defined here often coincide with those from the literature (Bianco Peroni 1994; de Marinis 1994); hence our keeping many established labels.

Object morphometry was especially helpful in defining certain dagger types and variants. In particular, daggers with short tangs and triangular/trapezoidal blades were split into types based on aggregated dagger total length vs maximum width ratio (A/B) and dagger maximum width vs tang width ratio (B/C) (see tables XII, XV and plate 9 in the supplementary material). If plotted against one another (fig. 5), the two parameters suggest that (a) Fontino-type daggers can be discriminated from Remedello-group daggers; and (b) Remedello group daggers can be split into three types: the slender Remedello I; the squat Remedello II (with or without a midrib); and the elongated Remedello III with an angular midrib. Further details on object classification are provided in the online supplementary material (see link at the bottom of the text).

One of these authors (CI) performed metalwork wear analysis on a sample of 110 axes, daggers and halberds from the database (see Dolfini 2011; Dolfini and Crellin 2016 for the method). The exercise allowed us to detect technical details and account for parameters that we deemed of no typological significance, e.g. anomalously short blades and asymmetrical cutting edges (both suggesting repeated sharpening). Preliminary results of the analysis are presented in Iaia and Dolfini 2020, while the full dataset will be discussed in a forthcoming paper.

Step 2: Co-occurrences of metal and non-metal object types

The object types and variants defined in Step 1 were organised into two seriation tables, one for northern Italy and one for peninsular Italy (except for Neolithic axes). The exercise had two aims: (1) to chart co-occurrences of metal and non-metal types in mainly one-phase burials; and (2) to define assemblage groupings of regional and chronological significance based on similarities between assemblages, including collective burials and hoards. We maintain that these groupings are informative of knowledge exchange dynamics within discrete areas; they also chart the development of metal technology over time.

Step 3: Typological crosslinks with dated metals from outside Italy

Crosslinks between Italian and non-Italian object types were established through critical literature review, focusing on central/eastern Europe. Typological comparisons of this kind are not without their problems, for many of the chrono-typological frameworks used in European prehistory rely on empirical classification criteria. Far-flung crosslinks must therefore be treated with caution. The axe with splayed butt and cutting edge from Casetta Mistici, t. 8, which displays close similarities to mid-3rd millennium Levantine axes, is a case in point (Carboni 2020: 490-491, fig. 5.1). Apparently, the axe is either a local imitation of an eastern Mediterranean type or an import, as its Cycladic isotopic fingerprint might suggest (Aurisicchio and Medeghini 2020). The object, however, is radiocarbon dated to the mid-4th millennium BC, showing a large time lag with its Levantine templates that is yet to be resolved (Cultraro 2020). Problems of this kind led us to limiting the comparative work to well-dated, uncontroversial sites and artefacts.

Step 4: Radiocarbon dating and Bayesian analysis

To strengthen the chronology built on assemblage groupings and *comparanda*, 32 AMS radiocarbon dates were collated from the literature and 12 AMS dates were newly performed. The former were mainly selected from short-lived samples associated with metals in one-phase burials, while the latter (to which we added four AMS dates published by Dolfini 2010) were all taken from Grotta della Spinosa, a burial cave in Tuscany that has yielded two Remedello-type daggers (Aranguren 2006; Aranguren-Guidi-Iardella 2004). We thought it reasonable to concentrate our limited resources on this site because Remedello-type daggers provide the backbone of Eneolithic chronologies in northern Italy, and are important further south. Finally, we modelled all 48 dates using Bayesian statistics to narrow down the groupings' chronologies. The exercise led to defining five metallurgical horizons, which not only securely date (sometimes for the first time) several types of axes, daggers and halberds, but also chart the evolution of early Italian metallurgy in unprecedented detail.

Early Italian Metalwork: A New Classification

Neolithic axes from northern and peninsular Italy

The single greatest obstacle to dating the earliest metal objects from Italy is the lack of contextual data and associated materials to be radiocarbon dated. The problem is especially acute with axes, which are mostly stray finds. Nonetheless, a consensus has recently emerged that a group of archaic-looking axes from northern and peninsular Italy is best assigned to the period 4500/4300 to 3700/3650 BC, i.e. the Late and Final Neolithic (Barfield 1996; Pearce 2007; Klassen 2010; Klassen-Cassen-Petrequin 2012; Dolfini 2013b; van Willingen 2017). The proposal is grounded in both morphological and technological considerations.

Morphologically, these axes are often inspired by Neolithic groundstone tools (Petrequin *et alii* 2012). Similarities with stone axes, whose Europe-wide circulation peaked in the late 5th and early 4th millennia BC, are apparent in their rounded side profiles and cross-sections, though certain specimens have straight sides, while others bear shaft holes. Technologically, these tools often display rough and bubbly surfaces, betraying a lack of casting skills. To be sure, poor casting does not automatically equate to great antiquity, but the overlap of archaic morphological traits *and* poor casting (in either monovalve or bivalve moulds) does suggest that these implements sit at the beginning of the Italian metallurgical sequence. Neolithic axes from central Europe show similar traits (Kienlin 2008: 98; Nielsen 2016: 152). When available, contextual data support the Late/Final Neolithic chronology of these objects (Dolfini 2013b; Pearce 2007: 38-46).

Close morphological and technological similarities between all Neolithic axes from Italy, and between Italian and non-Italian specimens, indicate that few production centres were probably active then. We do not know if any of the Italian axes were cast south of the Alps considering that no mining or metalworking sites are known for this early period. Some of the copper circulating in Italy in the Late/Final Neolithic seemingly originated from the Balkans (Artioli *et alii* 2020). It is thus possible that some of these objects, and perhaps all, are imports. Further research is needed to clarify the problem.

Neolithic grouping (NeoG)

We grouped together all Neolithic axes from northern and peninsular Italy based on morphological similarities (see above). They were categorised into a class, i.e. (1) *shaft-hole axes*, and three subclasses, i.e. (1a) *elongated axes*; (1b) *triangular axes*; and (1c) *trapezoidal axes*.

Shaft-hole axes comprise a single specimen from Trento (Suppl. mat. plate 4.1). The object is similar to late 5th millennium BC Pločnik-type axes from the Balkans (van Willingen 2017: 921); this suggests its chronology, and perhaps its provenance (Carancini 1993).

Elongated axes comprise two specimens from central Italy featuring thin elongated blades and perforated butts, probably instrumental to hafting the blades (Suppl. mat. plate 1.9-10). We propose a chronology in the Final Neolithic, c.4000-3650 BC, based on comparisons with a specimen from Ballstädt, east-central Germany (Klassen-Dobes-Petrequin 2008-2009: 28) (Suppl. mat. plate 1.11). Technologically, one of the Italian axes (Suppl. mat. plate 1.9) displays rudimentary casting features, which is in line with the Neolithic chronology proposed here (Dolfini 2011, table 3.71).

Triangular axes comprise 10 specimens (Suppl. mat. plate 1.1-8)[1]. Morphological similarities with objects from the northern Alps and the Balkans dating to 4200-3800 BC (especially Split and Kaka types) suggest a chronology for the Italian tools (Klassen-Cassen-Petrequin 2012: 1292-4). Axes of this type are absent from mid-4th millennium Alpine lakeside settlements, indicating that their production must have ceased by 3800 BC or thereabout.

Trapezoidal axes (previously known as 'Bocca Lorenza' axes) encompass six specimens, three of which hail from the Bocca Lorenza cave, north-east Italy. They feature thick elongated bodies and splayed cutting edges (Suppl. mat. plate 5.8-9). The Bocca Lorenza cave has yielded both Late Neolithic and Eneolithic material. The axes were recovered from the undisturbed Neolithic deposit, which features diagnostic artefacts including VBQ III pottery (also known as Square Mouth Vessels III style; Barfield 1996; de Marinis 1997, 2013; Dolfini 2013b; Pearce 2007: 42-44; Skeates 1993). Klassen (2010) proposed dating such axes to a narrow timespan, *c*.4000-3800 BC. The latest research, however, suggests that this ought to be widened to about 4200-3800 BC based on comparisons with Boljun-Szakálhát-type axes from eastern Europe (van Willingen 2017: 923).

Eneolithic axes and daggers/halberds from peninsular Italy

We have assigned the Eneolithic metalwork from peninsular Italy to four groupings comprising 56 types of metal objects, which are associated to distinctive flint, hardstone, bone and ceramic objects in burials. Object assemblages may be hard to discern in Eneolithic burials as chamber tombs

[1] Supplementary material, table II. See van Willingen 2017 for a recent overview. For comments: Dolfini 2013b: 134-138; Giardino 2013; Pearce 2007.

were often reopened by the mourners to manipulate human remains and, presumably, grave goods (Dolfini 2020). Therefore, we preferentially selected chamber tombs comprising single-phase articulated burials, as well as trench graves. These burials yielded several radiocarbon dates providing the backbone of our chronological sequence (see below).

Peninsular Grouping 1 *(PenG1)* (table 3; fig. 6.1-22)

The grouping comprises 26 assemblages marking out the most typical manifestations of the 'Rinaldone culture', an Eneolithic funerary tradition from central Italy. This burial style features individual and collective inhumation in underground chamber tombs and, more rarely, trench graves (Anzidei and Carboni 2020a, 2020b; Cocchi Genick 2008, 2011; Negroni Catacchio 2011). Peninsular Grouping *PenG1* captures the first mature metalworking tradition to emerge in prehistoric Italy and the earliest uses of metals in identity-defining burial practices (Dolfini 2020).

In Rinaldone-style burials, metal weapons and tool/weapons were normally placed with adult males, while women and children may be accompanied by silver and antimony ornaments, as well as copper awls. Guardistallo-type daggers, Calvatone-type halberds, and flat trapezoidal axes of various descriptions, mostly with convex or rectilinear sides, are typical of *PenG1* male burials (fig. 6.4-16). Metals are frequently associated with groundstone hammer-axes and mace-heads, flint daggers or knives, arrowheads, and pendants/sharpeners (Anzidei and Carboni 2020a, 2020b; Cocchi Genick 2011) (fig. 6.1-3, 17). These assemblages belong to a wider phenomenon of 'over-equipped' warrior burials, which arose in several regions of Europe in the 4th millennium BC (Dolfini, 2022; Hansen 2002; Jeunesse 2017).

With regard to ceramics, *PenG1* burials have yielded bowls and globular flasks with cylindrical necks (Anzidei and Carboni 2020b; Cocchi Genick 2008, 2011) (fig. 6.19-22). These vessels display archaic features reminiscent of Final Neolithic pottery, such as large cylindrical necks and tubular handles (e.g. Lunghezzina, t. 4; Rinaldone, t. 3; Pianetti-Ortaccia, t. 4). Table 4 lists the metal types exclusive (or near exclusive) to *PenG1*.

Comparisons with well-dated metals from the northern Alps and eastern Europe suggest that *PenG1* developed within a discrete horizon in the second and third quarters of the 4th millennium BC. The chronology is supported by close similarities between (1) flat axes with rounded outlines from Pianetti and Lunghezzina (Trapezoidal axes, Biconvex 2A and 3) and French and Pfyn-culture central European specimens dating to 3800-3400 BC (Klassen 2000; Lefranc *et alii* 2019, abb. 19.13-15) (fig. 7.1-5); (2) Pianetti-type foliate daggers and archaic copper daggers from eastern Europe, in particular Carpathian specimens (*Lanzett-Dolche*) dating to the early/mid-4th millennium BC (Matuschick 1998: 214, abb. 218, 1-4; 8-9; Vajsov 1993: 129, nn. 39.1, 39.2; Wilk 2016) (fig. 7.6-10); and (3) Guardistallo-type daggers (found in over 50% of *PenG1* burials) and Cucuteni-type daggers (Mondsee variant) from the northern Alps and the Balkans (fig. 7.11-15) (Vajsov 1993; Matuschick 1998). A Mondsee variant dagger from south-western Germany (fig. 7.13) is dendrochronologically dated to 3738-3731 BC (Matuschick 1998: abb. 226; Billamboz 1998: 381). Table 5 lists the metal types predominantly documented at *PenG1* contexts and also occasionally found at *PenG2* sites.

Calvatone-type halberds, which are typical of the west-central Italian metal repertoire, are occasionally found in northern Italy (see Suppl. mat. table XIV). At S. Biagio della Valle, Perugia (an individual burial radiocarbon dated to the late 4th and early 3rd millennia BC; De Angelis 1995-96), a Calvatone-type halberd is associated with a Massa Marittima-type dagger (typical of *PenG2*), suggesting that the object type straddles *PenG1* and *PenG2*.

Peninsular Grouping 2 *(PenG2)* (table 3; fig. 6.23-35)

The grouping comprises 13 assemblages. Most burials belong to Rinaldone-style cemeteries dated to the Middle Eneolithic, *c*.3350-2900 BC. They are mostly individual inhumations in either chamber or trench graves. Grave 3 from Poggio delle Sorche, Tuscany, is most probably a disturbed chamber or trench grave comprising a set of tool/weapons associated with an articulated individual burial (Marianelli 2010). Uncertainties surround Pianizzoli di Massa Marittima, a site that is thought to be either a rock shelter used for collective burial or an alignment of trench graves under a cliff (Cocchi Genick, Grifoni Cremonesi 1989: 67).

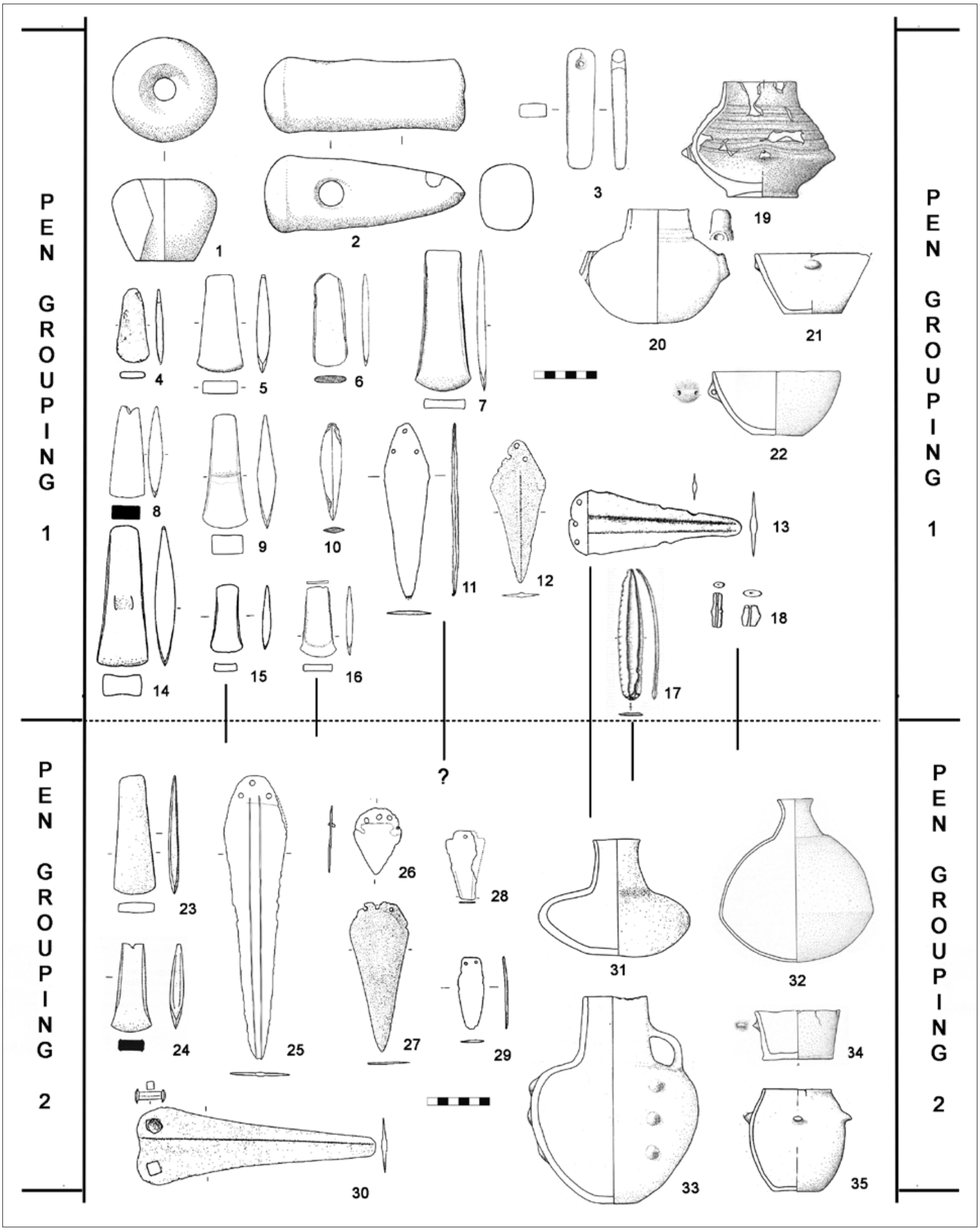


Fig. 6 - Metal and non-metal object types defining peninsular groupings *PenG1* and *PenG2*. See table 3 for the seriation of object types. Scale c. 1:4 (after Anzidei and Carboni 2020a, 2020b; Aranguren *et alii* 1987-88; Bianco Peroni 1994; Buresta *et alii* 2006; Carancini 1993; De Angelis 1995-96; Dolfini 2004; Falchetti 1982; Miari 1993; Negroni Catacchio 1992. No 7: courtesy G. L. Carancini; 16, 25, 28: original drawings by C. Iaia.).

Tipi di oggetti in metallo e non metallici che definiscono i raggruppamenti peninsulari PenG1 e PenG2. Si veda la tabella 3 per la seriazione dei tipi di oggetto. Scala ca 1:4 (da Anzidei e Carboni 2020a, 2020b; Aranguren et alii 1987-88; Bianco Peroni 1994; Buresta et alii 2006; Carancini 1993; De Angelis 1995-96; Dolfini 2004; Falchetti 1982; Miari 1993; Negroni Catacchio 1992. N. 7: cortesia di G. L. Carancini; 16, 25, 28: disegni originali di C. Iaia.).

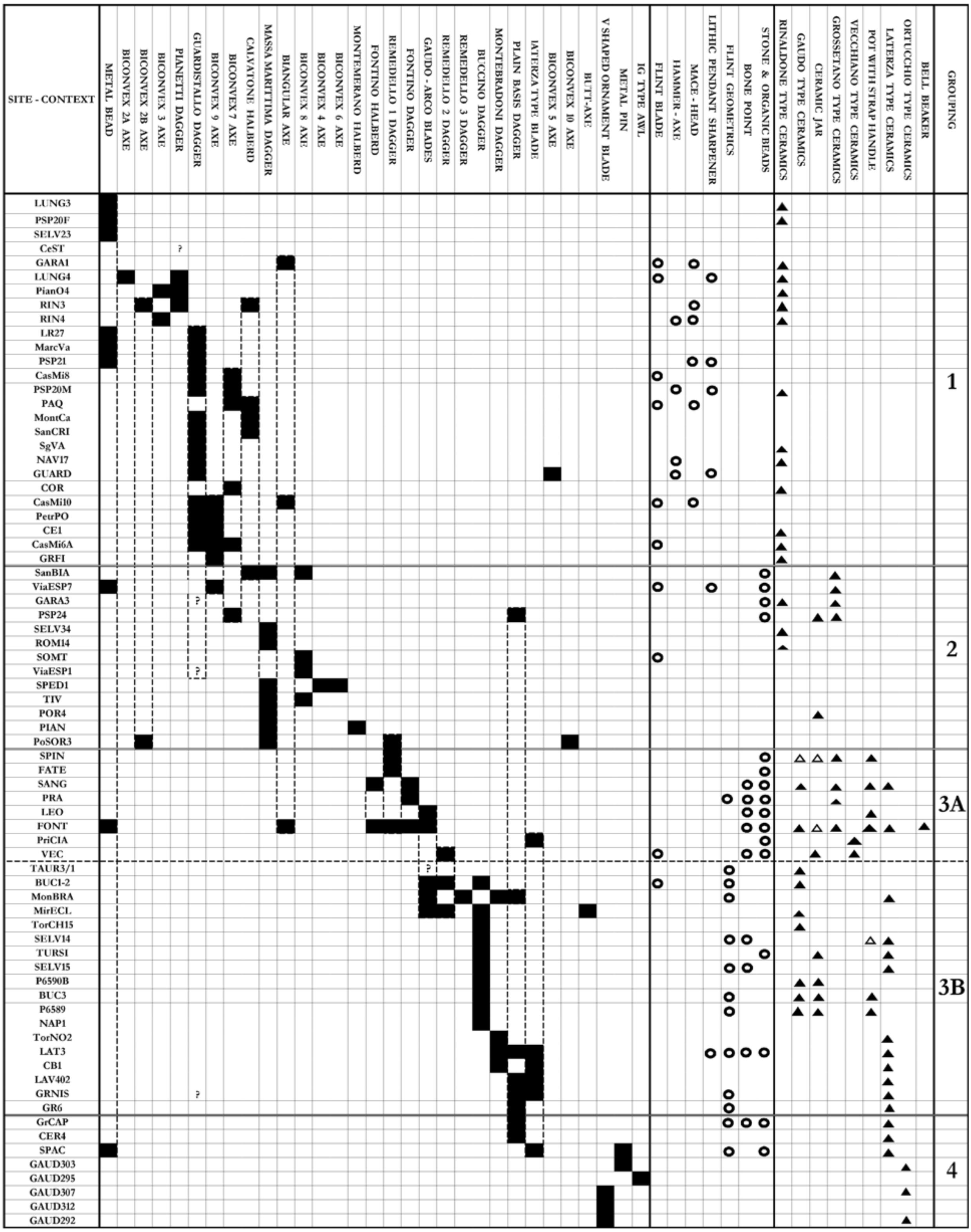


Table 3A-3B - Seriation table of Eneolithic axes and daggers/halberds from peninsular Italy. 3A, left to right: (1) sites and find contexts; (2) metal types; (3) flint, hardstone, and bone objects; (4) pottery styles; and (5) peninsular groupings *PenG1-4*. 3B, left to right, expansion of abbreviation of site/context name and bibliographical references.

Tabella di seriazione delle asce e pugnali/alabarde eneolitici dall'Italia peninsulare. 3A, da sinistra a destra: (1) siti e contesti di rinvenimento; (2) tipi metallici; (3) oggetti in selce, pietra dura e osso; (4) stili ceramici; (5) raggruppamenti peninsulari PenG1-4. 3B, da sinistra a destra, scioglimento delle abbreviazioni dei nomi di siti/contesti e riferimenti bibliografici.

SITE - CONTEXT ABBREVIATION	FULL NAME	LITERATURE
LUNG3	Lunghezzina T. 3	Anzidei, Carboni 2020a
PSP20F	Ponte S. Pietro T. 20F	Miari 1993
SELV23	Selvicciola T. 23	Petitti et al. 2002, 2011
CeST	Cerreta di Stroncone tomb	Colini 1912
GARA1	Garavicchio T. 1	Aranguren et al. 1987-88
LUNG4	Lunghezzina T. 4	Anzidei, Carboni 2020a
PianO4	Pianetti Ortaccia T. 4	Falchetti 1982
RIN3	Rinaldone T. 3	Dolfini 2004
RIN4	Rinaldone T. 4	Dolfini 2004
LR27	Lucrezia Romana T. 27	Anzidei, Carboni 2020a
MarcVa	Marcellina - Vasoli tomb	Anzidei, Carboni 2020a
PSP21	Ponte S. Pietro T. 21	Miari 1993
CasMi8	Casetta Mistici T. 8	Anzidei, Carboni 2020a
PSP20M	Ponte S. Pietro T. 20M	Miari 1993
PAQ	Poggio Aquilone tomb	Brizio 1899
MontCa	Montalto di Castro tomb?	Bianco Peroni 1994
SanCRI	San Cristoforo delle Vertighe	Buresta et al. 2006
SgVA	Sgurgola Valle Anagnina tomb	Anzidei, Carboni 2020a
NAV17	Naviglione T. 17	Bianco Peroni 1994
GUARD	Guardistallo tomb	Cocchi Genick , Grifoni Cremonesi 1989
COR	Corano tomb	Cocchi Genick , Grifoni Cremonesi 1989
CasMi10	Casetta Mistici T. 10	Anzidei, Carboni 2020a
PetrPO	Petrignano di Pozzuolo tomb	Del Vita 1919
CE1	Chiusa d'Ermini T. 1	Aspesi 2012; Negroni et al. 2015
CasMi6A	Casetta Mistici T. 6 A	Anzidei, Carboni 2020a
GRFI	Grotta Fichina tomb	China et al. 1993
SanBIA	San Biagio della Valle tomb	De Angelis 1995-96
ViaESP7	Casetta M. via Esperide T. 7	Anzidei, Carboni 2020a
GARA3	Garavicchio T. 3	Aranguren et al. 1987-88
PSP24	Ponte S. Pietro T. 24	Miari 1993
SELV34	Selvicciola T. 34	Petitti et al. 2011; Conti , Persiani 2008
ROM14	Romanina T. 14	Anzidei, Carboni 2020a
SOMT	Casale Somaini tomb	Cianfriglia et al. 2011
ViaESP1	Casetta Mistici - via Esperide T. 1	Anzidei, Carboni 2020a
SPED1	Spedaletto di Pienza T. 1	Cocchi Genick, Grifoni Cremonesi 1989
TIV	Tivoli Passo Stonio tomb?	Anzidei, Carboni 2020a
POR4	Porcareccia T. 4	Negroni 1992; Bianco Peroni 1994
PIAN	Pianizzoli, cave?	Cocchi Genick, Grifoni Cremonesi 1989
PoSOR3	Poggio Sorche T. 3	Unpublished
SPIN	Grotta Spinosa	Aranguren 2006; Aranguren et al. 2004
FATE	Grotta delle Fate	Cocchi Genick, Grifoni Cremonesi 1989
SANG	Grotta San Giuseppe	Cemonesi 2001
PRA	Grotta Prato	Cocchi Genick, Grifoni Cremonesi 1989
LEO	Grotta del Leone	Cocchi Genick, Grifoni Cremonesi 1989
FONT	Grotta Fontino	Vigliardi 2002
PriCIA	Da Prima Ciappa Superiore	Maggi, Formicola 1978
VEC	Castello di Vecchiano	Cocchi Genick, Grifoni Cremonesi 1989
TAUR3/1	San Martino, Taurasi T.3/1	Talamo 2006
BUC1-2	Buccino TT. 1-2	Holloway 1973
MonBRA	Monte Bradoni hypogeum	Cocchi Genick, Grifoni Cremonesi 1989
MirECL	Mirabella Eclano T. Capotribù	Onorato 1960; Bianco Peroni 1994
TorCH15	Torre d. Chiesaccia T. 15	Anzidei, Carboni 2020a
SELV14	Selvicciola T. 14	Petitti et al. 2011; Conti , Persiani 2008
TURSI	Tursi, Masseria tomb	Cremonesi 1976
SELV15	Selvicciola T. 15	Petitti et al. 2011; Conti , Persiani 2008
P6590B	Pontecagnano T. 6590B	Bailo Modesti, Salerno 1998
BUC3	Buccino T. 3	Holloway 1973
P6589	Pontecagnano T. 6589	Bailo Modesti, Salerno 1998
NAP1	Napoli Rione Materdei T. I	Marzocchella 1980
TorNO2	Felette - Torre Nocelle T. 2	Palermo Rossetti, Talamo 2011
LAT3	Laterza T. 3 Livv. XI-XIII	Biancofiore 1967; Bianco Peroni 1994
CB1	Creta Bianca T. 1	Tunzi Sisto 2015
LAV402	Lavello Casino T. 402	Bianco Peroni 1994
GRNIS	Grotta Nisco	Venturo et al. 2011
GR6	Gricignano Forum T. 6 Bibliot.	Salerno, Marino 2011
GrCAP	Grotta Cappuccini	Ingravallo 2002
CER4	Paestum T. di Cerere T. 4	Albore Livadie 2011
SPAC	Buca di Spaccasasso	Cavanna, Pellegrini 2007
GAUD303	Gaudello T. 303	Mancusi, Bonifacio 2020
GAUD295	Gaudello T. 295	Mancusi, Bonifacio 2020
GAUD307	Gaudello T. 307	Mancusi, Bonifacio 2020
GAUD312	Gaudello T. 312	Mancusi, Bonifacio 2020
GAUD292	Gaudello T. 292	Mancusi, Bonifacio 2020

Object type	Supplementary material	Figure
Pianetti-type daggers	Table X; plate 8.1-3	6.10
Guardistallo-type daggers, variants A-B	Table XI; plate 8.4-7	6.11-12
Trapezoidal axes, Bi-angular	Table IV; plate 2.1-4	6.8-9
Trapezoidal axes, Biconvex type 2	Table V; plate 2.7-9	6.4-5; 7.1-5
Trapezoidal axes, Biconvex type 3	Table V; plate 2.10	6.6
Trapezoidal axes, Biconvex type 5	Table V; plate 2.13-14	6.7
Trapezoidal axes, Biconvex type 7	Table V; plate 2.16-19	6.14

Table 4 - Object types assigned to peninsular grouping *PenG1*.
Tipi di oggetti attribuiti al raggruppamento peninsulare PenG1.

PenG2 metals are associated with fewer distinctive vessels compared to *PenG1*. The vessels show transitional characters between earlier and later Rinaldone-style pottery, supporting the chronology proposed here. They comprise flasks with narrow necks (e.g. Romanina, t.14, and San Biagio della Valle; fig. 6.31-32) as well as pottery types commonly found in the burial caves of coastal Tuscany including handle-jugs with tall necks and decorative bosses, ovoid jars, and conical bowls (fig. 6.33-35; see also *PenG3A* below). A similar repertoire is documented at Le Cerquete-Fianello and San Lorenzo a Greve, two late 4th millennium BC settlement sites (Aranguren *et alii* 2009; Cocchi Genick 2008; Marconi 2020). Table 6 lists the metal types assigned to *PenG2*.

Comparisons with eastern Europe support the late 4th and early 3rd millennium chronology of the grouping proposed here. In particular, the large dagger/halberd akin to the Guardistallo type from Poggio delle Sorche (fig. 7.16) resembles the early 3rd millennium BC 'Lovas B variant' of Cucuteni-type daggers (Matuschick 1998: 225, abb. 225 and 231; Kulcsár and Szeverényi 2013: 70) (fig. 7.17-18).

Peninsular Grouping 3 *(PenG3)* (table 3; fig. 8).

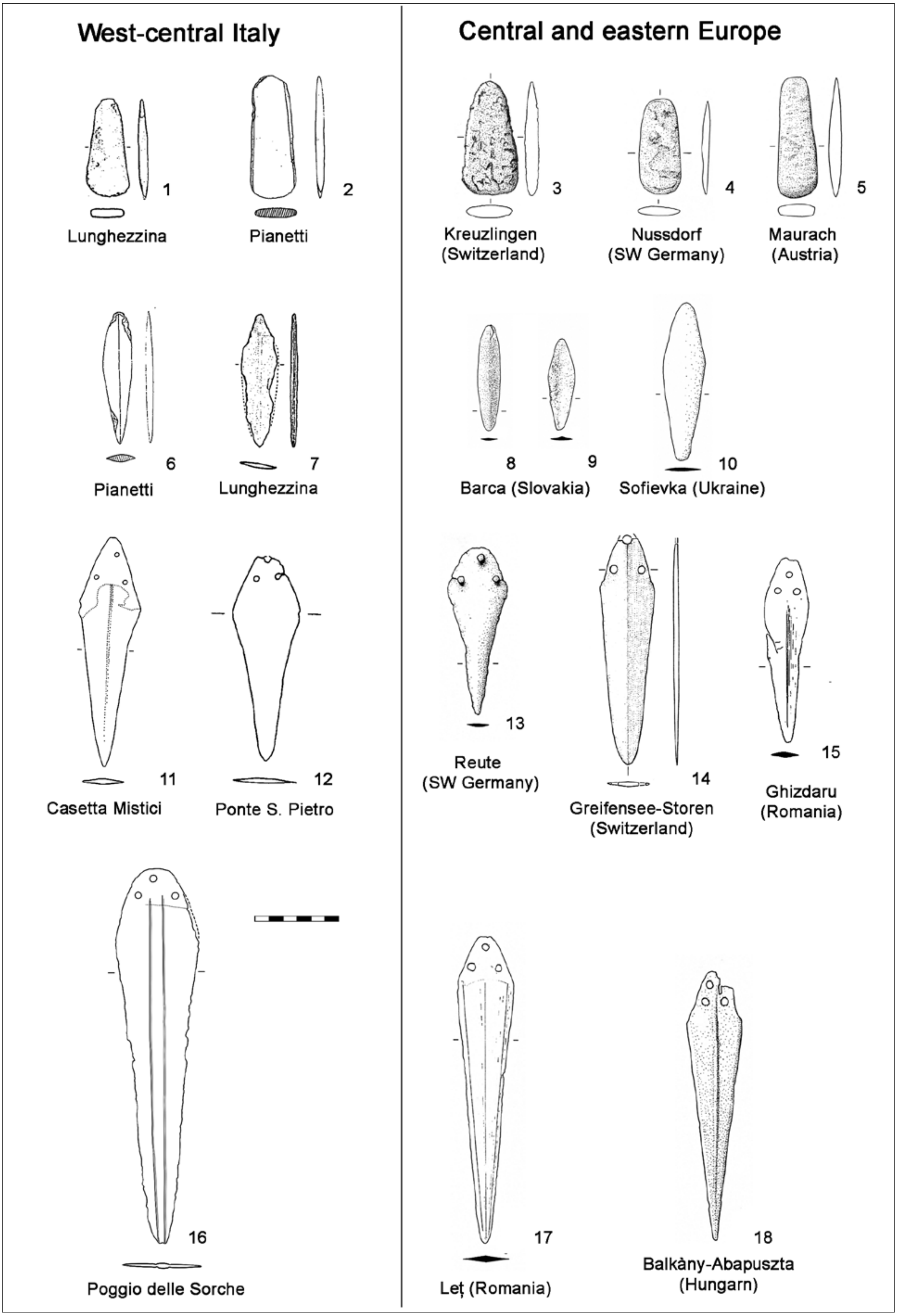
The grouping comprises 26 assemblages. We have split *PenG3* into subsets *PenG3A* and *PenG3B* to account for partly separate metal inventories and object distribution zones (table 3).

Grouping *PenG3A* encompasses metal and non-metal objects from the collective burial caves of coastal Tuscany (so-called *Vecchiano* and *Grossetano* cultural groups; Cocchi Genick 2008: 329-334; Cocchi Genick, Grifoni Cremonesi 1989; Vigliardi 2002). Mortuary practices at these sites feature extreme dismemberment and mixing of human remains, making it impossible to discern one-phase associations between objects and burials (Dolfini 2020). Notwithstanding this limitation, *PenG3A* metal assemblages share distinctive morphological traits and show notable differences with *PenG1* and *PenG2* Rinaldone burials. This is suggestive of a tight chronological horizon and self-contained production and exchange areas. Table 7 lists the metal types assigned to *PenG3A*.

Grouping *PenG3B* features several assemblages from Gaudo-style and Laterza-style funerary sites, as well as a few burials from west-central Italy (e.g. Montebradoni, Selvicciola and Torre della Chiesaccia). Contexts include collective burials in chamber tombs and individual inhumations in trench and cist graves (Anzidei and Carboni 2020a, 2020b; Bailo Modesti and Salerno 1998; Cocchi Genick 2007, 2008, 2011) (table 3). Table 8 lists the metal types typical of *PenG3B*, while table 9 lists the metal types shared by both *PenG3A* and *PenG3B*.

Furnishings from *PenG3A* and *PenG3B* graves normally include flint microliths, animal bone projectile points, and stone and animal tooth beads and pendants (fig. 8.13-16). Diagnostic pottery encompasses biconical vessels, neck-jugs, and cups with strap handles, which are com-

Fig. 7 (next page) - Morphological similarities between the Italian and central/eastern European axes and daggers/halberds shown in the image support a chronology of peninsular groupings *PenG1* and *PenG2* from mid-4th to early 3rd millennia BC. Scale 1:3 (sources: Nos 1, 7 and 11: Anzidei and Carboni 2020b; 2, 6: Falchetti 1982; 12: Miari 1993; 3-5: Lefranc *et alii* 2019; 8-13 and 15-18: Matuschick 1998; 14: Müller 2013; 16: original drawing by C. Iaia).
Le similarità morfologiche tra le asce e i pugnali/alabarde italiani e del Centro-Est Europa riprodotti nell'immagine supportano una cronologia dei raggruppamenti peninsulari PenG1 e PenG2 dalla metà del IV al principio del III millennio BC. Scala 1:3 (fonti: nn. 1, 7, 11: Anzidei e Carboni 2020b; 2, 6: Falchetti 1982; 12: Miari 1993; 3-5: Lefranc et alii 2019; 8-13, 15-18: Matuschick 1998; 14: Müller 2013; 16: disegno originale di C. Iaia).


West-central Italy
Central and eastern Europe
1
Lunghezzina
2
Pianetti
3
Kreuzlingen
(Switzerland)
4
Nussdorf
(SW Germany)
5
Maurach
(Austria)
6
Pianetti
7
Lunghezzina
8
9
Barca (Slovakia)
10
Sofievka (Ukraine)
11
Casetta Mistici
12
Ponte S. Pietro
13
Reute
(SW Germany)
14
Greifensee-Storen
(Switzerland)
15
Ghizdaru
(Romania)
16
Poggio delle Sorche
17
Leţ (Romania)
18
Balkàny-Abapuszta
(Hungarn)

Object type	Supplementary material	Figure
Silver/antimony/valentinite beads (various shapes)		6.18
Atypical Guardistallo-type daggers (e.g. Garavicchio, t. 3; Casetta Mistici-via Esperide, t. 1)		
Calvatone-type halberds	Table XIV; plate 11.1-3.	6.13
Trapezoidal axes, Bi-angular type 3	Table IV; plate 2.4	
Trapezoidal axes, Biconvex type 7A	Table V; plate 2.16	
Trapezoidal axes, Biconvex type 9	Table V; plate 3.6-8	

Table 5 - Object types mostly occurring in *PenG1*, but occasionally documented at *PenG2* sites.
Tipi di oggetti ricorrenti prevalentemente nei siti PenG1*, ma attestati occasionalmente nei siti* PenG2*.*

Object type	Supplementary material	Figure
Massa Marittima-type daggers	Table XI; plate 8.8-15	6.26-27
Ponte S. Pietro-type daggers	Table XI; plate 8.16	6.29
Large daggers/halberds akin to the Guardistallo type	Table XI; plate 8.13	6.25
Remedello-group daggers, type IB1	Table XII; plate 9.12	6.28
Montemerano-type halberds (uncertain)	Table XIV; plate 11.5	6.30
Trapezoidal axes, Biconvex type 8	Table V; plate 3.1-5	6.24

Table 6 - Object types assigned to peninsular grouping *PenG2*.
Tipi di oggetti attribuiti al raggruppamento peninsulare PenG2.

mon at both Tuscan burial caves and Gaudo and Laterza sites (fig. 8.4-8; 25-31).

Overall, several radiocarbon dates from the hinterland of Rome and the Campania region indicate that the Gaudo and Laterza burial traditions developed one after the other (Anzidei and Carboni 2020a, 2020b; Aurino 2013; Cocchi Genick 2011; Passariello *et alii* 2010; Talamo *et alii* 2011). Gaudo-style sites are mostly dated to *c*.3300-2850 BC, while Laterza-type sites are *c*.2800-2600/2500 BC (Anzidei and Carboni 2020b: 149-202). These dates provide a chronology for *PenG3*.

Peninsular Grouping 4 *(PenG4)* (table 3; fig. 9).

The grouping comprises 8 assemblages. This is the least characterised grouping in the peninsular series as evidence is scarce and patchily dated. In central and southern Italy, this horizon features Ortucchio-type domestic and burial sites dated to 2700-2100 BC, as well as late Laterza, Bell Beaker and Cetina sites (Anzidei and Carboni 2020b: 203-252). Rinaldone-style burials are still found in parts of west-central Italy, but grave furnishings are scarcer than in previous phases, and different in character[2]. In south-eastern Italy, this phase encompasses the Cellino San Marco pottery style, dated to *c*.2500-2300 BC at Grotta Cappuccini (Ingravallo 2002). Based on these considerations, we propose dating *PenG4* to the Final Eneolithic, i.e. mid/late 3rd millennium BC.

At Gaudello near Acerra, Naples, poorly preserved trench graves dug into the strata deriving from the Agnano-Monte Spina eruption show clear connections with Ortucchio and Cetina cultural groups (Mancusi, Bonifacio 2020). Unfortunately, the site is not yet radiocarbon dated. However, the Agnano Monte Spina eruption provides a *post quem* for Gaudello at 2575-2470 2σ cal. BC (Passariello *et alii* 2010: table 2, fig. 8). The site has yielded all metal types defining *PenG4* (table 10). They are an interesting technological synthesis of Eneolithic and Early Bronze Age craft traditions, suggesting that *PenG4* might straddle the two periods.

Comparisons from the circum-Alpine region support this proposal. The daggers/halberds from Gaudello are morphologically similar to objects dating to the Bronzezeit A1 in central Europe,

[2] See Selvicciola: Petitti-Conti-Persiani 2006: fig. 4; Fontanile di Raim: Petitti *et alii* 2002b; Manfredini 2012; Manfredini *et alii* 2009; Romanina, tt. 10-12: Anzidei and Carboni 2020a: 522-526.

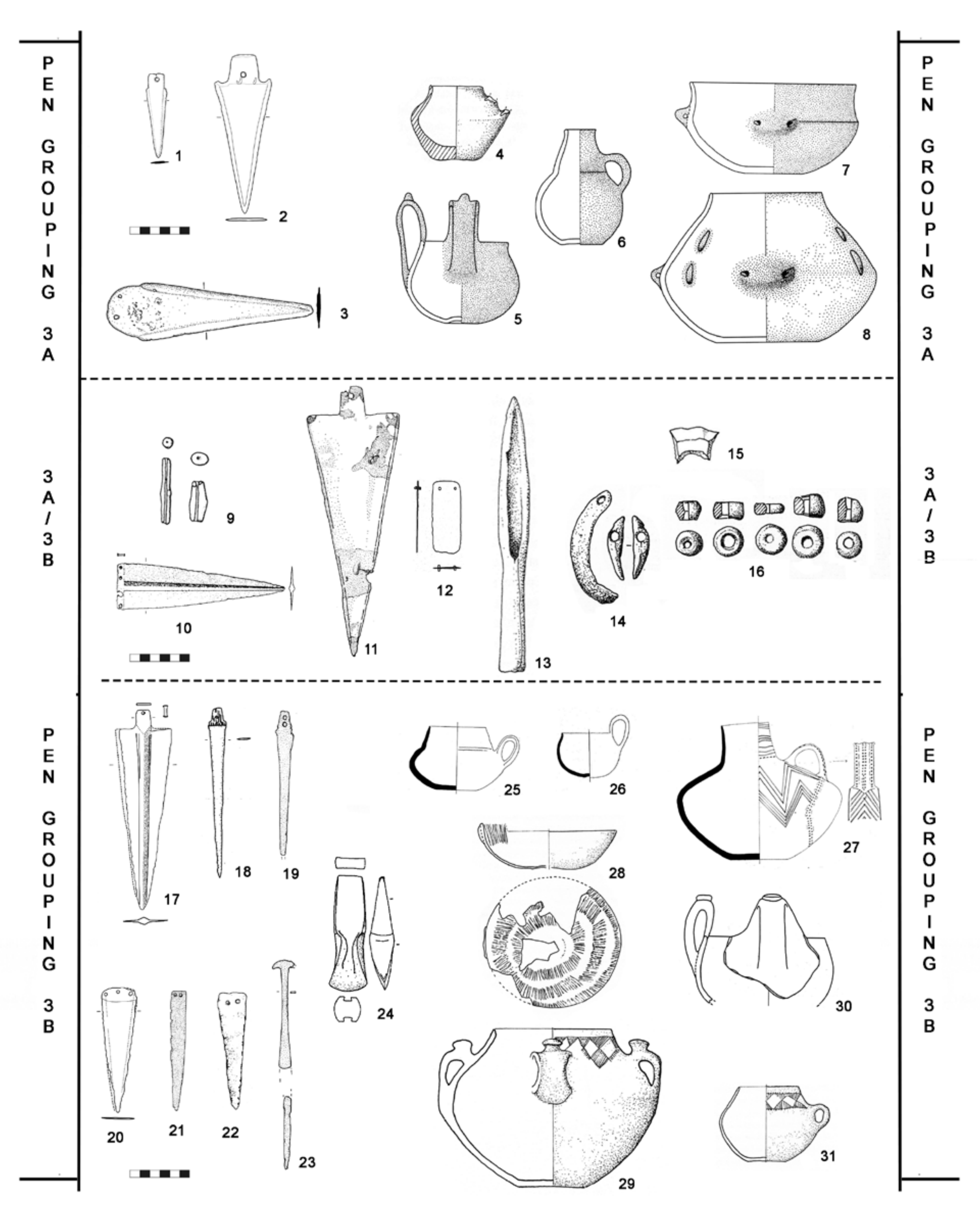


Fig. 8 - Metal and non-metal object types defining peninsular groupings *PenG3A* and *PenG3B*. See table 3 for the seriation of object types. Scale c. 1:4 (after Bianco Peroni 1994; Carancini 1993; Cocchi Genick 2008; Cocchi Genick and Grifoni Cremonesi 1989; Maggi and Formicola 1978; Holloway 1973; and Zanini 2002. Nos 2, 17 original drawings by C. Iaia).
Tipi di oggetti in metallo e non metallici che definiscono i raggruppamenti peninsulari PenG3A e PenG3B. Si veda la tabella 3 per la seriazione dei tipi di oggetto. Scala ca 1:4 (da Bianco Peroni 1994; Carancini 1993; Cocchi Genick 2008; Cocchi Genick e Grifoni Cremonesi 1989; Maggi e Formicola 1978; Holloway 1973; Zanini 2002. Nn 2, 17 disegni originali di C. Iaia).

Object type	Supplementary material	Figure
Fontino-type daggers	Table XII; plate 9.1-7	8.1
Fontino-type halberds	Table XIV; plate 11.4	8.3
Remedello-group daggers, type I	Table XII; plate 9.8-9,11,13	8.2

Table 7 - Object types assigned to peninsular grouping *PenG3A*.
Tipi di oggetti attribuiti al raggruppamento peninsulare PenG3A.

Object type	Supplementary material	Figure
Remedello-group daggers, type III	Table XII; plate 9.20	8.17
Buccino-type daggers	Table XII; plate 10.4-5	8.18,19
Montebradoni-type daggers	Table XIII; plate 10.6	8.23
Grotta Cappuccini-type daggers	Table XI; plate 10.1-2	8.21-22
Butt-axes of the Mirabella Eclano type	Table VI; plate 3.11-12	8.24

Table 8 - Object types assigned to peninsular grouping *PenG3B*.
Tipi di oggetti attribuiti al raggruppamento peninsulare PenG3B.

Object type	Supplementary material	Figure
Remedello-group daggers, type II	Table XII; plate 9.18	8.11
Gaudo-Arco type blades	Table XIV; plate 10.8-12	8.10
Laterza-type blades	Table XI; plate 10.3	8.12

Table 9 - Object types shared by peninsular groupings *PenG3A* and *PenG3B*.
Tipi di oggetti condivisi dai raggruppamenti peninsulari PenG3A *e* PenG3B.

Object type	Supplementary material	Figure
Various types of daggers/halberds with round or slightly rounded hafting plates, multiple rivet holes, triangular blades, and V-shaped decorations close to the Lussan type	Table XI	9.3-5
Ig II-type awl with a lozenge-shaped head		9.1
Pin with a rolled head and curved stem		9.2

Table 10 - Object types assigned to peninsular grouping *PenG4*. All objects listed above were found at Gaudello, a Final Eneolithic-Early Bronze Age burial site near Acerra, Naples (Mancusi and Bonifacio 2020).
Tipi di oggetti attribuiti al raggruppamento peninsulare PenG4. Tutti gli oggetti elencati sopra sono stati rinvenuti a Gaudello, sito funerario dell'Eneolitico finale-Bronzo antico presso Acerra, Napoli (Mancusi e Bonifacio 2020).

such as Lussan-type daggers (David-Elbiali and David 2008: 8, fig. 3.A-B). The Ig II-type awl is copiously documented at Final Eneolithic and initial Early Bronze Age sites in Trentino-Alto Adige/South Tyrol and Slovenia.[3] The pin with rolled head has a similar chronology.[4] These types are associated with ceramics close to the Ortucchio and Cetina groups, also dating to this time period (Fig. 9.6-8).

Northern Italy

Unlike the peninsula, Eneolithic northern Italy features a relative dearth of single-phase burials with metal objects; this makes any seriation exercise challenging. The problem is due to the funerary behaviour practised in the southern Alps and northern Apennines, which centred on collective burial in caves and rock shelters (Barfield 1985). Metalwork is exceedingly rare at these sites. In the Alps, metal objects are frequently engraved on rock panels and stelae, often with such detail that specialists can classify the engravings by compari-

3 Dal Ri and Tecchiati 1994: 30, fig. 16.4-8; Oberrauch 2019: 436, abb. 5.3 (Pigloner Kopf, Alto Adige, dated c.2700-2400 BC); Perini 1972: fig. 10.140.141 (Montesei di Serso, Trentino).

4 Hoard 6 from Pigloner Kopf, where the pin is associated with the abovementioned Ig II-type awl. See Oberrauch 2019: 436, fig. 5.1. For the initial EBA in central Europe (phase Gemeinlebarn 1), see Bertemes and Heyd 2015: fig. 5. For the initial EBA in northern Italy, see de Marinis and Valzolgher 2013: fig. 2A.1, 2B1 (Sorbara di Asola).

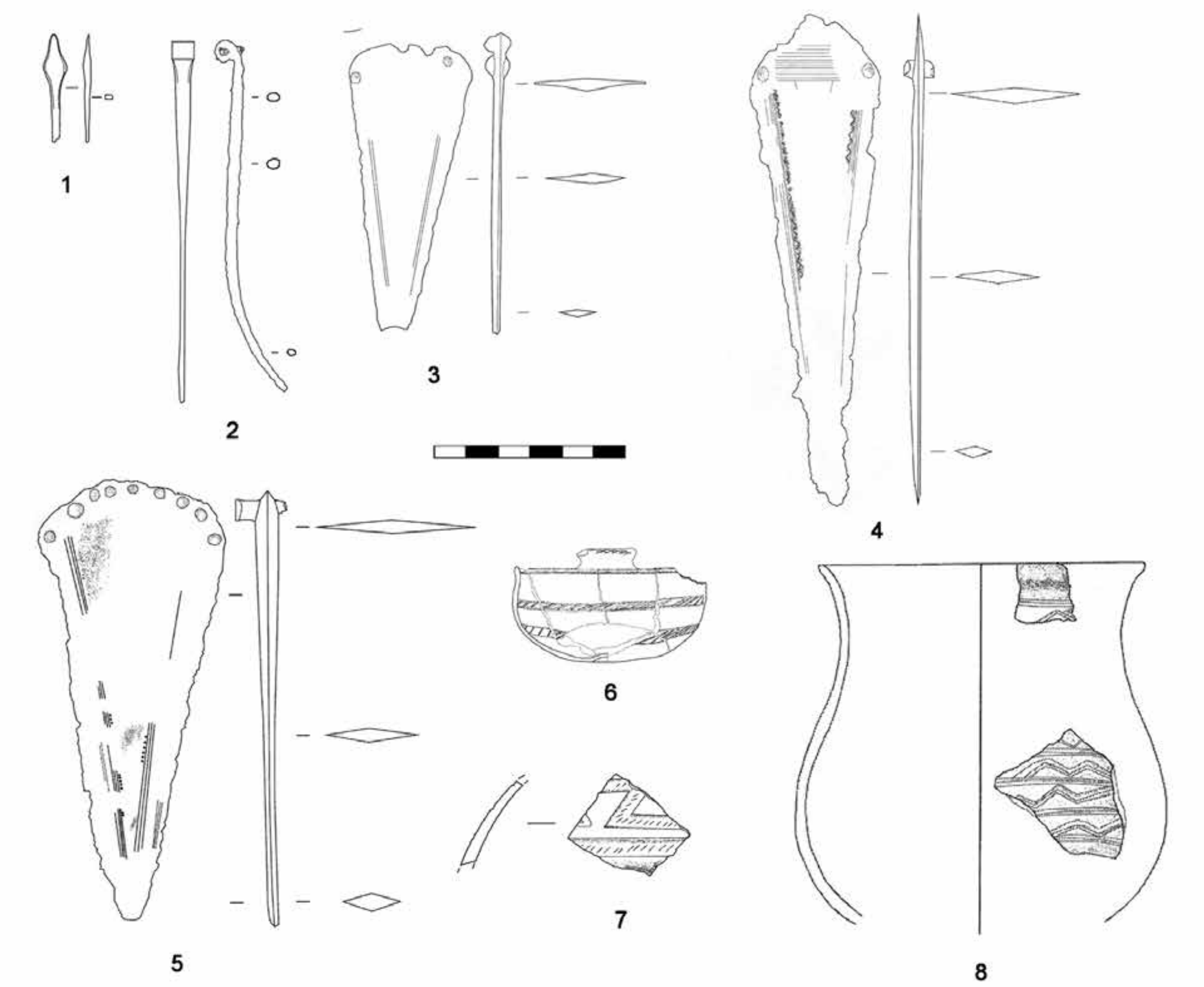


Fig. 9 - Metal and non-metal object types defining peninsular grouping *PenG4.* Scale 1:3. (drawings after Mancusi and Bonifacio 2020).
Tipi di oggetti in metallo e non metallici che definiscono il raggruppamento peninsulare PenG4. Scala 1:3. (disegni da Mancusi e Bonifacio 2020).

son with archaeological objects (de Marinis 1994; Casini-de Marinis-Fossati 2014). Most collective burials and stelae date to the 3rd millennium BC (e.g. Riparo Valtenesi; Barfield 2007; Barfield *et alii* 2010). Recent research, however, shows that burial caves were first utilised in the mid-4th millennium BC, bringing the evidence in line with the peninsula (Miari *et alii* forthcoming).

Individual burial in trench graves prevails in the Po plain. This is the area that has yielded some of the most iconic (and metal-rich) cemeteries from Eneolithic Italy including Remedello Sotto (de Marinis 1997; 2013; 2014), Spilamberto (Bagolini 1981; Ferrari and Steffè 2009), and Celletta dei Passeri (Miari-Bestetti-Rasia 2017). The latter was pivotal to building the north Italian sequence as it provides well-preserved metals, high-quality excavation data, and several radiocarbon dates.

We have identified three assemblage groupings in northern Italy. They are grounded in 24 types of metal objects and other culturally significant materials, as discussed below. As metals are rarely associated with one another in burials, the seriation exercise is partly grounded in typological comparisons and crosslinks.

Northern Grouping 1 *(NG1)* (table 11; fig. 10.1-13).

The grouping comprises 14 object asseblages[5] ascribed to the Middle Eneolithic, i.e. late 4th and early 3rd millennia BC; it is therefore con-

5 It is uncertain if Celletta dei Passeri, tomb 27, is to be assigned to *NG1* or *NG2*. The burial and object assemblage might mark the transition between the two groupings.

SITE - CONTEXT	TRENCH GRAVE	COLLECTIVE BURIAL IN CAVE	UNSPECIFIED BURIAL	HOARD	FACETED 1 AXE	SMALL HALBERD?	UNCLASSIFIABLE DAGGER	PLAIN SIDES 7 AXE	BONE REMEDELLO 1 DAGGER	PLAIN SIDES 3B AXE	REMEDELLO 1 DAGGER	PLAIN SIDES 6A AXE	PLAIN SIDES 6B AXE	REMEDELLO 2 DAGGER	FACETED 5 AXE	SILVER T-HEADED PIN	FACETED 2 AXE	FACETED 3 AXE	PLAIN SIDES 8A AXE	FACETED 4 AXE	FACETED 6 AXE	SHAFT-HOLE AXE	CLOSE TO REMEDELLO 3 TYPE	SIMPLE AWL	IG II TYPE AWL	ROLLED-HEADED PIN	V-SHAPED ORNAMENT DAGGER	FLINT DAGGER	ARROW-HEAD	GROUNDSTONE AXE	FLINT GEOMETRICS	WHETSTONE	STONE BEAD	SHELL BEAD	BONE/ANTLER TOOL	BONE POINT	NECKED JUG	RUSTICATED POTTERY	BELL BEAKER	LITERATURE	GROUPING
Tiesenjoch/Similaun			X		■																							○												Kaufmann 2014	
Remedello T. 102	X				■																							○	○											Longhi 1994	
Remedello T. 106	X						■																							○										de Marinis 2013	
Celletta T. 75	X					■		■																																Miari, Bestetti, Rasia 2017	
Celletta T. 74	X							■																?					○											Miari, Bestetti, Rasia 2017	
Spilamberto T. 5	X								■																				○										▲		Ferrari, Steffè 2009	
Spilamberto T. 27	X								■																				○										▲		Ferrari, Steffè 2009	1
Cumarola Gastaldi	X									■	■																													de Marinis, Gambari, Faudino 2013	
Spilamberto T. 1	X										■																		○									▲			Ferrari, Steffè 2009	
Spilamberto T. 9A	X										■																		○									▲			Ferrari, Steffè 2009	
Remedello T. 83	X										■																		○					○	○						Longhi 1994; de Marinis 2013	
Celletta T. 83	X										■	■												■					○				○					▲			Miari, Bestetti, Rasia 2017	
Remedello T. 78	X											■																○	○							○					Longhi 1994; de Marinis 2013	
Celletta T. 40	X											■												■					○									▲			Miari, Bestetti, Rasia 2017	
Celletta T. 27	X										■		■																									▲			Miari, Bestetti, Rasia 2017	1/2
Celletta T. 47	X												■	■																								▲			Miari, Bestetti, Rasia 2017	
Celletta T. 64	X													■																			○					▲			Miari, Bestetti, Rasia 2017	
Volongo T. 1	X													■															○	○											Odone 1994	2
Sabbione Tomb	?													■	■																										Pearce 2007	
Remedello T. BSII	X															■													○												de Marinis 2013	
Remedello T. 4	?																■											○	○												de Marinis 2013	
Col del Buson Hoard				X													■					■			■																Bianchin Citton 2013	
Grotta Tanaccia		X															■																							▲	Massi Pasi, Morico 1997	
Pigloner Kopf hoards 4,5				X																		■																			Oberrauch 2019	
Pigloner Kopf hoard 6				X																					■	■															Oberrauch 2019	3
Fontanella T. XI	X																						■							○			○	○	○	○					Acanfora 1956; Bianco Peroni 1994	
S. Cristina T. sud	X																		■												○				?					▲	Odone 1994	
Remedello Sopra Hoard				X														■		■	■																				de Marinis 1979	
Alba, via T. Bubbio	X																										■														Venturino et al. 2018	

Table 11 - Seriation table of Eneolithic axes and daggers/halberds from northern Italy. The columns show, left to right: (1) sites and find contexts (T. = tomb or grave); (2) nature of contexts; (3) metal types; (4) flint, hardstone, shell and bone objects; (5) pottery styles; (6) references; and (7) Northern Italian groupings *NG1-3*.
Tabella di seriazione di asce e pugnali/alabarde eneolitici dall'Italia settentrionale. Le colonne mostrano, da sinistra a destra: (1) siti e contesti di rinvenimento (T. = tomba o sepoltura); (2) natura dei contesti; (3) tipi metallici; (4) oggetti in selce, pietra dura, conchiglie e osso; (5) stili ceramici; (6) riferimenti bibliografici; (7) raggruppamenti dell'Italia settentrionale NG1-3.

temporary to *PenG2* south of the Apennines. We postulate that an Early Eneolithic phase similar to *PenG1* would exist in northern Italy, which, however, is currently undocumented in the sphere of metalwork production and usage. A dagger from Cave Spalletti, t. 79, is one of very few metals dating to this phase (Miari *et alii* forthcoming).

The chronology of *NG1* is grounded in burial assemblages from Spilamberto, Celletta dei Passeri and Remedello Sotto, and in radiocarbon dates from the latter two sites. Considering its homogenous material culture, we argue that Spilamberto is a short-lived site dating to the late 4th millennium BC. Several crosslinks support the proposal including: (1) a jug from t. 1 akin to vessels from Adriatic Italy dating to the mid/late 4th millennium BC (Cocchi Genick 2012: 375-6; Cazzella-Pignocchi-Silvestrini 2013: 129, fig. 4) (fig. 10.13); (2) rusticated pottery (*ceramica a squame*, fig. 10.11-12) with close *comparanda* from nearby Cave Marchi, layers radiocarbon dated to 3370-2920 cal. BC (Dal Santo *et alii* 2014: fig. 26); and (3) a lithic dagger (or halberd) from t. 28 (fig. 11.1) similar to an object from Arbon Bleiche 3, Switzerland (fig. 11.2), dendrochronologically dated to 3384-3370 BC (Mottes 2001: 530, fig. 9-10; Honegger 2006: fig. 1). Celletta dei Passeri ostensibly covers a longer timespan than Spilamberto as most radiocarbon dates range from 3350-2580 BC (Miari, Bestetti and Rasia 2017: table II). Table 12 lists the metal types assigned to *NG1*.

Axes with slightly raised margins and faceted sides (or Similaun type; fig. 11.6-7) compare well with specimens from the northern Alps and east-central Europe dating to the late 4th and early 3rd

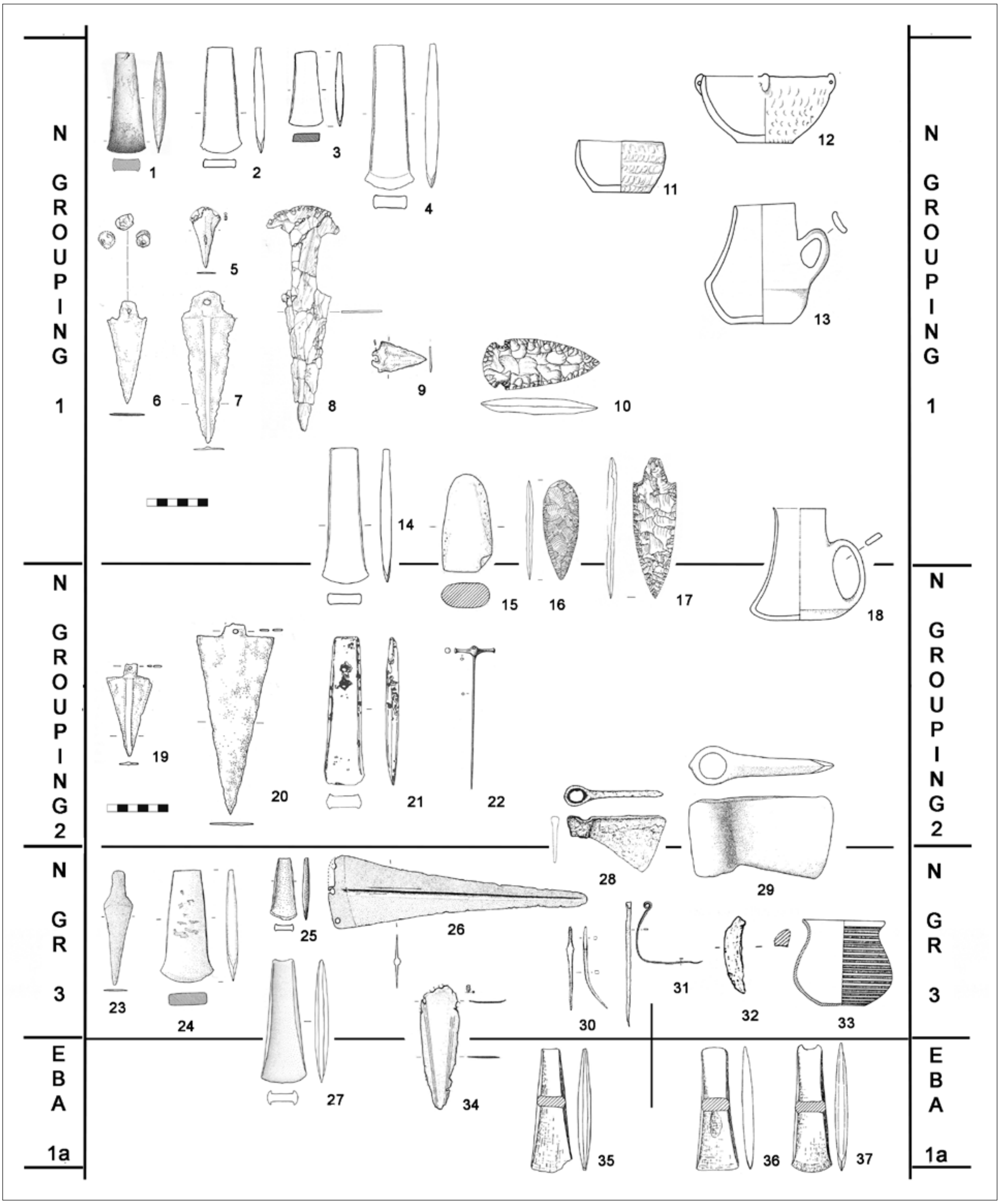


Fig. 10 - Metal and non-metal object types defining northern Italian groupings *NG1-3 and EBA 1a*. See Table 11 for the seriation of object types. Scale c. 1:4 (after Bagolini 1981; Bianchin Citton 2013; Bianco Peroni 1994; de Marinis 1979, 1992, 2013; Ferrari and Steffè 2009; Kaufmann 2014; Longhi 1994; Miari *et alii* 2017; Oberrauch 2019; Pearce 2007; Tecchiati 1992; Venturino *et alii* 2018. Nos 2, 4, 14, 25 original drawings by C. Iaia).

Tipi di oggetti in metallo e non metallici che definiscono i raggruppamenti dell'Italia settentrionale NG1-3 e BA 1a. Si veda la tabella 11 per la seriazione dei tipi di oggetto. Scala ca 1:4 (da Bagolini 1981; Bianchin Citton 2013; Bianco Peroni 1994; de Marinis 1979, 1992, 2013; Ferrari e Steffè 2009; Kaufmann 2014; Longhi 1994; Miari et alii 2017; Oberrauch 2019; Pearce 2007; Tecchiati 1992; Venturino et alii 2018. Nn. 2, 4, 14, 25 disegni originali di C. Iaia).

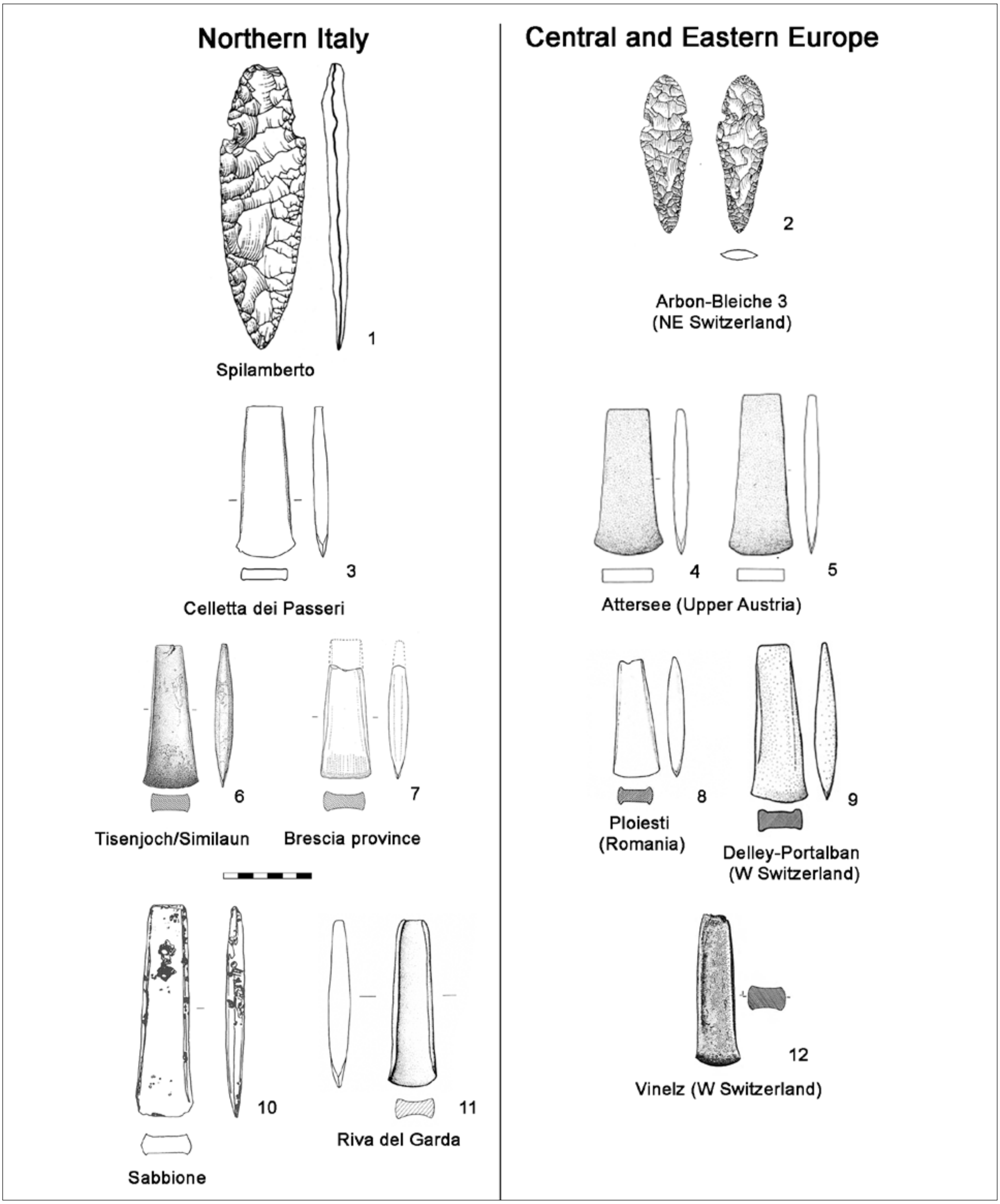


Fig. 11 - Morphological similarities between the Italian and central/eastern European axes and bifacial flint dagger shown in the image support a chronology of northern Italian grouping *NG1* in the late 4th and early 3rd millennia BC. Scale 1:3 (sources: No 1: Ferrari and Steffè 2009; 2: Mottes 2001; 3: original drawing by C. Iaia; 4, 5: Mayer 1977; 6: Kaufmann 2014; 7: de Marinis 1992; 8: Frinculeasa-Preda-Heyd 2015; 9: Klimscha 2013; 10: Pearce 2007; 11: Dal Ri and Tecchiati 1994; 12: Strahm 1974).

Le similarità morfologiche tra le asce e il pugnale bifacciale in selce dell'Italia e del Centro-Est Europa riprodotti nell'immagine supportano una cronologia del raggruppamento dell'Italia settentrionale NG1 dal tardo IV al principio del III millennio BC. Scala 1:3 (fonti: No 1: Ferrari e Steffè 2009; 2: Mottes 2001; 3: disegno originale di C. Iaia; 4, 5: Mayer 1977; 6: Kaufmann 2014; 7: de Marinis 1992; 8: Frinculeasa-Preda-Heyd 2015; 9: Klimscha 2013; 10: Pearce 2007; 11: Dal Ri e Tecchiati 1994; 12: Strahm 1974).

Object type	Supplementary material	Figure
Remedello-group daggers, type I	Table XII; plate 9.9-10,14-15	10.6-8
Bone skeumorph of a Remedello dagger, possibly akin to type I	Table XII	10.8
Trapezoidal axes, Faceted sides type 1 (or Similaun type)	Table IX; plate 7.1-4.	10.1
Trapezoidal axes, Plain sides type 3B	Table VIII; plate 5.10-12	10.3
Trapezoidal axes, Plain sides type 6A	Table VIII; plate 6.1-2	10.4
Trapezoidal axes, Plain sides type 7	Table VIII; plate 6.4-5	10.2

Table 12 - Object types assigned to northern Italian grouping *NG1*.
Tipi di oggetti attribuiti al raggruppamento dell'Italia settentrionale NG1.

Object type	Supplementary material	Figure
Remedello-group daggers, type II	Table XII; plate 9.16-17, 19	10.19-20
Trapezoidal axes, Faceted sides type 5	Table IX; plate 7.13-14	10.21
Silver T-headed pin		10.22

Table 13 - Object types assigned to northern Italian grouping *NG2*.
Tipi di oggetti attribuiti al raggruppamento dell'Italia settentrionale NG2.

millennia BC (fig. 11.8-9)[6]. Moreover, type 7 axes show strong similarities with a slender variant of central European Altheim-type axes dating to the later 4th millennium BC (fig. 11.3-5)[7].

Northern Grouping 2 (*NG2*) (table 11; fig. 10.19-22).

The grouping comprises 5 assemblages; it is based on a limited metallic repertoire and very few radiocarbon dates. Therefore, its chronology is largely grounded in cross-cultural comparisons. Grouping *NG2* partly corresponds to *PenG3* south of the Apennines as well as de Marinis' (1997) Remedello phase II, notwithstanding certain differences in our object classification and chronology. Table 13 lists the metal objects assigned to *NG2*.

The following crosslinks suggest that both *NG2* and the *Auvernier cordé* horizon of the Corded Ware culture, northern Alps, date to the second quarter of the 3rd millennium BC (Winiger 2014): (1) Italian faceted type 5 axes with elongated bodies and straight flanged sides comparing well with a specimen from Vinelz, Switzerland (Strahm 1974: 24, abb.1); (2) Remedello type IIA daggers (fig. 10.19-20) carved on stone stelae from Arco (Trento) and Sion, Dolmen MVI (Valais, Switzerland) (de Marinis 1994: 74); and (3) a silver T-headed pin from Remedello Sotto, t. BS II, comparing with Corded Ware – *Auvernier cordé* specimens (de Marinis 2013: 332-3, fig. 29) (fig. 10.22). Similar silver pins were found at Ponte delle Sette Miglia, Rome, but their chronology is unclear (Anzidei and Carboni 2020b: 329. fig. 3.9.71; Carboni 2020: 503).

Northern Grouping 3 (*NG3*) (table 11; fig. 10.23-37).

The grouping comprises 9 assemblages. Like *NG2*, *NG3* is somewhat difficult to pinpoint due to the scarce burial assemblages and radiocarbon dates available. Nonetheless, it seems roughly to correspond to de Marinis' (1997) Remedello 3 phase and our peninsular *PenG4* grouping, mid/late 3rd millennium BC. Multiple crosslinks with peninsular Italy and continental Europe support this chronology. The large number of object types belonging to *NG3* suggests that this phase may have lasted longer than the previous. Table 14 lists the metal types assigned to *NG3*.

NG3 assemblages show significant, if not numerous, ties with Beaker-style pottery (and other mid/late 3rd millennium cultural groupings) strengthening the chronology proposed here. Suffice it to mention: (1) two axes from S. Cristina and Grotta Tanaccia, both associated

6 Kaufmann 2014: 72-76.; see in particular an axe from Delley-Portalban, assigned to the Horgen phase and dated to 3200-2700 BC: Klimscha 2013: abb. 13.4 (fig. 11.9) and the recently found axe from Ploiesti, Romania (fig. 11.8), radiocarbon dated to around 3000 BC (Frînculeasa-Preda-Heyd 2015: pl. 18.3).

7 Mayer 1977: 53; Kienlin 2010: 54-55. The north Italian specimens can be best compared to slender versions of the type: see Schwarzberg 2016: abb. 8.4,5.

Object type	Supplementary material	Figure
Ciempozuelos-type daggers	Table XII; plate 10.7	10.23
Villafranca-Tivoli type halberds	Table XIV; plate 11.7	
Gambara-type halberds	Table XIV; plate 11.8	10.26
Lussan-type dagger	Table XI	10.34
Trapezoidal axes, Faceted type 2	Table IX; plate 7.5-7	10.25
Trapezoidal axes, Faceted type 3	Table IX; plate 7.8-10	10.27
Trapezoidal axes, Plain sides type 8A	Table VIII; plate 6.6-90	10.24
Faisz-type shaft-hole axes	Table VII; plate 4.2-3	10.29
Freisach-type shaft-hole axes	Table VII; plate 4.4	10.28
Ig II-type awl		10.30
Pin with rolled head and curved stem		10.31

Table 14 - Object types assigned to northern Italian grouping *NG3*.
Tipi di oggetti attribuiti al raggruppamento dell'Italia settentrionale NG3.

with Beaker-style pottery (fig. 10.33); (2) Villafranca and Gambara-type halberds, which de Marinis (1994: 78-82; 2014: 209) dates to this horizon by reference to rock carvings; and (3) shaft-hole axes from Col del Buson and Piglon-er Kopf (fig. 10.28-29) dating to the Late/Final Eneolithic (Bianchin Citton 2013; Oberrauch 2014, 2019).

A diverse body of evidence including hoards, burials and settlement sites suggests that, like *PenG4* further south, *NG3* might straddle the Final Eneolithic and initial Early Bronze Age. The evidence is circumstantial but coherent. Within the Remedello Sopra hoard, which de Marinis (2012: 218) dates to the Early Bronze Age, phase IA, typical Early Bronze Age axes (fig. 10.36-37) sit alongside implements of older tradition, such as two fully flanged axes not too dissimilar to the Similaun type (fig. 10.35; see also Carancini and Peroni 1999; de Marinis 1979, 2012). Further west, a trench grave from Alba-via Bubbio has yielded a fragmentary Lussan-type dagger radiocarbon dated to 2200-2040 cal. BC (Venturino *et alii* 2018: 17-18, fig. 4) (fig. 10.34). The object's shape and features are reminiscent of Early Bronze Age metals, as is fitting considering its chronology. Similar daggers are found at Gaudello, Naples, alongside Final Eneolithic Ortucchio-style pottery (see above). Overall, the evidence suggests that the transition from the Eneolithic to the Bronze Age was not abrupt, for older and newer metallurgical practices would have coexisted side by side for some time, as one expects they would.

RADIOCARBON DATING AND BAYESIAN ANALYSIS

The chronology of northern and peninsular groupings proposed above is strengthened and detailed by the re-examination of 32 radiocarbon dates from the literature (table 15). We have considered 25 AMS dates from short-lived human bone samples that are directly associated to metal objects in burials. Most dates are from articulated burials where one-phase associations between human remains and objects are either demonstrated or extremely likely (see Dolfini 2006, 2010 for discussion). Four dates are from collective burials where bone and metals are not securely linked. Two dates from Lunghezzina, t. 3, and Torre della Chiesaccia, t. 15, are from charcoal (Anzidei and Carboni 2020b). The former dates the burial chamber and should therefore be considered a *post quem* for the grave goods, whereas the latter is from a layer dating the chamber's latest utilisation and should be taken as an *ante quem* for the objects. One date is a combination of four AMS dates taken from the Iceman's axe shaft (Kaufmann 2014: fig. 10) (fig. 12).

Most dates listed in table 15 cluster from 3650-2700 BC; this reflects the nature of the evidence, as individual metal-rich burials are more common in the Early/Middle Eneolithic than later, especially in west-central Italy. In general, metals are less visible archaeologically in the 3rd millennium BC, hence our greater reliance on *comparanda* in dating later groupings. No dates are available for the Neolithic beginnings of the sequence. Here, uncertainties persist about the chronology of specific object types as well as when exactly metal

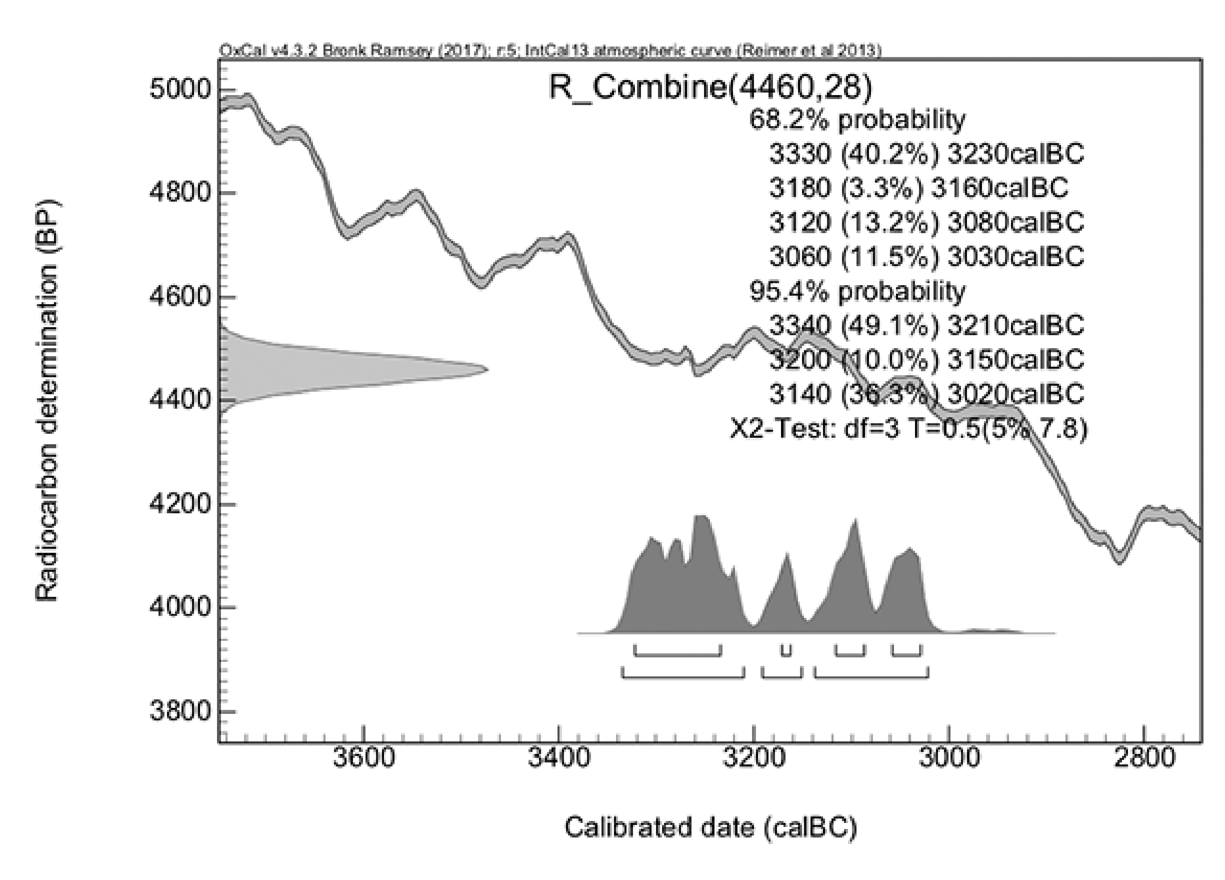


Fig. 12 - Combined calibration plot of four AMS radiocarbon dates taken from the Iceman's axe shaft (data from Kaufmann 2014: fig. 10).
Grafico di calibrazione che combina quattro date radiocarboniche AMS dall'impugnatura dell'ascia di Ötzi (dati da Kaufmann 2014: fig. 10).

axes were first imported (or made) south of the Alps. Based on the available evidence, we presume that this is no earlier than 4500 BC and no later than 4200 BC (Artioli *et alii* 2020; Dolfini 2013b, 2014).

To supplement the literature and strengthen our chronology, we performed fresh AMS dates from Grotta della Spinosa, a burial cave from southern Tuscany. Here, the archaeological deposit comprises a partly undisturbed Eneolithic layer some 25-35 cm thick, which contains several dozen disarticulated and fragmented burials and objects, including a Remedello dagger, type I (fig. 8.2; Suppl. mat. plate 9.11). Another Remedello dagger, type I (Suppl. mat., plate 9.8), was recovered from the disturbed deposit nearby (Aranguren 2006; Aranguren, Guidi, Iardella 2004). One of these authors (AD) suggested that the dagger from the intact deposit dates to the late 4th millennium BC owing to four radiocarbon dates from nearby human remains (Dolfini 2010). This contradicts conventional wisdom that all Remedello-type daggers date to *c.*2900-2500 BC (de Marinis 1997). Dolfini's proposal was contested on the grounds that no secure linkages between radiocarbon-dated bones and objects could be discerned in the commingled burial deposit (de Marinis 2013: 327; Valzolgher 2014).

To resolve the controversy, we took 12 new samples of human remains from the Eneolithic layer, forming a near-continuous sequence. We sent the samples to Beta Analytic for preparation and AMS dating. The new dates agree with the previous in showing that the site was utilised for burial in the late 4th and initial 3rd millennia BC (table 16). Notably, both old and new dates (16 overall) form an internally coherent sequence, showing that (a) the cave's frequentation lasted no more than 350 years, and probably less than that (see below); and (b) both daggers must have been deposited at this time. This buttresses our view that Remedello daggers, type I, belong to

SITE – GRAVE – BURIAL	BURIAL TYPE	LAB CODE	SAMPLE	AGE BP	68.3% confidence	95.4% confidence	LITERATURE
Ponte San Pietro (Ischia di Castro, ViterboT), T.21, PSP IV.1bis (male)	Double burial	OxA-18217	Human fibula	4872 ± 35	3700 - 3630	3750 - 3530	Dolfini 2010
Ponte San Pietro (Ischia di Castro, Viterbo), T.20, PSP VII (female)	Double burial	LTL-213A	Human bone	4809 ± 60	3660 - 3520	3710 - 3370	Anzidei and Carboni 2020b
Casetta Mistici (Roma), T.6, burial A	Double burial	LTL-4802A	Human bone	4766 ± 45	3640 - 3520	3650 - 3370	Anzidei and Carboni 2020b
Casetta Mistici (Roma), T.8	Single burial	LTL-4804A	Human bone	4763 ± 50	3640 - 3520	3650 - 3370	Anzidei and Carboni 2020b
Lunghezzina (Roma) T.3	Single burial	OxA-8078	Charcoal (Acer sp.)	4740 ± 45	3640 - 3380	3640 - 3370	Anzidei and Carboni 2020b
Selvicciola (Ischia di Castro, Viterbo), T.23, burial H58	Multiple burial	GrA -16883	Human bone	4735 ± 40	3640 - 3380	3640 - 3370	Petitti *et alii* 2002, 2011
Selvicciola (Ischia di Castro, Viterbo), T.23, burial H59	Multiple burial	GrA -16885	Human bone	4730 ± 50	3640 - 3380	3640 - 3370	Petitti *et alii* 2002, 2011
Ponte San Pietro (Ischia di Castro, Viterbo), T.21, PSP IV.1	Double burial	OxA-18216	Human radius	4725 ± 33	3630 - 3380	3640 - 3370	Dolfini 2010
Selvicciola (Ischia di Castro, Viterbo), T.23, burial H57	Single burial in collective tomb	GrA -16882	Human bone	4715 ± 40	3630 - 3370	3640 - 3370	Petitti *et alii* 2002, 2011
Ponte San Pietro (Ischia di Castro, Viterbo), T.20, PSP VII (male)	Double burial	LTL-212A	Human bone	4693 ± 60	3630 - 3370	3640 - 3360	Anzidei and Carboni 2020b
Valle Anagnina (Sgurgola, Frosinone)	Single burial	LTL-4813A	Human bone	4677 ± 45	3520 - 3370	3630 - 3360	Anzidei and Carboni 2020b
Casetta Mistici (Roma), T.10	Single burial	LTL-14198A	Human bone	4667 ± 45	3520 - 3370	3630 - 3360	Anzidei and Carboni 2020b
Iceman, or Uomo del Similaun (Tisenjoch, Senales, Bolzano/Bozen)	Wooden shaft of the copper axe	Combined date	Wood	4460 ± 28	3330 - 3030	3340 - 3020	Kaufmann 2014
Remedello Sotto (Remedello, Brescia), T.106	Single burial	ETH-12182	Human skull	4485 ± 60	3340 - 3090	3370 - 2940	de Marinis 1997; de Marinis and Pedrotti 1997
Celletta dei Passeri (Forlì), T.75	Single burial	LTL-5748A	Human bones	4466 ± 40	3330 - 3030	3350 - 3010	Miari *et alii* 2017
Casetta Mistici (Roma), T.6, burial B	Double burial	LTL-4801A	Human bone	4448 ± 50	3330 - 3020	3340 - 2920	Anzidei and Carboni 2020b
Mirabella Eclano (Avellino), Tomba del Capo Tribù	Single burial	LYON-16357	Human bone	4400 ± 35	3090 - 2920	3310 - 2910	Anzidei and Carboni 2020b
San Biagio della Valle (Marsciano, Perugia)	Single burial	LTL-1783A	Human femur	4396 ± 60	3100 - 2910	3340 - 2900	Manfredini *et alii* 2009; Manfredini 2012
Celletta dei Passeri (Forlì), T.25	Single burial	OxA-31982	Human ulna	4374 ± 32	3020 - 2920	3090 - 2900	Miari *et alii* 2017
Torre della Chiesaccia (Roma), T.15	Double burial	LTL-2906A	Charcoal (*Prunus sp.)*	4369 ± 45	3030 - 2910	3270 - 2890	Anzidei and Carboni 2020b
Celletta dei Passeri (Forlì), T.27	Single burial	Oxa-31983	Human fibula	4365 ± 30	3020 - 2920	3090 - 2900	Miari *et alii.* 2017
Remedello Sotto (Remedello, Brescia), T.83	Single burial	OxA-29927	Diaphysis humerus	4364 ± 29	3020 - 2920	3090 - 2900	Valzolgher 2014
Remedello Sotto (Remedello, Brescia), T.78	Single burial	OxA-29926	Human bone	4352 ± 28	3020 - 2910	3090 - 2900	Valzolgher 2014
Romanina (Roma), T.14	Multiple burial	LTL-5369A	Human bone	4334 ± 45	3020 - 2900	3100 - 2880	Anzidei and Carboni 2020b
Porcareccia (Pitigliano, Grosseto), T.4, burial POR.IV,3	Multiple burial	LTL-12531	Human tibia	4323 ± 45	3020 - 2890	3090 - 2880	Negroni *et alii* 2014
Celletta dei Passeri (Forlì), T.47	Single burial	LTL-5078A	Human bone	4249 ± 50	2920 - 2710	3010 - 2660	Miari *et alii* 2017

Casetta Mistici (Roma), via Esperide, T.7	Single burial	LTL-15364A	Human bone	4241 ± 45	2910 - 2750	2930 - 2660	Anzidei and Carboni 2020b
Romanina (Roma), T.14	Multiple burial	LTL-14203A	Human bone	4220 ± 45	2900 - 2700	2920 - 2660	Anzidei and Carboni 2020b
Selvicciola (Ischia di Castro, Viterbo), T.15, burial H29	Single burial in collective tomb	OZC-175	Human bone	4194 ± 42	2890 - 2690	2900 - 2630	Conti *et alii* 1997
Celletta dei Passeri (Forlì), T.64	Single burial	LTL-5079A	Human bone	4158 ± 50	2880 - 2670	2890 - 2580	Miari *et alii* 2017
Remedello Sotto (Remedello, Brescia), T. BSII	Single burial	ETH-6196	Human calcaneum	4070 ± 70	2860 - 2490	2880 - 2470	Biagi 1991; de Marinis and Pedrotti 1997
Alba, via Bubbio (Alba)	Single burial	OZE-577	Human tibia	3728 ± 29	2200 - 2040	2210 - 2030	Venturino *et alii* 2018

Table 15 - Radiocarbon dates from the literature selected for the research. Most dates are from human tissue samples that are directly associated to metal objects in single-phase burials. Dates BP were calibrated using OxCal 4.3.2 (Bronk Ramsey 2017); curve resolution: 5; atmospheric curve: IntCal13 (Reimer et alii 2013). The date from the Iceman, or *Uomo del Similaun*, is a combination of four AMS dates taken from the axe shaft (see fig. 12).
Date radiocarboniche dalla letteratura selezionate per questa ricerca. Gran parte delle date derivano da campioni di tessuto umano direttamente associate a oggetti in metallo in sepolture di fase singola. Le date BP sono state calibrate utilizzando OxCal 4.3.2 (Bronk Ramsey 2017); risoluzione della curva: 5; curva atmosferica: IntCal13 (Reimer et alii 2013). La data ricavata da Iceman, o Uomo del Similaun, risulta della combinazione di quattro date AMS ottenute dall'impugnatura dell'ascia (si veda fig. 12).

the Middle Eneolithic, *c*.3350-2900 BC. Remedello daggers, types II and III, were seemingly used for a longer timespan straddling the Middle and Late Eneolithic (see *NG2* and *NG3* above).

To verify that northern and peninsular groupings formed a coherent chronological sequence, we applied Bayesian statistical analysis to the 32 AMS dates listed in table 15. We modelled the dates using OxCal 4.3.2 and the IntCal13 calibration curve (Bronk Ramsey 2009; Hamilton and Krus 2018). The model is presented in table 17 and fig. 13. The *prior beliefs* constraining the sequence are that groupings *PenG1-4* and *NG1-3* can be arranged into four metallurgical horizons (numbered from 2-5) covering the entire Eneolithic sequence. Horizon 1, *c*.4500-3650 BC, was not included in the exercise as no radiocarbon dates are yet available for it. Since horizons 2-5 are not defined stratigraphically (as they comprise multiple sites and contexts), the assemblages defining them were organised based on radiocarbon dating, typological considerations, and crosslinks, as discussed above.

The Bayesian model is grounded in the assumption that dated events are uniformly spread within phases. For the analysis, we used a contiguous variant of the model postulating that the horizons follow one another without gaps. However, upon modelling the late 3rd millennium date from Alba-via Bubbio, a large gap does emerge between Horizons 4 and 5 after 2700/2600 BC (table 17; fig. 13). This is due to the dearth of radiocarbon dates in Horizon 5. The model displays an overall *agreement index* (*Amodel*) of 100.1 %, confirming its consistency.

Horizons 2-5 have yielded the following probability ranges at 68.3% confidence (dates are rounded to the next 10 years):

- *Metallurgical horizon 2* (Early Eneolithic): between 3700/3630 and 3520/3370 cal. BC
- *Metallurgical horizon 3* (Middle Eneolithic): between 3340/3090 and 3020/2890 cal. BC
- *Metallurgical horizon 4* (Late Eneolithic): between 2920/2710 and 2880/2670 cal. BC
- *Metallurgical horizon 5* (Final Eneolithic - Early Bronze Age 1a): 2200-2040 cal. BC

To fill the gap inherent in the Bayesian model, we propose placing the transition between Horizons 4 and 5 at 2700/2600 BC. Further research is needed to validate the proposal.

We also applied Bayesian statistics to the 16 radiocarbon dates taken from Grotta della Spinosa (table 16). All 16 dates were arranged according to a 'bounded phase model' (Hamilton and Krus 2018: 197) giving a reliable agreement index (*Amodel*) of 89.2% (see plot in fig. 14). Thus modelled, the dates range from 3250-2910 cal. BC at 68.3% confidence, strengthening our view that the cave was solely used as a burial place in the Middle Eneolithic.

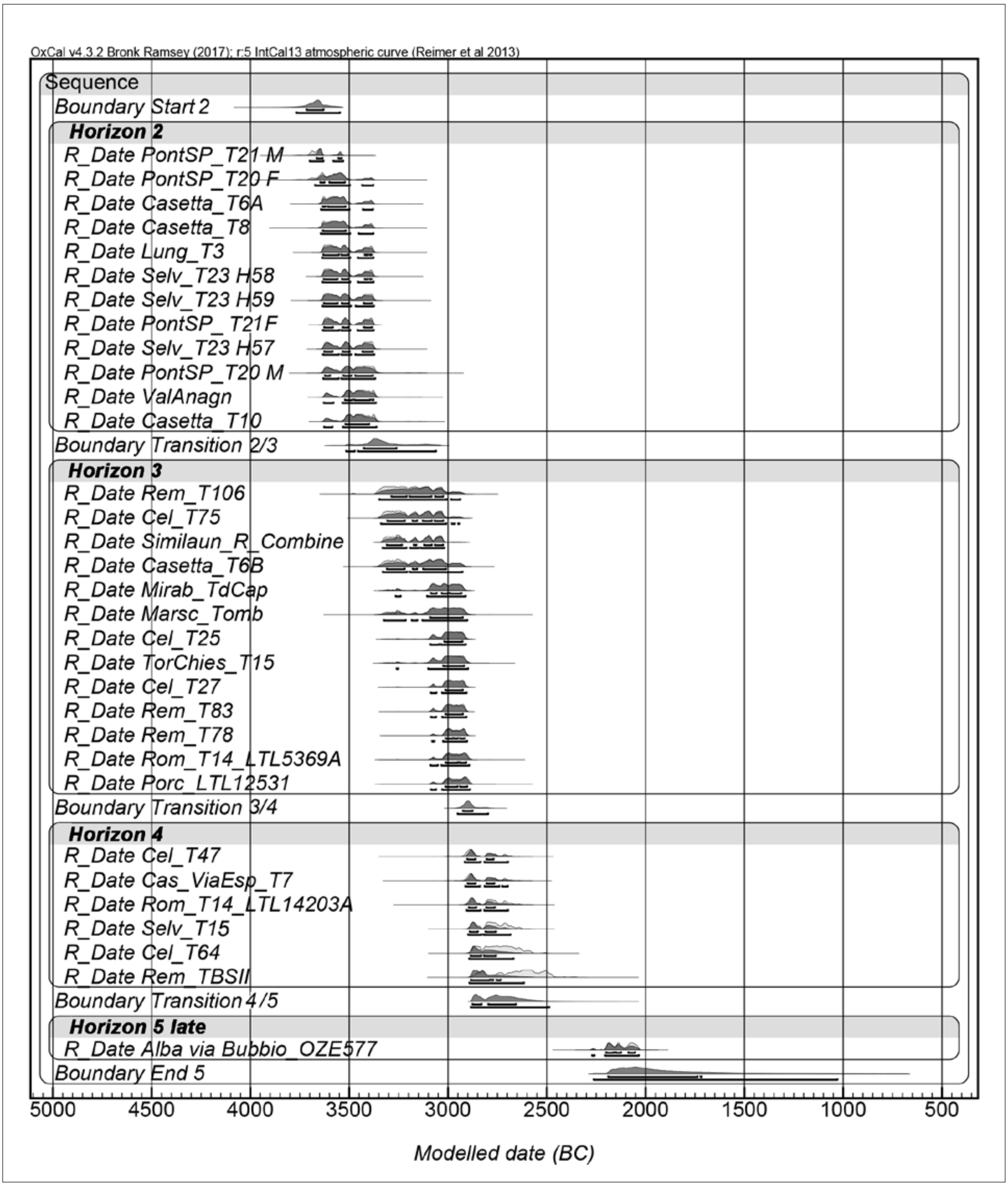


Fig. 13 - Bayesian modelling of the 32 AMS radiocarbon dates listed in table 15, showing four of the five metallurgical horizons discussed in the article. The modelled dates are listed in table 17. The model was developed with OxCal 4.3.2 (Bronk Ramsey 2017); curve resolution: 5; atmospheric curve IntCal13 (Reimer *et alii* 2013). Calibrated dates are light grey while posterior density estimates are dark grey. Overall Agreement index (*Amodel):* 100.1 %. Individual agreement index in table 17.

Modellizzazione Bayesiana delle 32 date radiocarboniche AMS elencate nella tabella 15, che mostra quattro dei cinque orizzonti metallurgici trattati nel testo. Le date modellizzate sono elencate nella tabella 17. Il modello è stato sviluppato con OxCal 4.3.2 (Bronk Ramsey 2017); risoluzione della curva: 5; curva atmosferica IntCal13 (Reimer et alii 2013). Le date calibrate sono in grigio chiaro mentre le stime della densità a posteriori sono in grigio scuro. Indice di accordo complessivo (Amodel): 100.1 %. L'indice di accordo individuale è nella tabella 17.

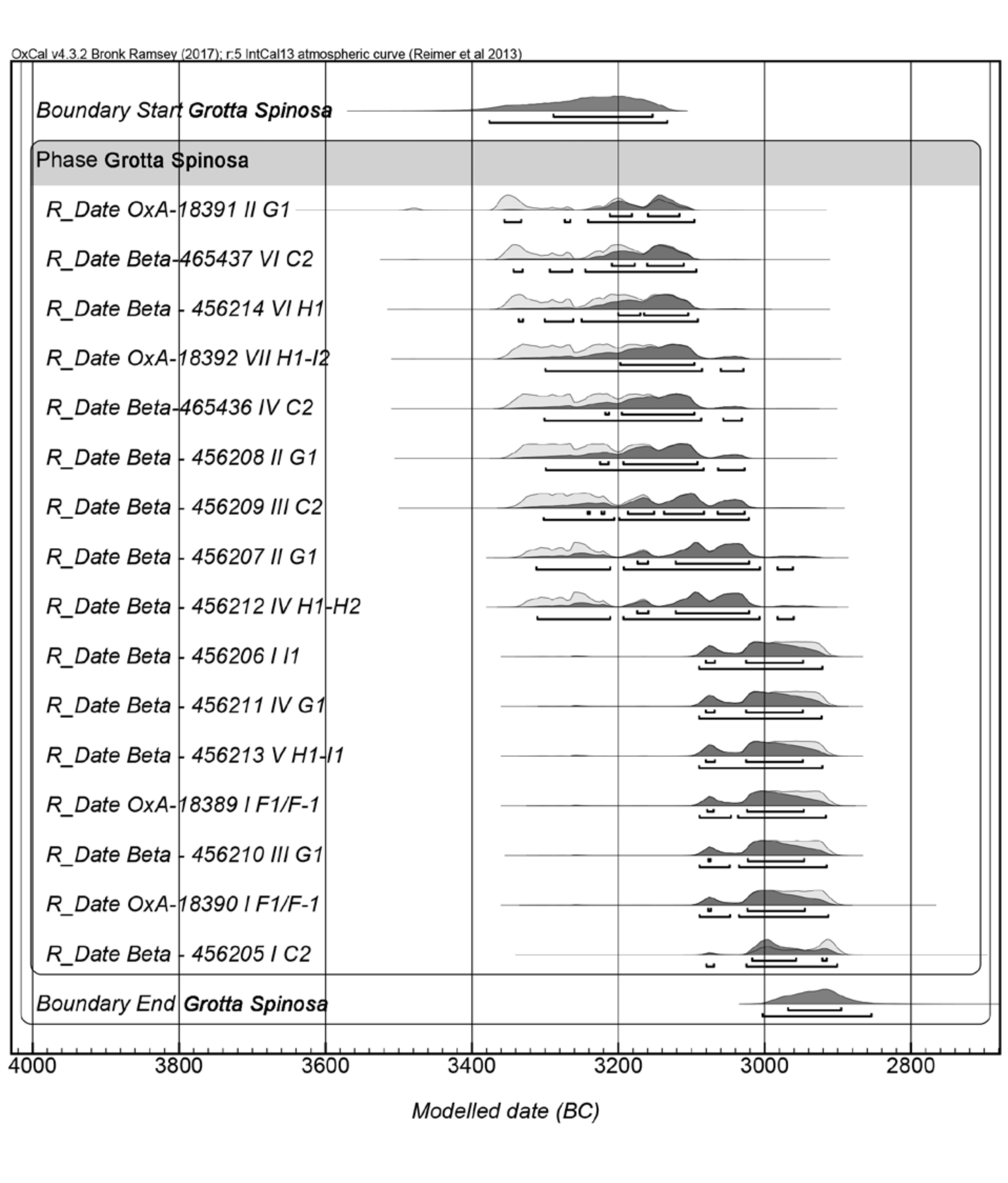


Fig. 14 - Bayesian modelling of the 16 AMS radiocarbon dates from Grotta della Spinosa listed in table 16. The model strengthens and confirms these authors' proposal that the site was solely utilised for burial in the late 4th and initial 3rd millennia BC. The model also provides a chronology for the two Remedello daggers, type I, from the site. The model was developed with OxCal 4.3.2 (Bronk Ramsey 2017); curve resolution: 5; atmospheric curve IntCal13 (Reimer *et alii* 2013). Calibrated dates are light grey, while posterior density estimates are dark grey. Overall Agreement index (*Amodel):* 89.2%. Individual Agreement index in table 16.

Modellizzazione Bayesiana delle 16 date radiocarboniche AMS dalla Grotta della Spinosa, elencate nella tabella 16. Il modello rafforza e conferma la proposta degli autori che il sito fu utilizzato esclusivamente a fini sepolcrali nel tardo IV e all'inizio del III millennio BC. Esso fornisce altresì una cronologia per i due pugnali Remedello tipo I, in esso rinvenuti. Il modello è stato sviluppato con OxCal 4.3.2 (Bronk Ramsey 2017); risoluzione della curva: 5; curva atmosferica IntCal13 (Reimer et alii 2013). Le date calibrate sono in grigio chiaro mentre le stime della densità a posteriori sono in grigio scuro. Indice di accordo complessivo (Amodel): 89.2%. L'indice di accordo individuale è nella tabella 16.

Lab code + sublayer + square	Sample	Age BP	∂13C	Calibrated dates 68.3% probability	Calibrated dates 95.4% probability	*Posterior distribution (cal. BC) 68.3% probability*	*Posterior distribution (cal. BC) 95.4% probability*	Agreement index	Literature
OxA-18391 II G1	Tibia	4555 ± 34	-19,3	3370 - 3120	3490 - 3100	*3220 - 3110*	*3360 - 3090*	90.7	Dolfini 2010
Beta-465437 VI C2	Long bone	4530 ± 30	-23,6	3360 - 3110	3370 - 3100	*3210 - 3110*	*3350 - 3090*	104	Unpublished
Beta - 456214 VI H1	Humerus	4520 ± 30	-19,7	3350 - 3110	3360 - 3100	*3210 - 3100*	*3340 - 3090*	104.9	Unpublished
OxA-18392 VII H1-I2	Humerus	4503 ± 33	-19,6	3340 - 3100	3360 - 3090	*3200 - 3090*	*3300 - 3020*	99.4	Dolfini 2010
Beta-465436 IV C2	Long bone	4500 ± 30	-19,7	3340 - 3100	3350 - 3090	*3220 - 3090*	*3310 - 3030*	98.8	Unpublished
Beta - 456208 II G1	Humerus	4490 ± 30	-19,9	3340 - 3100	3350 - 3090	*3230 - 3090*	*3300 - 3020*	94.1	Unpublished
Beta - 456209 III C2	Tibia	4470 ± 30	-19,6	3330 - 3090	3340 - 3020	*3250 - 3020*	*3310 - 3020*	89.1	Unpublished
Beta - 456207 II G1	Femur	4450 ± 30	-19,5	3320 - 3020	3340 - 2940	*3180 - 3020*	*3320 - 2960*	101.2	Unpublished
Beta - 456212 IV H1-H2	Femur	4450 ± 30	-19,4	3320 - 3020	3340 - 2940	*3180 - 3020*	*3320 - 2960*	101	Unpublished
Beta - 456206 I I1	Femur	4380 ± 30	-19,5	3020 - 2920	3090 - 2910	*3090 - 2940*	*3090 - 2920*	98.6	Unpublished
Beta - 456211 IV G1	Tibia	4380 ± 30	-20,1	3020 - 2920	3090 - 2910	*3090 - 2940*	*3090 - 2920*	98.5	Unpublished
Beta - 456213 V H1-I1	Humerus	4380 ± 30	-19,8	3020 - 2920	3090 - 2910	*3090 - 2940*	*3090 - 2920*	98.5	Unpublished
OxA-18389 I F1/F-1	Rib	4371 ± 32	-19,6	3020 - 2920	3090 - 2900	*3080 - 2940*	*3090 - 2910*	98.3	Dolfini 2010
Beta - 456210 III G1	Ulna	4370 ± 30	-19,6	3020 - 2920	3090 - 2900	*3080 - 2940*	*3090 - 2910*	98.1	Unpublished
OxA-18390 I F1/F-1	Vertebra	4364 ± 33	-20	3020 - 2920	3090 - 2900	*3080 - 2940*	*3090 - 2910*	97.9	Dolfini 2010
Beta - 456205 I C2	Femur?	4330 ± 30	-19,8	3010 - 2890	3020 - 2890	*3020 - 2910*	*3080 - 2900*	79.1	Unpublished

Table 16 - Radiocarbon dates from Grotta della Spinosa, Massa Marittima, Tuscany. The human tissue samples that have yielded the dates were taken from a near-continuous sequence of spits (or arbitrarily assigned sublayers) cutting through the Eneolithic burial deposit. The table lists both calibrated and Bayesian-modelled dates. See fig. 14 for the Bayesian model. Calibrations and posterior density estimates were calculated using OxCal 4.3.2 (Bronk Ramsey 2017); curve resolution: 5; atmospheric curve: IntCal13 (Reimer *et alii* 2013). Calibration ranges are rounded to the next 10 years.
Date radiocarboniche dalla Grotta della Spinosa, Massa Marittima, Toscana. I campioni di tessuto umano che hanno fornito le date sono stati prelevati da una sequenza pressoché continua di tagli (o sottolivelli attribuiti arbitrariamente) effettuati attraverso il deposito funerario eneolitico. La tabella elenca date calibrate e date con modellizzazione Bayesiana. Si veda la fig. 14 per il modello Bayesiano. Le calibrazioni e le stime della densità a posteriori sono state calcolate utilizzando OxCal 4.3.2 (Bronk Ramsey 2017); risoluzione della curva: 5; curva atmosferica: IntCal13 (Reimer et alii 2013). I parametri di calibrazione sono approssimati ai 10 anni.

A New Metallurgical Sequence for Prehistoric Italy, 4500-2100 BC

The classification, grouping and dating of early Italian metals outlined above has enabled these authors to propose an original sequence of five metallurgical horizons, which we present below. Boundary dates are rounded to the next 50 years (table 18; fig. 15).

Horizon 1 (Late and Final Neolithic), 4500 - 3650 BC

Horizon 1 comprises Neolithic metal objects including copper-alloy awls, axes, and a few ornaments (e.g. rings). The horizon is entirely dated through *comparanda* and contextual considerations. The earliest metal awls from Italy are radiocarbon dated to 4500-4350 BC (Mazzieri and Dal Santo 2007; Visentini 2005), but it is presently unclear if axes are this old. By 4200-3800 BC, however, several axe types circulated across the region. Most Neolithic metals characterised to

Site – grave – burial	Lab code	Date BP	Calibrated dates		Posterior distribution (cal. BC)		Agreement index	Horizon
			68.3% confidence	95.4% confidence	68.3% confidence	95.4% confidence		
Ponte S. Pietro, T.21, Male	OxA-18217	4872 ± 35	3700 - 3630	3750 - 3530	3670 - 3530	3700 - 3530	85.4	2
Ponte S. Pietro, T.20, Female	LTL-213A	4809 ± 60	3660 - 3520	3710 - 3370	3650 - 3520	3680 - 3370	106.3	2
Casetta Mistici, T.6A	LTL-4802A	4766 ± 45	3640 - 3520	3650 - 3370	3640 - 3510	3650 - 3380	101.2	2
Casetta Mistici, T.8	LTL-4804A	4763 ± 50	3640 - 3520	3650 - 3370	3640 - 3510	3650 - 3370	101.4	2
Lunghezzina, T.3	OxA-8078	4740 ± 45	3640 - 3380	3640 - 3370	3640 - 3380	3640 - 3370	99.9	2
Selvicciola, T.23, H58	GrA -16883	4735 ± 40	3640 - 3380	3640 - 3370	3630 - 3380	3640 - 3370	99.5	2
Selvicciola, T.23, H59	GrA -16885	4730 ± 50	3640 - 3380	3640 - 3370	3630 - 3380	3640 - 3370	99.6	2
Ponte S. Pietro, T.21, Female	OxA-18216	4725 ± 33	3630 - 3380	3640 - 3370	3630 - 3380	3640 - 3370	98.5	2
Selvicciola, T.23, H57	GrA -16882	4715 ± 40	3630 - 3370	3640 - 3370	3630 - 3380	3640 - 3370	98.5	2
Ponte S. Pietro, T.20, Male	LTL-212A	4693 ± 60	3630 - 3370	3640 - 3360	3630 - 3380	3640 - 3370	100	2
Valle Anagnina	LTL-4813A	4677 ± 45	3520 - 3370	3630 - 3360	3530 - 3370	3630 - 3360	98.6	2
Casetta Mistici, T.10	LTL-14198A	4667 ± 45	3520 - 3370	3630 - 3360	3520 - 3400	3630 - 3360	99.1	2
Remedello Sotto, T.106	ETH-12182	4485 ± 60	3340 - 3090	3370 - 2940	3290 - 3020	3350 - 2930	96.1	3
Celletta dei Passeri, T.75	LTL-5748A	4466 ± 40	3330 - 3030	3350 - 3010	3310 - 3020	3350 - 2940	96.2	3
Iceman (Similaun), axe shaft	Combined date	4460 ± 28	3330 - 3030	3340 - 3020	3310 - 3020	3340 - 3020	97.2	3
Casetta Mistici, T.6B	LTL-4801A	4448 ± 50	3330 - 3020	3340 - 2920	3310 - 3010	3340 - 2920	99.9	3
Mirabella Eclano, Tomba del Capo Tribù	LYON-16357	4400 ± 35	3090 - 2920	3310 - 2910	3090 - 2930	3270 - 2910	101.9	3
San Biagio della Valle	LTL-1783A	4396 ± 60	3100 - 2910	3340 - 2900	3100 - 2920	3330 - 2900	104.8	3
Celletta dei Passeri, T.25	OxA-31982	4374 ± 32	3020 - 2920	3090 - 2900	3020 - 2920	3090 - 2900	100.5	3
Torre della Chiesaccia, T.15	LTL-2906A	4369 ± 45	3030 - 2910	3270 - 2890	3030 - 2910	3270 - 2890	101.9	3
Celletta dei Passeri, T.27	Oxa-31983	4365 ± 30	3020 - 2920	3090 - 2900	3020 - 2920	3090 - 2900	100.5	3
Remedello Sotto, T.83	OxA-29927	4364 ± 29	3020 - 2920	3090 - 2900	3020 - 2920	3090 - 2900	100.4	3
Remedello Sotto, T.78	OxA-29926	4352 ± 28	3020 - 2910	3090 - 2900	3020 - 2910	3090 - 2900	99.8	3
Romanina, T.14	LTL-5369A	4334 ± 45	3020 - 2900	3100 - 2880	3020 - 2900	3090 - 2890	99.2	3
Porcareccia, T.4, POR. IV,3	LTL-12531	4323 ± 45	3020 - 2890	3090 - 2880	3020 - 2900	3090 - 2880	96.7	3
Celletta dei Passeri, T.47	LTL-5078A	4249 ± 50	2920 - 2710	3010 - 2660	2910 - 2770	2920 - 2770	112.1	4
Casetta Mistici – Via Esperide, T.7	LTL-15364A	4241 ± 45	2910 - 2750	2930 - 2660	2910 - 2760	2910 - 2770	110.1	4
Romanina, T.14	LTL-14203A	4220 ± 45	2900 - 2700	2920 - 2660	2900 - 2760	2910 - 2760	113.7	4
Selvicciola, T.15, H29	OZC-175	4194 ± 42	2890 - 2690	2900 - 2630	2890 - 2750	2910 - 2760	109.2	4
Celletta dei Passeri, T.64	LTL-5079A	4158 ± 50	2880 - 2670	2890 - 2580	2890 - 2750	2910 - 2760	103.2	4
Remedello Sotto, T. BSII	ETH-6196	4070 ± 70	2860 - 2490	2880 - 2470	2890 - 2730	2880 - 2500	78.8	4
Alba, via Bubbio	OZE-577	3728 ± 29	2200 - 2040	2210 - 2030	2200 - 2050	2280 - 2030	97.2	5

Table 17 - Bayesian statistical modelling of the radiocarbon dates listed in table 15 (Bronk Ramsey 2009; Hamilton and Krus 2018). The modelling helped to define a sequence of metallurgical horizons charting the evolution of metal technology and object design in Eneolithic Italy. Calibrated and modelled BC dates were calculated using OxCal 4.3.2 (Bronk Ramsey 2017); curve resolution: 5; atmospheric curve: IntCal13 (Reimer *et alii* 2013). Calibration ranges are rounded to the next 10 years.
Modellizzazione statistica Bayesiana delle date radiocarboniche riportate nella tabella 15 (Bronk Ramsey 2009; Hamilton e Krus 2018). La modellizzazione ha contribuito a definire una sequenza di orizzonti metallurgici che tracciano l'evoluzione della tecnologia dei metalli e della ideazione degli oggetti nell'Eneolitico in Italia. Le date BC calibrate e modellizzate sono state calcolate impiegando OxCal 4.3.2 (Bronk Ramsey 2017); risoluzione della curva: 5; curva atmosferica: IntCal13 (Reimer et alii 2013). I parametri di calibrazione sono approssimati ai 10 anni.

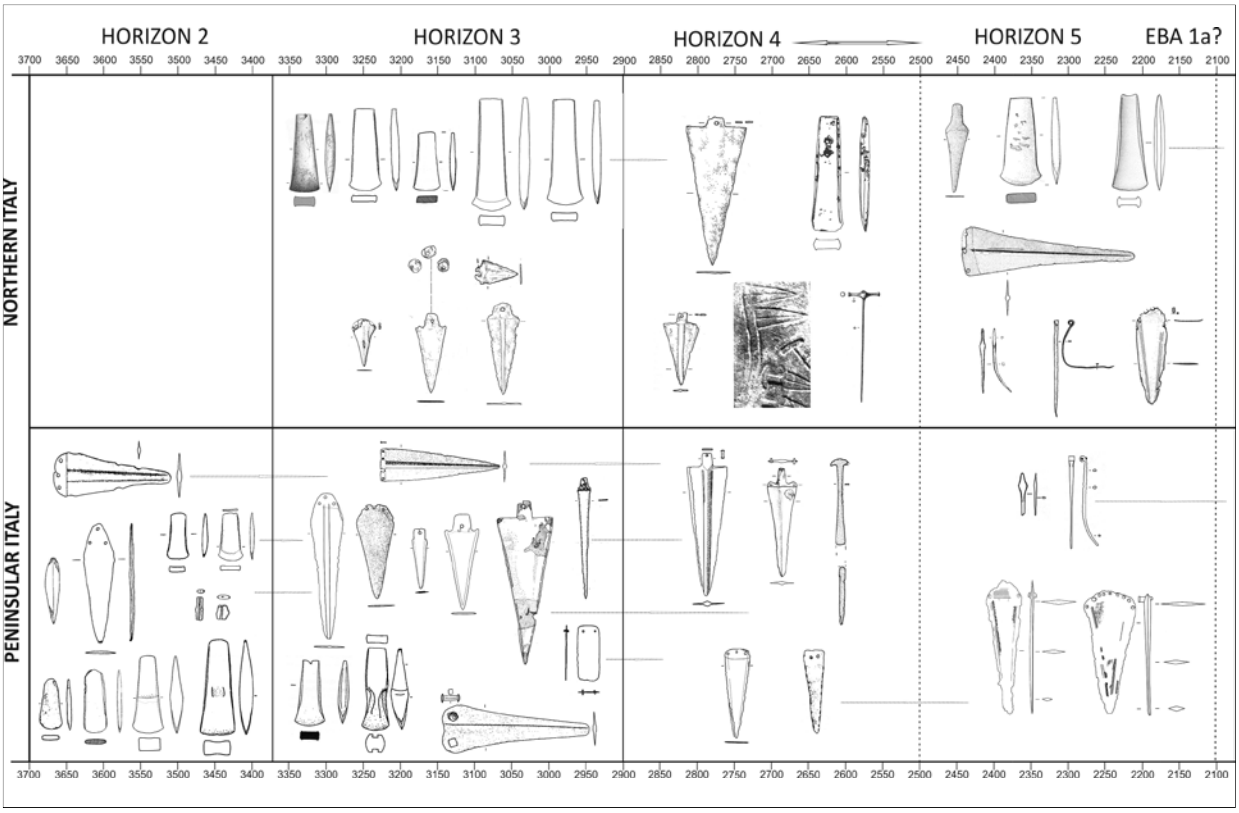


Fig. 15 - Synopsis of the main metal object types characterising Horizons 2-5 in northern and peninsular Italy. Drawings are not to scale.
Quadro sinottico dei principali tipi di oggetti metallici che caratterizzano gli Orizzonti 2-5 nell'Italia settentrionale e peninsulare. Disegni non in scala.

ARCHAEOLOGICAL PHASE	DATES BC	GROUPING (NORTH)	GROUPING (PENINSULA)	METALLURGICAL HORIZON
LATE/FINAL NEOLITHIC (Neolitico Recente/Finale)	4500 – 3650	NeoG	NeoG	1
EARLY ENEOLITHIC (Eneolitico Antico)	3650 – 3350	–	PenG1	2
MIDDLE ENEOLITHIC (Eneolitico Medio)	3350 – 2900	NG1	PenG2-3	3
LATE ENEOLITHIC (Eneolitico Recente)	2900 – 2700/2600	NG2	PenG3	4
FINAL ENEOLITHIC (Eneolitico Finale)	2700/2600 – 2100	NG3	PenG4	5

Table 18 - Synoptic table of archaeological phases, northern Italian and peninsular groupings, and metallurgical horizons as discussed in the article.
Tabella sinottica delle fasi archeologiche, raggruppamenti dell'Italia settentrionale e peninsulare, e orizzonti metallurgici trattati nel testo.

date bear lead isotope signatures compatible with Balkan sources, suggesting importation from this area (Artioli *et alii* 2020). This strengthens the model of the spread of metallurgical knowledge proposed by Dolfini (2013a).

Unlike later horizons, all axes from both northern and peninsular Italy cluster into common subclasses and types based on shared techno-morphological traits. This indicates that Late/Final Neolithic communities partook in wide-ranging communication dynamics enabling the unfettered sharing of artefacts and ideas. This is unsurprising considering that Lipari obsidian and Alpine greenstone circulated over long distances (Dolfini 2020, with references). This state of affairs was not meant to last, however. By the mid-4th millennium BC, northern Italy and the peninsula had gone their own separate ways in the realm of metal production, exchange, and usage.

Horizon 2 (Early Eneolithic) 3650 - 3350 BC

Horizon 2 marks the beginning of the Eneolithic metallurgical sequence in peninsular Italy. The horizon is well defined both archaeologically and radiometrically. Modelled dates provide a probability range between the intervals 3700/3630 BC for the upper boundary and 3520/3370 BC for the lower boundary, rounded here to 3650-3350 BC for the whole range. The horizon comprises peninsular grouping *PenG1* (table 18).

Horizon 2 marks the rise of technologically advanced copper, silver, and antimony extraction and working in the west-central peninsula. It also marks the earliest deposition of metals in Rinaldone-style burials, defining funerary identities in strikingly new ways (Dolfini 2022; Robb 2007). Several axe types bearing new typological and technological traits were first made in this period, as well as daggers and, most probably, halberds (Horn 2014). Object morphology highlights instances of long-distance communication with the northern Alps and eastern Europe, for example in the Guardistallo-Cucuteni/Mondsee daggers and certain axe types akin to Mondsee-Pfyn and Carpathian exemplars (see *PenG1* above). This sharply contrasts with lead isotope data indicating that central Italy partook in westward-looking copper exchange networks (Dolfini-Angelini-Artioli 2020). The puzzle is complicated by the lack of metals from northern Italy (see below).

By the mid-4th millennium BC, the coppersmiths of west-central Italy had effected a remarkable step-change in casting and working technology compared to their Neolithic forebears. This is highlighted by the disappearance of coarse and wrinkled axes, which were then superseded by smooth-surfaced axes and adzes and thin daggers and halberds. Smiths consciously selected different alloys to make different objects: they mostly made axes/adzes from low-impurity copper and daggers/halberds from an alloy enriched by arsenic and antimony, ensuring greater castability and strength (de Marinis 2006; Dolfini 2014). Craftspeople’s skill, object design, and intended uses all contributed to technological choices (Kuijpers 2018; Nørgaard 2018). This can be appreciated in the use of either monovalve or bivalve moulds depending on object shape and function (Iaia, Dolfini 2020). Woodworking traces and combat marks suggest that metals were often used as working tools and weapons (Dolfini 2011).

Horizon 2 is solely found in the west-central peninsula. This is where the copper sources lie and most metal was arguably cast and worked. A handful of objects from east-central and southern Italy might belong to this period, but they are few and poorly dated. Virtually no metals are recorded in northern Italy. This is an original and, indeed, unexpected finding of the research, which was hidden by the coarser-grained chronologies hitherto available. Further research is needed to clarify why budding Neolithic metallurgy vanished north of the Apennines while it boomed further south. We tentatively propose that this might either be a visibility bias due to the prevalence of collective burial (not dictating the use of metalwork to define individual identities) or a real hiatus in metal production, perhaps motivated by a dearth of oxidised ores in the southern Alps.

Horizon 3 (Middle Eneolithic): 3350 - 2900 BC

The boundary between Horizons 2 and 3 falls between the modelled ranges 3520/3370 and 3340/3090 for the upper boundary (68.3%), rounded here to 3350 BC. The calibration ranges of most dates stretch to *c.*2900 BC, providing a lower boundary for the horizon. Horizon 3 ostensibly covers a 450-year-long timespan, although its length might be a function of the notorious late 4th millennium calibration plateau (Meadows *et alii* 2020). The horizon is defined by several metal-rich burials and radiocarbon dates including those from Grotta della Spinosa (table16). It comprises assemblage groupings *PenG2,* part of *PenG3* and *NG1* (table18).

Horizon 3 marks a new dawn in metalwork production and consumption all over Italy, with the possible exception the Adriatic coast and the far south. It also marks the birth of regionally differentiated technological styles that came to define ‘classic’ funerary traditions in Eneolithic Italy, e.g. Remedello and Gaudo. The coppersmiths of west-central Italy probably played a key role in transmitting metallurgical knowledge at the onset of Horizon 3. Though initially imported, the craft rapidly took hold both north and south, initiating long-lasting regional metalworking traditions (Dolfini 2014). New object types were also manufactured in west-central Italy (e.g. Massa Marittima-type daggers), suggesting continuing technological development in the birthplace of Italian metallurgy.

Remarkably, west-central Italy witnessed at this time the emergence of a new metallurgical style, akin yet subtly different to 'Rinaldone metallurgy'. It comprises Remedello- and Fontino-type daggers and Arco- and Fontino-type halberds, which are extremely rare in Rinaldone-style burials (fig. 15). These objects are overwhelmingly found in the collective burial caves of coastal Tuscany. Specialists of Eneolithic Italy have long noted differences in funerary behaviour and material culture in coastal vs inner Tuscany and northern Latium (Cocchi Genick and Grifoni Cremonesi 1989; Vigliardi 2002; Cocchi Genick 2011). We now add metalwork production and consumption to these differences. This strengthens the case for partly independent connectivity networks in the two areas, which might have encouraged different forms of collective identity to take hold. The copper metal, however, seemingly flowed freely between the two areas (Dolfini-Angelini-Artioli 2020).

In southwest Italy, metal objects were mainly placed in Gaudo-style chamber tombs. Funerary behaviour displays remarkable similarities with the Rinaldone burial tradition, e.g. in using weapons and tool/weapons to define male interments (Bailo Modesti and Salerno 1998; Anzidei and Carboni 2020b). Objects include Remedello- and Buccino-type daggers, Arco-type halberds, and massive flanged axes of the Mirabella Eclano type, which a radiocarbon date from *Tomba del Capo Tribù* ascribes to this period (table 3; fig. 15)[8]. 'Gaudo metallurgy' displays notable differences, as well as similarities, with the west-central peninsula (see *PenG3A* and *PenG3B* above). Both may be explained by postulating that wide-ranging connectivity networks would co-exist with local production and circulation.

Metals reappeared in northern Italy in the late 4th millennium BC. They were mainly deposited in individual trench graves in the Po valley. Here, like further south, metals defined significant aspects of personal identity such as gender and age. Object design displays similarities with peninsular Italy (e.g. Remedello- and Fontino-style daggers; fig. 15), as well as techno-morphological traits suggesting local manufacture and consumption. This apparent contradiction may be due to the importation of metalworking technology from west-central Italy, where it had been underway since Horizon 2. The Tuscan isotopic signature of the Iceman's axe (and of a similar, coeval implement from Zug, Switzerland) hints at late 4th millennium links between the two regions (Artioli *et alii* 2017; Gross-Schaeren-Villa 2017). By the 3rd millennium BC, however, north Italian metalworkers were exploiting the rich copper deposits of the southeastern Alps, securing local production and exchange (Artioli *et alii* 2020).

Horizon 4 (Late Eneolithic): 2900 - 2700/2600 BC

Horizons 4 features far fewer dated burials than Horizons 2 and 3 (table 17). The Bayesian analysis places the horizon's upper boundary between 2920/2710 and 2860/2490, but most dates end around 2700 cal. BC; hence the uncertainty with the lower boundary, which we tentatively place at 2700/2600 BC. The horizon comprises assemblage groupings *PenG3* and *NG2* (table 18). The waning of metals from the record reflects changing ideas of the dead in 3rd millennium BC Italy. Metal-rich male and female burials become increasingly rare at this time, especially in west-central and southern Italy, whereas they persist somewhat longer up north. Metals are now found at Laterza-style cemeteries, south-central Italy, but they are relatively rare. It is unclear if this is real scarcity due to overstretched procurement networks or a function of local deposition practices.

The horizon features notable developments in object design, e.g. in Remedello, type II and III daggers. New objects also appeared at this time, e.g. Montebradoni-type daggers, but they are not numerous. The picture is likely skewed

[8] The burial has yielded two dates that are at odds with each other: (1): DSH-547; 4104±48 BP; 2880-2490 cal BC (Passariello et alii 2010, table 2); (2): LYON-16357; 4400±35 BP; 3110-2900 cal BC. The Lyon laboratory also produced a date from a dismembered female burial from the same grave, which is contemporary to the male burial (LYON-16359; 4430±35 BP; 3130-2920 cal BC; Carboni 2020: 509). We propose rejecting the first date as problematic, for it is completely at odds with the overall chronology of the Gaudo burial tradition (to which the burial belongs), which the latest research assigns to the period c.3300-2850 BC (Anzidei and Carboni 2020b: 149-202). The date from the female burial strengthens our proposal.

by a visibility bias obscuring the many metals that ended their lives in a crucible instead of a grave. This is suggested by Alpine stelae displaying rich weapon panoplies that are nowhere to be seen on the ground. Long-distance connectivity networks can still be fathomed despite the scarce evidence available, e.g. in Corded Ware-style T-headed silver pins and flanged axes with rectilinear margins from north-central Italy (fig. 15).

Horizon 5 (Final Eneolithic): 2700/2600 - 2100 BC

Horizon 5 comprises a single date from Albavia Bubbio whose 68% modelled range provides the phase's lower boundary at 2200/2050 BC, rounded here at 2100 BC (table 15). The horizon marks the Italian Final Eneolithic straddling the initial Early Bronze Age, whose onset is traditionally placed at 2200 BC. Horizon 5 suffers from the same visibility bias as Horizon 4. Metals are mainly found at late Remedello, Rinaldone, and Laterza funerary sites, as well as Beaker burials (groupings *PenG4 and NG3*).

The dearth of well-dated evidence makes it hard to assess the character of metal production and consumption in Horizon 5. Europe-wide connectivity is apparent in Beaker-type metals such as Ciempozuelos-type daggers and S. Cristina-type axes, while Ig II-type awls, Faisz-type axes, and Freisach-type shaft-hole axes document ongoing contacts with the north-eastern Alps. Communication between northern and peninsular Italy continued to some extent. A few new object types appeared at this time (i.e. Villafranca and Gambara-type halberds) and flanged axes became ubiquitous. This is the latest development of a longstanding technological trend that had begun in the 4th millennium BC with the hammering and thickening of margins by coppersmiths. For the first time, metals were deposited in hoards as well as graves. The earliest Italian hoards (i.e. Col del Buson and Pigloner Kopf) are comparatively small, but the new practice gathered momentum rapidly. By 2200/2100 BC, hoarding had acquired the character that will define it throughout the Early Bronze Age, as seen at Remedello Sopra (de Marinis 1979; 2012). This transitional hoard marks the end of Eneolithic metallurgy and ushers in the Bronze Age.

Conclusion

The article has discussed a new seriation and chronology for prehistoric Italian metalwork, *c.*4500-2100 BC. The work was grounded in (a) a reclassification of early Italian metals enhanced by object morphometry and metalwork wear analysis; (b) a reassessment of metal-rich burial assemblages, which were clustered into regional and chronological groupings based on meaningful associations between metal and non-metal objects; and (c) a reappraisal of 32 radiocarbon dates from (mainly one-phase) metal-rich burials, integrated by new AMS dates and typological comparisons with selected non-Italian metals. Thus modelled, the data have enabled these authors to chart in unprecedented detail the development of metalwork production and use from late 5th to late 3rd millennia BC. The work contributes significantly to a debate initiated 50 years ago by the late Renato Peroni and continued by some of the foremost scholars of later Italian prehistory.

The data discussed in these pages will be especially beneficial to colleagues studying the development of metal technology in early Europe, and how it ties to cultural phenomena and deposition practices. The meaningful yet complex relationship that the research has highlighted between burial customs and assemblage groupings is especially interesting. While its assessment goes beyond the scope of this paper, it is clear that regional (and often super-regional) connectivity is apparent in both funerary behaviour and metallurgical knowledge, as well as other cultural markers (e.g. pottery styles). It is equally clear, however, that many empirically defined cultural labels are not visible in the realm of copper metallurgy. We should ask ourselves hard questions about what they reveal of past societies, if anything at all (Steiniger 2005).

Another problem requiring further exploration is the gap in metal circulation and use highlighted by the research in Early Eneolithic northern Italy, 3650-3350 BC. This is analogous, and partly coeval, to the metallurgical hiatus long highlighted in eastern Europe and the northern Alps (Strahm 1994; Strahm and Hauptmann 2009). That northern Italy may have experienced such a hiatus in the mid-4th millennium BC is an unexpected finding that lay hidden by the coarser-grained chronologies of old. Future research should validate and explain the hiatus: is it a visibility bias due to the lack of individual burials? Or is it due to the delayed inception of metalworking vis-à-vis west-central Italy, perhaps due to copper sulphides prevailing in the southern Alps? Either way, why did imports from further south not flow into the region? These are but some of the new questions that the data and interpretations discussed above have enabled. More questions will certainly arise in years to come within the fast-moving fields of archaeometallurgy and Copper Age studies.

ACKNOWLEDGEMENTS

The TEMPI project - The Time of Early Metalwork in Prehistoric Italy - was funded as a Marie Skłodowska-Curie Action under H2020-EU.1.3.2, grant agreement 657211 (Principal Investigator: A. Dolfini; Research Fellow: C. Iaia) and hosted by Newcastle University (UK) in 2015-2017. We thank B.M. Aranguren, S. Casini, A. De Santis, the late F.M. Gambari, R. Macellari, L. Malnati, M. Miari, A. Pessina, and F. Rubat Borel for issuing permits to examine metal objects in their care; P. Boccuccia, M. Cardosa, L. Cianfriglia, A. Ferrari, M. Gatto, G. Kaufmann, C. Mangani, L. Minarini, P. Rendini, and F. Rossi for facilitating access to, or analysis of, the objects; B.M. Aranguren and E. Pacciani for their help in sampling human remains; F. Carrer for help with statistical modelling; C. Alexander for advice on Bayesian statistics and data modelling; and G. Kaufmann and G.L. Carancini for liberally sharing with us unpublished object drawings. We are also grateful to the late G. Carboni and A.P. Anzidei for inviting us to participate in their important research on the Eneolithic in the Rome area, drawing our attention to relevant materials and discussing with us data and interpretations. Finally, we thank the anonymous journal reviewers for their comments on an earlier manuscript. All opinions and errors are our own.

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RIVISTA DI SCIENZE PREISTORICHE
Vol. LXXI - 2021

INDICE

Finito di stampare in Italia nel mese di aprile 2022
da Pacini Editore Industrie Grafiche – Ospedaletto (PI)
per conto di Edifir-Edizioni Firenze

RIVISTA DI SCIENZE PREISTORICHE
dell'Istituto Italiano di Preistoria e Protostoria

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ISSN 0035-6514
e-ISSN 2282-457X