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The Neolithic beginnings of metallurgy in the central Mediterranean region

Andrea Dolfini

INTRODUCTION

Interest in the beginnings of metallurgy in Italy and surrounding areas is, one might say, as old as archaeology. However, only recently has the antiquity of the local metallurgical practices and products been fully recognised (but see Barfield 1966 and Renfrew & Whitehouse 1974 for notable exceptions). Skeates (1993), in particular, was the first to draw attention to the growing amount of data concerning Neolithic metalwork from this region. Grounding his study in a detailed review of the evidence and chronology then available, he claimed that the first metal-using horizon in the central Mediterranean was to be ascribed to the last centuries of the Neolithic, in the late 5th and early 4th millennia cal BC. His view was further confirmed by Pearce (1993; 2000; 2007) and Barfield (1996), who mainly researched the northern Italian evidence.

Curiously, most of the Italian scholarship took for a long time a very different stance. With few exceptions (e.g. Cazzella 1994; De Marinis 1997), Italian prehistorians argued that the first metallurgical ‘cultures’ found in the Italian peninsula (namely Remedello in the north, Rinaldone in the centre, Gaudo in the south-west and Laterza in the south-east) had not actually flourished until the late 4th or early 3rd millennia cal BC, in the developed Copper Age (Bianco Peroni 1994; Carancini 1993; 1999; 2001; 2006; Peroni 1971; 1989; 1996). They also controversially dated a large section of copper and arsenical-copper metalwork, which was previously thought to be Copper Age, to the first phase of the Early Bronze Age.

Radiocarbon has now disproved both elements of this hypothesis, thus reinstating early Italian metallurgy (and especially the key Rinaldone evidence from ore-rich west-central Italy) within its Late Neolithic and Early Copper Age context (Dolfini 2010; 2013; 2014; Giardino 2009–2012; Passariello et al. 2010). However, one fundamental question still remains unanswered: when did metallurgy begin in the central Mediterranean? In the Middle Neolithic, as Barfield (1966) once controversially proposed, or in the Late Neolithic,
as most scholars seem now keen to believe? And if the latter proves true, when exactly can we date its inception considering that the Italian Late Neolithic lasted for about 700 years (Table 1)?

The aim of this paper is to address this basic yet surprisingly long-standing question. The method chosen for my enquiry is a systematic if somewhat pedantic review of the current evidence concerning the earliest stages of metal-using and metal-working in the central Mediterranean. The first section examines whether some of the most archaic copper axes from this region can be dated to the Middle Neolithic. The second section discusses the growing amount of evidence for Late and Final Neolithic metal-using and metal-working. In particular, two problems will be investigated: first, whether central Mediterranean society relied solely on metalwork imported from neighbouring regions, or if local smelters and smiths were also active in such an early time period; second, whether large implements including axes were imported, or locally manufactured, prior to the Copper Age – something that many Italian scholars seem rather reluctant to postulate (e.g. Carancini 2001; 2006; Pessina & Tiné 2008: 132–4). The final section introduces Copper Age metallurgy, which saw the full scale development of the first experiments carried out in the Neolithic with the novel metal technology. Concluding remarks concerning the social and technological transformation that occurred at the transition between Neolithic and Copper Age will also be put forward in this section.

REASSESSING MIDDLE NEOLITHIC METALWORK

Ore deposits and prehistoric mining

The central Mediterranean region features three major ore-mineral districts in the Alps, west-central Italy, and Sardinia. These are complemented by a plethora of relatively minor deposits and outcrops scattered across most of the region with the notable exception of the circum-Adriatic area, the Maltese archipelago, and most of Sicily. The nature of the ore deposits is extremely varied, comprising as it does primary and enriched copper and iron-copper sulphides (e.g. chalcocite, chalcopyrite and bornite), fahlores (i.e. polymetallic copper sulphides such as tetrahedrite and tennantite, which may be naturally rich in arsenic and antimony), and galena (lead sulphide), the latter occasionally argentiferous. Secondary (or supergene) deposits resulting from the weathering of primary ores are also found abundantly; these may include copper oxides and carbonates such as malachite, azurite and cuprite (Baumgarten et al. 1998; Carobbi & Rodolico 1976; Cavinato 1964; Pearce 2007; Preuschen 1973; Valera & Valera 2005; Valera et al. 2005). Stibnite (antimony sulphide) and cassiterite (tin oxide) are also found in Tuscany and Sardinia. Whereas the former was almost certainly smelted in the Copper Age to make antimony necklace beads, prehistoric exploitation of the latter is still debated (Giardino et al. 2011; Penhallurick 1986: 79–83; Tanelli 1983; 1989). Significant iron, zinc and mercury deposits are also present in the region, but their exploitation began at a later stage.

<table>
<thead>
<tr>
<th>Archaeological Phase</th>
<th>Absolute chronology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Neolithic</td>
<td>5000–4500 cal BC</td>
</tr>
<tr>
<td>Late Neolithic</td>
<td>4500–3800 cal BC</td>
</tr>
<tr>
<td>Final Neolithic</td>
<td>3800–3600 cal BC</td>
</tr>
<tr>
<td>Early Copper Age</td>
<td>3600–3300 cal BC</td>
</tr>
<tr>
<td>Middle Copper Age</td>
<td>3300–2700 cal BC</td>
</tr>
<tr>
<td>Late Copper Age</td>
<td>2700–2200 cal BC</td>
</tr>
</tbody>
</table>

Table 1 Chronology of the time period from the 5th to the late 3rd millennia cal BC in the central Mediterranean region
Although industrial-scale utilisation of the Italian and Sardinian ore deposits in the 19th and 20th centuries destroyed most ancient workings (Colini 1898–1902; Mochi 1915), evidence of prehistoric ore mining was recently brought to light across the region. For example, a high altitude bornite mine has been excavated at Saint Véran in the French Alps (Fig. 1: site 15), whose first exploitation dates to the transition between Copper and Bronze Ages c.2400–2000 cal BC (Bourgarit et al. 2008). At the other end of the peninsula, Neolithic through to Bronze Age procurement of bright-coloured copper and iron compounds was revealed at Grotta della Monaca, a cave site in Calabria. However, it is unclear whether these ores were sourced for their metal content or as pigments (Geniola et al. 2006; Larocca 2005).

The oldest evidence for metallurgical copper mining in this region (and, for that matter, in the whole of western Europe), is documented at Libiola and Monte Loreto in Liguria, northwest Italy. Here, extensive workings of the local chalcopyrite have been brought to light by an Anglo-Italian team, whose findings included: artificial galleries backfilled in prehistory once the cupriferous veins had been depleted; evidence of fire-setting to loosen the rock; and extensive dumps of graded mining debris, which are informative of in situ beneficiation (i.e. rock grinding and sieving aimed at separating the high-grade ore from the gangue). Radiocarbon dating indicates that these mines were worked from the Early Copper Age onwards (Maggi & Pearce 2005; Pearce 2007). Interestingly, an isolated date obtained from *viburnum* charcoal (a short-lived Mediterranean shrub) found in the dumping grounds at Monte Loreto calibrates in the Late/Final Neolithic (Beta-203528; 5010±40; 3944–3704 cal BC: Campana et al. 2006). However, it is unclear whether this should be considered proof of the Neolithic sourcing of chalcopyrite, an isolated experiment in the procurement of native copper (or supergene ores), or simply an unreliable outlying date. Thus, in spite of their richness, diversity and overall accessibility, the central Mediterranean ore deposits still defy any attempt to date their exploitation (at least for the purpose of copper smelting) to periods earlier than the Copper Age.

**Middle Neolithic copper axes?**

In the light of this problem, the debate over the earliest metallurgy in this region has long centred upon a handful of archaic copper axes from northern Italy, which Barfield (1966) controversially claimed to be Middle Neolithic (c.5000–4500 cal BC). These originally comprised three tools from Chiozza di Scandiano, Quinzano Veronese (now missing) and Campegine, but similar implements from Pizzo di Bodio, Valle Fontega and Stankovci (the latter in Dalmatia) were later taken into the debate (Pearce 2007: 38–42; Skeates 1993). Other tools from both northern and central Italy should probably be added to the list on the grounds of their archaic shapes and features, but assessment is difficult due to the lack of a complete catalogue of early Italian axes (Table 2). Barfield’s contentious proposal was subsequently reviewed by Skeates (1993), Pearce (2007) and later Barfield himself (Barfield 1996), and I shall ground the present discussion in the most recent review by Pearce.

The argument for dating these objects to the Middle Neolithic rests upon three main considerations: firstly, they are still reminiscent of Neolithic groundstone axes in their triangular shapes, rounded profiles and pointed butts. Secondly, they frequently display rough and bumpy surfaces, which seem to denote casting in monovalve moulds and, overall, poor command over the metal technology on the part of the smiths. Thirdly, they have been found in areas where Middle Neolithic evidence, and in particular pottery in the VBQ I (linear-geometric) and VBQ II (spiral-meander) styles, is plentiful, but later material is generally absent. To confuse the matter further still, the VBQ II style is now understood to have continued into the Late Neolithic, up to about 4200 cal BC (Pessina & Tiné 2008: 58).

De Marinis (1992: 389) assigned these axes to Colini’s (1900) type I (triangular axes with pointed butt) and type II (thick trapezoidal axes with rounded butt). Following Carancini (1993: 126), I would propose splitting the first group into two separate categories: (i) short
### Table 2 Probable Neolithic copper axes from the central Mediterranean region (c.4500–3600 cal BC).

Analysis: AAS: Atomic Absorption Spectroscopy; ND: Neutron Diffraction; OES: Optical Emission Spectroscopy. Site numbers refer to Fig. 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Site</th>
<th>Commune (Province)</th>
<th>Axe type</th>
<th>Context</th>
<th>Analysis</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Campegine</td>
<td>Campegine (Reggio Emilia)</td>
<td>Short triangular</td>
<td>Unknown</td>
<td>-</td>
<td>Malavolti 1946; De Marinis 1992</td>
</tr>
<tr>
<td>13</td>
<td>Pizzo di Bodio</td>
<td>Bodio Lomnago (Varese)</td>
<td>Short triangular</td>
<td>Stray find</td>
<td>-</td>
<td>Banchieri 1999</td>
</tr>
<tr>
<td>11</td>
<td>“Bergamo”</td>
<td>N/A (Bergamo?)</td>
<td>Long triangular</td>
<td>Unknown</td>
<td>Artioli 2007 (ND)</td>
<td>De Marinis, 1992</td>
</tr>
<tr>
<td>12</td>
<td>Moltrasio</td>
<td>Moltrasio (Como)</td>
<td>Trapezoidal</td>
<td>Unknown</td>
<td>-</td>
<td>De Marinis 1992</td>
</tr>
<tr>
<td>21</td>
<td>San Polo</td>
<td>San Polo (Reggio Emilia)</td>
<td>Trapezoidal</td>
<td>Unknown</td>
<td>-</td>
<td>Colini 1898–1902; De Marinis 1992</td>
</tr>
<tr>
<td>4</td>
<td>Bocca Lorenza</td>
<td>Santorso (Vicenza)</td>
<td>Splayed cutting edge</td>
<td>Cave site</td>
<td>Artioli 2007 (ND); Matteoli &amp; Storti 1982 (metallography)</td>
<td>Bianchin Citton 1988; De Marinis 1992</td>
</tr>
<tr>
<td>2</td>
<td>Lana</td>
<td>Lana (Bolzano/Bozen)</td>
<td>Splayed cutting edge</td>
<td>Unknown</td>
<td>-</td>
<td>Lunz 1973; De Marinis 1992</td>
</tr>
<tr>
<td>9</td>
<td>San Briccio di Lavagno</td>
<td>Lavagno (Verona)</td>
<td>Splayed cutting edge</td>
<td>Unknown</td>
<td>Otto &amp; Witter 1952: no.114 (AAS)</td>
<td>Rizzetto 1977; De Marinis 1992</td>
</tr>
<tr>
<td>10</td>
<td>Marendole</td>
<td>Monselice (Padova)</td>
<td>Splayed cutting edge</td>
<td>Unknown</td>
<td>-</td>
<td>Colini 1898–1902; De Marinis 1992</td>
</tr>
<tr>
<td>28</td>
<td>San Gimignanello</td>
<td>Rapolano Terme (Siena)</td>
<td>Long triangular</td>
<td>Unknown</td>
<td>-</td>
<td>Carancini 1993: Cocchi &amp; Grifoni 1989: fig. 29.12</td>
</tr>
<tr>
<td>29</td>
<td>“Perugia”</td>
<td>N/A (Perugia)</td>
<td>Short triangular</td>
<td>Unknown</td>
<td>-</td>
<td>Carancini 1993: 126</td>
</tr>
<tr>
<td>30</td>
<td>Badiola</td>
<td>Marsciano (Perugia)</td>
<td>Short triangular</td>
<td>Unknown</td>
<td>-</td>
<td>Carancini 1993: 126</td>
</tr>
<tr>
<td>36</td>
<td>Collelongo</td>
<td>Collelongo (L’Aquila)</td>
<td>Long triangular</td>
<td>Unknown</td>
<td>-</td>
<td>Carancini 1993: 126</td>
</tr>
<tr>
<td>35</td>
<td>Sgurgola-Casali</td>
<td>Sgurgola (Frosinone)</td>
<td>Long triangular</td>
<td>Burial</td>
<td>-</td>
<td>Pinza 1905; Carboni 2002</td>
</tr>
</tbody>
</table>

Triangular axes with pointed butts (Carancini’s Badiola type) and (ii) elongated triangular axes with pointed butts and rounded or irregular cross-sections (Carancini’s Sgurgola type). Classification of the trapezoidal (Colini’s type II) axes is far more difficult, for implements of this shape are commonest prior to the Bronze Age. I would only assign to my group iii those axes whose technology shows undeniably archaic traits (*e.g.* very rough surfaces), with the understanding that it is often impossible to discriminate between earlier and later tools in the absence of any contextual evidence. Axes of the Bocca Lorenza type (group iv) also predate the inception of the Copper Age, but these will be discussed below (Fig. 2).

Upon considering the archaic shape and technology of these objects, it is easy to agree with Barfield (1966) when he suggested that they were intentionally made as skeumorphs...
Fig. 2 Early axes from the central Mediterranean region. Type (i): short triangular axes with pointed butts. Type (ii): elongated triangular axes with pointed butts and rounded or irregular cross-sections. Type (iii): trapezoidal axes with rough surfaces or other archaic traits. Type (iv) elongated axes with stout body, quasi-parallel margins and splayed cutting edge ('Bocca Lorenza' type) (De Marinis 1992, modified)

of groundstone axes; thus, they must have been manufactured at the very first stages of metalworking. However, this does not prove a decisive factor for their dating to the Middle Neolithic. Although stone axes were certainly common in the early/mid 5th millennium cal BC, one must note that their production and circulation peaked in the late 5th and early 4th millennia cal BC (Pétrequin & Jeunesse 1995; Pétrequin et al. 2005). The one inference we can draw from their archaic shape and technology is that, in all likelihood, these axes were amongst the first heavy tools to be made from copper in the Italian peninsula, or were imported from neighbouring regions at a time when metalworking was still in its infancy. Whether this is the Middle Neolithic, the Late/Final Neolithic or the Early Copper Age is a matter of contention. However, given their strong formal links with groundstone axes, it seems very probable that these tools mostly predate the significant decrease in the circulation of polished-stone tools that occurred in Italy at the end of the Neolithic, from about 3800 cal BC. Unfortunately, compositional analysis cannot help to determine their chronology since, like most of the early Italian axes, these implements were often made from rather pure copper (Giardino 2009–2012; Pearce 2007: 38–42).

With regard to the claim that these axes were frequently found at Middle Neolithic sites, it must be noted that they are all from imprecisely recorded contexts. For example, the tool from Pizzo di Bodio is a surface find that is not stratigraphically associated with the VBQ I and VBQ II evidence brought to light there (Banchieri 1999); the Valle Fontega specimen is from a site that has yielded both Middle Neolithic and Copper Age material (Capuis et al. 1992: 42); and it is far from certain if the Campegine axe is from the Middle Neolithic settlement at La Razza as was suggested (Malavolti 1946: 322). As for the
Quinzano tool, Zorzi (1956: 140) reported that it had indeed been found in the same quarry as the VBQ I material, but as a stray find from the quarry’s surface, not from the pits that yielded the Neolithic pottery. Moreover, Pearce (2007: 39–40) pointed out that the only sketch available for this now-missing object – published by Junghans et al. (1960, no. 637) with the erroneous label ‘Quinzano Doglio’ (Quinzano d’Oglio – this is the correct spelling – is a commune in east Lombardy, not the suburb of Verona where the axe was found) – would suggest a chronology in the Late Copper Age. Due to the uncertainties surrounding the identification of the sketch and analysis published by Junghans et al. (1960), the object had better be taken out of the present discussion.

The one exception to this rather depressing list of stray finds lies in the copper axe from Chiozza. Colini (1900: 235) reported that it had been found in a clay pit from ‘Boschetti di Villa Chiozza’ (a different find-spot from the nearby Neolithic site at Chiozza di Scandiano) along with five shell buttons, four greenstone axes, and a long flint blade. This context, which Pearce (2007: 39) interpreted as a grave assemblage, is normally considered to be Copper Age on account of the simple trapezoidal shape of the axe (Pearce 2007; Skeates 1993). However, I would argue that this assemblage need not be so late: the long flint blade and the shell buttons, which Barfield (pers. comm. reported in Skeates 1993: 9) suggested might be of Spondylus, could as well (and perhaps best) be assigned to the last few centuries of the Neolithic, and this chronology would obviously fit the greenstone axes too. Importantly, it would also fit the copper axe whose rough and bubbly surface points backwards to the earliest experiments with metallurgy.

In the light of this review, it is my contention that the linkage between Middle Neolithic sites and the copper axes discussed here is likely to be accidental, or perhaps motivated by long-term social acquaintance with meaningful places in the landscape. Several authors have suggested that groundstone axes, and especially large over-polished specimens made from the best Alpine metamorphic stones, were ritually deposited off-site in Neolithic Italy (Bernabò Brea et al. 2012: 852; Robb 2007: 213). In a similar vein, I have proposed that this practice was afforded to metal axes in the ensuing Copper Age on account of the high number of stray items in the record (Dolfini 2008). It seems to me entirely plausible that the Neolithic custom of depositing isolated stone axes in the landscape was extended to the first metal axes as a strategy to imbue the novel technology with a recognisable social meaning. The striking similarities in shape and features between groundstone and early copper axes are also suggestive of overlapping meanings and values, thus further confirming this reading. Moreover, it has been pointed out that abandoned Middle Neolithic settlements frequently provided foci for the deposition of objects and bodies in the 5th and 4th millennia BC (Conati Barbaro 2007–2008), and this might explain why some of the aforementioned metal axes were found in proximity to Middle Neolithic sites.

The decisive argument for rejecting Middle Neolithic dating for these implements lies, in my opinion, in the absolute chronology of this time period, which the latest scholarship assigns to c.5000–4500 cal BC (Pessina & Tiné 2008). Were we to assign them to the Middle Neolithic, the problem would arise as to where they could have been imported from. This is still a pre-metallurgical era not only in this region but also in the whole of central and western Europe including, crucially, the northern Alps. Acceptance of Barfield’s proposal would imply postulating far-flung contacts with eastern Europe to account for the procurement of these objects. Of course this is what Barfield (1966) suggested in the first place. However, eastern European metallurgy is mainly characterised, in the first half of the 5th millennium cal BC, by the production of heavy copper implements such as hammer-axes and massive chisels, which are mostly found in the Vinča culture of the northern-central Balkans as well as in neighbouring cultural groups of the Carpathian basin. None of these objects have been found to date in the central Mediterranean including the areas that should be the most likely to display eastern influence – northeastern Italy and the northern Adriatic sphere. Although flat axes were also made in this period throughout eastern Europe, they are not nearly as numerous as in the ensuing phases and, above all, provide only generic parallels to
the earliest Italian tools (Novotná 1970; Patay 1984; Todorova 1981). Groundstone-looking copper axes of the kind discussed here are found across most of Europe at the earliest stages of metal production. Given their non-specific typological and technological traits, they cannot be used as evidence for exchange or direct technology transfer.

Furthermore, if we look at the earliest metal-using evidence in the north Alpine region, two important elements come to the fore: firstly, unlike Italy, contacts with eastern Europe are highlighted by imports of typologically distinctive implements including shaft-hole axes (Kienlin 2010: fig. 2.10), and this should be considered when drawing parallels between early metallurgical practices north and south of the Alps. Secondly, and perhaps more importantly, the north Alpine evidence is overall dated to the late 5th and early 4th millennia cal BC, in what south of the Alps is called the Late Neolithic (Bartelheim et al. 2002; Kienlin 2010: 13–15; Krause 2009: 49).

In sum, the state of the evidence indicates that claims for Middle Neolithic metalwork are at best unproven, and most probably incorrect. Significantly, this was recognised by the later Barfield (1996: 67), who tempered his earlier statements by noting that archaic copper axes are normally found in later contexts in the circum-Alpine and circum-Adriatic areas. It is therefore to later phases that we must turn our attention if we are to understand the emergence of metallurgy south of the Alps.

METAL-USING AND METAL-WORKING IN THE LATE AND FINAL NEOLITHIC

The first metal artefacts from the central Mediterranean

In contrast with the controversial evidence for Middle Neolithic axes, some twenty copper and silver objects from Italy and Sardinia can be securely assigned to the Late or Final Neolithic; these are all dated by radiocarbon or associated pottery. A good deal of early metalwork is also found along the eastern Adriatic coast, but this is not discussed in this paper as these objects display unmistakable eastern European traits, thus suggesting origins within the Balkan metallurgical sphere (Žeravica 1993). Findings from the central Mediterranean encompass small pointed tools that are generally classified as ‘awls’ (but alternative labels including ‘rods’ and ‘points’ are also encountered in the literature), ornaments such as rings and beads, and tiny, unclassifiable fragments (Table 3). Previous accounts of Neolithic metalwork from this region also encompassed a fragmentary copper blade from Pizzica Pantanello near Metaponto (Bianco & Cipolloni Sampò 1987), which analysis has now shown to be made of greenstone (Giardino, pers. comm.). Evidence including slag, crucibles and a finished object from Terrina IV in Corsica was also taken into consideration (Pearce 2007: 47; Skeates 1993: 8). However, this site ought to be considered Copper Age on the grounds of its thirteen radiocarbon dates, which recent Bayesian statistics would assign to the late 4th or 3rd millennia cal BC (Camps 1988: 83; Pearce 2009–2012). True, one date is earlier (MC-2077; 4950±90; 3961-3536 cal BC), but the excavator considers it an outlier. One must also note that its calibration plot partly overlaps with later determinations and that, in general terms, it would seem unwise to give too much credit to a single date that many would today regard with suspicion due to its large standard deviation (±90). Significantly, the pottery unearthed at this site, and especially the vessels with multi-perforated rims, are consistent with Copper Age chronology.

In an opposite fashion, it would be tempting to ascribe a small copper fragment (erroneously referred to as a dagger in Giardino 2009–2012: 18) from Valvisciolo, a multi-phase burial cave in southern Latium, to the Final Neolithic (Barocelli 1939). The context, which is generally thought to be Copper Age, yielded a bowl whose unusual incised and graffito decoration is reminiscent of the late Chassey style (Carboni 2002: fig. 4.9), while further comparisons can be drawn with Tuscan contexts marking the transition to the Copper Age such as Neto-Via Verga, horizon 5 (Sarti 1998; Sarti & Volante 2002). Interestingly, radiometric evidence now pinpoints a handful of Rinaldone-style burials from
<table>
<thead>
<tr>
<th>No</th>
<th>Site</th>
<th>Commune (Province)</th>
<th>Context</th>
<th>Evidence</th>
<th>Associated pottery</th>
<th>Date cal BC</th>
<th>Analysis</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Bannia-Palazzine di Sopra</td>
<td>Fiume Veneto (Pordenone)</td>
<td>Open settlement</td>
<td>Copper awl</td>
<td>VBO III</td>
<td>4520-4360*</td>
<td>Giunlia-Mair 2005a; 2005b (XRF, SEM-EDS)</td>
<td>Visentini 2002; 2005</td>
</tr>
<tr>
<td>6</td>
<td>Palù di Livenza</td>
<td>Canevà (Pordenone)</td>
<td>Open settlement</td>
<td>Copper point</td>
<td>VBO III &amp; Lagozza</td>
<td>c.4250-3800*</td>
<td>-</td>
<td>Peretto &amp; Taffarelli 1973; Visentini 2002</td>
</tr>
<tr>
<td>8</td>
<td>Rocca di Rivoli</td>
<td>Rivoli Veronese (Verona)</td>
<td>Open settlement</td>
<td>Copper rod</td>
<td>VBO III</td>
<td>c.4250-3800</td>
<td>-</td>
<td>Barfield &amp; Bagolini 1976</td>
</tr>
<tr>
<td>3</td>
<td>Isera, phase 2</td>
<td>Isera (Trento)</td>
<td>Open settlement</td>
<td>Rolled copper bead</td>
<td>VBO III</td>
<td>c.4200-3800</td>
<td>Artioli et al. 2003 (SEM-EDS, metallography)</td>
<td>Pedrotti 2001</td>
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<tr>
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<td>Isera, phase 3</td>
<td>Isera (Trento)</td>
<td>Open settlement</td>
<td>Copper rod</td>
<td>Fiavé 1</td>
<td>c.3800-3600</td>
<td>Artioli et al. 2003 (SEM-EDS, metallography)</td>
<td>Pedrotti 2001</td>
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<td>14</td>
<td>Alba</td>
<td>Alba (Cuneo)</td>
<td>Open settlement</td>
<td>Copper awl</td>
<td>Chassey</td>
<td>4335-4050***</td>
<td>-</td>
<td>Venturino Gambini 2002; Zamagni 1995</td>
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<td>16</td>
<td>Arene Candide</td>
<td>Final Ligure (Gavona)</td>
<td>Cave site</td>
<td>Copper awl [+ oxidised bone]</td>
<td>Chassey</td>
<td>c.4250-3800</td>
<td>Campana &amp; Franceschi 1997 (SEM, XRD &amp; metallography)</td>
<td>Maggi 1997</td>
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<td>17</td>
<td>Sant'Andrea di Travo</td>
<td>Travo (Piacenza)</td>
<td>Open settlement</td>
<td>Copper awl</td>
<td>Chassey-Lagozza</td>
<td>c.4250-3800</td>
<td>-</td>
<td>Bernabò Brea et al. 2002</td>
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<td>37</td>
<td>Fossacesia</td>
<td>Fossacesia (Chieti)</td>
<td>Open settlement</td>
<td>Copper awl</td>
<td>Late Ripoli &amp; late Serra d’Alto</td>
<td>c.4300-3800</td>
<td>-</td>
<td>Cremonesi 1973; Skeates 1993</td>
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<td>31</td>
<td>Attiggio - Cava Giacometti, (layer 6)</td>
<td>Fabriano (Ancona)</td>
<td>Open settlement</td>
<td>Copper fragment</td>
<td>Lagozza</td>
<td>c. 4000-3600</td>
<td>?</td>
<td>Lollini 1965; Skeates 1993</td>
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<td>32</td>
<td>S. Maria in Selva</td>
<td>Treia (Macerata)</td>
<td>Open settlement</td>
<td>Copper awl and fragments [+slag]</td>
<td>Late Ripoli, Lagozza</td>
<td>c.4000-3600</td>
<td>-</td>
<td>Lollini 1965; Silvestrini et al. 2002</td>
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<td>41</td>
<td>Contrada Matinelle</td>
<td>Matera (Matera)</td>
<td>Cist grave</td>
<td>Copper fragment</td>
<td>Late Serra d’Alto</td>
<td>c.4400-4000</td>
<td>-</td>
<td>Lo Porto 1988; Ridola 1912</td>
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<td>38</td>
<td>Grotta Sa Korona di Monte Majore</td>
<td>Thiesis (Sassari)</td>
<td>Cave site</td>
<td>Copper bead [+ oxidised bone]</td>
<td>Ozieri</td>
<td>c.4300-3600</td>
<td>-</td>
<td>Lo Schiavo 1989; Usai 2005</td>
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<td>39</td>
<td>Pranu Mutteddu, tomb 5</td>
<td>Goni (Cagliari)</td>
<td>Cemetery</td>
<td>2 silver rings</td>
<td>Ozieri</td>
<td>c.4300-3600</td>
<td>-</td>
<td>Lo Schiavo 1989; Usai 2005</td>
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<td>44</td>
<td>Lipari acropolis</td>
<td>Lipari (Messina)</td>
<td>Open settlement</td>
<td>Crucible</td>
<td>Late Diana</td>
<td>c.4000-3600</td>
<td>-</td>
<td>Bernabò Brea &amp; Cavalier 1980</td>
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</table>

* Cf. Visentini 2002 for radiocarbon dates
** HD-25298; 5619±25 BP
*** GX-25859; 5380±40 BP

Table 3 Late and Final Neolithic metal objects from the central Mediterranean region (c.4500–3600 cal BC). Analysis: SEM-EDS: Scanning Electron Microscope and Energy-Dispersive X-ray Spectroscopy; XRD: X-ray Diffraction; XRF: X-ray Fluorescence. Site numbers refer to Fig. 1.
central Italy to the Final Neolithic (c.3800–3600 cal BC: Cazzella & Silvestrini 2005), and this chronology could certainly be appropriate for the context. However, other ceramics look decidedly Copper Age (Carboni 2002: figs. 4.3, 4.7), and, given the lack of stratigraphic data, it is probably safer to assign the copper fragment to this phase.

**Assessing local production**

Where were these objects made? In the metal-rich districts of the central Mediterranean, either by working nuggets of native copper or by smelting the local ore? Or were they all imported from neighbouring areas where metal technology had already set foot? Until recently, Neolithic metal production south of the Alps was often denied (Barfield et al. 2003; Carancini 2006; Mottes et al. 2002). Those who argued otherwise based their claims upon three findings: an isolated crucible from Lipari in the Aeolian Archipelago; alleged copper and silver slags from Su Coddu-Canelles (also known as Su Coddu-Selargius) in Sardinia; and alleged slags from Orti Bottagone in Tuscany. The first find consists of a potsherd with a lump of greenish substance adhering to it, which was brought to light in a stratified context on the Lipari ‘acropolis’; it is dated to the early 4th millennium cal BC by associated pottery in the late Diana style (Bernabò Brea & Cavalier 1980: 490). A radiocarbon date from charcoal is also available for this context, but its large standard deviation makes it unusable (R-180; 5000±200 BP; 4310–3370 cal BC). Lacking any analysis, however, assessment of this much-cited (but poorly understood) piece of evidence is most problematic. Is it a smelting or a melting crucible? Indeed, is the greenish substance sticking to it copper slag or just the by-product of other, non-metallurgical processes? No answer is possible until the ‘slag’ is examined for its chemical composition and micro-structure.

Su Coddu-Canelles is a more complex case. Copper and silver slags were allegedly found in the Neolithic Ozieri layers (c.4300–3600 cal BC) at this open settlement, and this was long taken as a proof of the precocious development, and perhaps independent invention, of polymetallic metallurgy in Sardinia (Skeates 1993; Ugas et al. 1985; 1989; Usai 2005). However, recent analysis has shown that these ‘slags’ may in fact be related to ceramic pyrotechnology, although a fuller physico-chemical assessment of the evidence is still awaited (Manunza et al. 2005–2006). At present, *in situ* metalworking is solely testified to by a crucible from the Copper Age Sub-Ozieri layers (c.3600–2900 cal BC: Melis 2005; 2009), and there is to date no unequivocal evidence that either copper or argentiferous lead ores were smelted anywhere in Sardinia during the Neolithic (Usai 2005).

As for Orti Bottagone, this is a surface assemblage consisting of a small amount of slag, processed ore, and potsherds in the late Ripoli and Lagozza styles (Fedeli 1999). Unfortunately, it is not clear whether the slag and pottery are coeval, in the absence of any stratigraphic data. Significantly, trial petrographic and chemical analyses highlighted the presence of well-reacted copper and iron minerals in the slag, and it is doubtful whether such an evolved reduction process could have been mastered at the very earliest stages of copper smelting (Artioli et al. 2007).

Such was the state of the evidence with regard to Neolithic metal production until the recent, comprehensive publication of excavations carried out at Botteghino, a Neolithic open settlement near Parma (Mazzieri & Dal Santo 2007). Two copper awls were found at this site along with ‘slags’ (not yet analysed) and a fragmentary crucible with copper lumps still adhering to it. A radiocarbon date taken from the same context as the crucible indicates that metal was worked here in the third quarter of the 5th millennium cal BC (Hd-25298; 5619±25 BP; 4500–4370 cal BC), while another date from a different context calibrates slightly later (Hd-25297; 5456±25 BP; 4350–4260 cal BC). This chronology seems further confirmed by the abundant pottery in the Chassey style, which is widespread in northwest Italy in the mid/late 5th millennium cal BC. If future analysis confirms that these
'slags' are metallurgical in nature, this would testify to south Alpine copper smelting in the third quarter of the 5th millennium cal BC. Interestingly, this is the time period when metal production is first documented north of the Alps at Brixlegg in the Inn Valley (Höpner et al. 2005; contra Gleirscher 2007).

Copper axes of the Late and Final Neolithic

Did Neolithic smiths solely manufacture small tools and ornaments or were they also capable of casting large, heavy implements such as axes? Contentious claims for copper axes being used in the central Mediterranean during the Middle Neolithic have been rebutted above. However, it is as yet unclear whether these tools were first made in the Late/Final Neolithic or the Copper Age. The latter reading is favoured by many Italian scholars, who argue that neither axes nor other large tools and weapons had been systematically produced in this region until the 3rd millennium cal BC (Carancini 1993; 1999; 2001; 2006; Peroni 1971; 1989; 1996). This interpretation has been especially favoured by Carancini, who wrote in 2001:

“[…] appare ormai in modo sempre più chiaro come – sia in ambito centrale che settentrionale della penisola – la fase cronologica corrispondente all’emergere di una consistente produzione metallurgica (‘primo orizzonte di metallurgia diffusa’) vada individuata in un momento avanzato dell’Eneolitico […]” (“it is becoming increasingly evident that – in both the central and northern Italian peninsula – the chronological phase marking the emergence of substantial metal production (‘first horizon with widespread metallurgy’) is to be dated to the advanced Copper Age”)

(Carancini 2001: 235, translation is mine).

To account for the large chronological gap that he postulated to occur between the earliest metallurgical experiments in the Late/Final Neolithic and the emergence of full blown metalworking in the advanced Copper Age, Carancini theorised the existence of a prolonged horizon with ‘incipient metallurgy’ (“orizzonte di metallurgia incipiente”), which, in his own words, would have been solely characterised by the manufacturing of a few awls (“pochi punteruoli”: Carancini 2001: 236).

However, a much-neglected piece of evidence from west-central Italy suggests that Neolithic copper smiths did not shy away from the manufacture of large implements. In the early 20th century, a groundstone-looking, elongated copper axe (Fig. 3) was discovered in a grave at Sgurgola-Casali along with two obsidian cores (Carboni 2002: 243; Pinza 1905). Despite the scarce data available, this context could be best assigned to the Late/Final Neolithic considering that the obsidian trade reached its peak in this period, only to dramatically decrease at the onset of the Copper Age (Gazzella 1994; Melis 2009; Robb & Farr 2005; Vaquer 2006). Moreover, the tomb structure – a trench grave covered by a stone heap – seems noticeably different from anything known in the area for the Copper Age period. It is also noteworthy that obsidian is never found in Copper Age burials of the Rinaldone culture, nor are archaic axes of this kind ever associated with Copper Age metalwork anywhere in Italy. Chronology in the admittedly broad timespan 4500–3600 cal BC could therefore be proposed for the axe, which one might suggest could be narrowed down to c. 4300–3800 cal BC by postulating that, on the one hand, the very first experiments with metal production did not entail the fabrication of heavy tools and, on the other hand, copper skeumorphs of groundstone axes ceased to be made once their stone templates had fallen out of fashion.

If this interpretation and chronology hold true, it would logically follow that most of the archaic axes discussed above could be assigned to this time period – starting from the San Gimignanello axe recently published by Giardino, which shows very similar shape and casting technology to the tool from Sgurgola-Casali (Giardino 2009–2012: 19–20). This chronology would notably tie in with what we know about the earliest flat axes north of the
Alps (Kienlin’s ‘horizon 1’), which are overall dated to the late 5th and early 4th millennia cal BC (Kienlin 2008; 2010). Importantly, many tools belonging to this horizon display the same shapes and features – and to some extent the same technology – as the earliest Italian axes (Kienlin et al. 2006). A radiocarbon date from horizon IIa at Maliq in Albania would also ascribe the first copper axes from the southeastern Adriatic to the mid/late 5th millennium cal BC (Ly-4975; 5530±110 BP; 4650–4060 cal BC: Guilaine & Prendi 1991). However, this is an isolated date whose standard deviation is too large to be unquestionably accepted. It is also unclear if this site in inner mountainous Albania exerted any influence on the development of metallurgy in the Italian peninsula. One would rather deny any such influences considering that metalwork is extremely scarce in southeast Italy until the emergence of the Laterza ‘culture’ in the advanced Copper Age (Passariello et al. 2010).

Further evidence suggests that copper axes were utilised, and almost certainly made, in the Italian peninsula during the Late and Final Neolithic. This consists of three elongated tools with stout body, quasi-parallel margins and splayed cutting edge that have been found, in two separate instances, in the Late Neolithic deposits at the Bocca Lorenza cave near Vicenza (Caddeo & Giacobbi 1961; Pellegrini 1910). Bagolini (1984), Bianchin Citton (1988) and De Marinis (1992) argued that these objects related to the Copper Age burials also found at this cave, for these cut down deeply into the underlying Neolithic stratification. However, Skeates (1993), Barfield (1971; 1996) and Pearce (2007: 42–4) highlighted that attentive examinations of the excavation diaries and publications do not confirm this reading. On the contrary, in both instances the excavators pointed out that the axes were found in the undisturbed Neolithic deposit, and that Neolithic artefacts including VBQ III (incised and impressed) potsherds were closely associated with them. Significantly, this interpretation was later accepted by De Marinis (1997: 36).

In a recent work, Klassen (2010) noted that the Bocca Lorenza axes belong to a larger group of objects that, despite being classified under unhelpfully differing labels, display similar features and sometimes similar chemical signatures; these are found over a broad area ranging from northeastern Italy to the northwestern Carpathians. Italian tools belonging to this type are not limited to the three axes from Bocca Lorenza, but also comprise stray finds from Lana (Adige valley), S. Braccio di Lavagno (Verona), and Marendole (Padova).
Based on their find contexts north and east of the Alps, Klassen (2010: 41) maintained that these axes could be dated to a relatively short span of time c.4000–3800 cal BC.

Compositional analysis and metallography of the Bocca Lorenza axes were carried out by Matteoli and Storti (1982), who claimed that they had been hot-hammered and subsequently forged to improve their working properties. Their conclusions are not fully confirmed by recent crystallographic texture analysis by means of Neutron Diffraction (Artioli 2007). It was observed that these tools, like most of the early Italian axes in the twenty-strong sample examined, had been slightly mechanically worked after casting and then partially annealed. According to Artioli (2007), this feature indicates that smithing was not aimed at hardening the metal to enhance its effectiveness, but just at reshaping tools after casting, or after deformation due to use. Previous claims that the Bocca Lorenza axes had been made from native copper (Matteoli & Storti 1982: 65) must also be regarded with caution, since such inferences are fraught with difficulties when solely based on the chemical composition of artefacts (Maddin et al. 1980; but see Pernicka et al. 1997 for a different opinion). Artioli et al. (2003) suggest that two Neolithic objects from Isera – an elongated bead and a small rod (Table 3) – might have been obtained from nuggets of native copper mechanically worked at room temperature, and the same was proposed for certain awls (Campana & Franceschi 1997: 616; Giumlia-Mair 2005b: 276). However, I would be wary of extending this interpretation to all Neolithic metalwork considering that smelting technology was probably available south of the Alps from the third quarter of the 5th millennium cal BC (Mazzieri & Dal Santo 2007). Furthermore, one should consider that the relatively pure copper from which early metalwork was frequently made can be obtained through the smelting of high-grade secondary ores (Rapp 1988).

Based on the evidence discussed in this section, a chronology can tentatively be proposed for the earliest types of copper axes, bearing in mind that the insufficient data make future revisions and corrections all the more likely. Given their strong similarities with Neolithic groundstone axes, I would suggest that both short and elongated triangular axes (types i and ii) were made in the time span c.4300–3800 cal BC, although earlier production or later utilisation cannot be a priori excluded. These were followed by the Bocca Lorenza axes (type iv), which were either imported from eastern Europe or locally made in northeastern Italy based upon foreign models. The first experiments with trapezoidal axes (type iii) were also carried out in the early to middle 4th millennium cal BC, until tools of this kind became dominant in the ensuing Copper Age (Table 4).

<table>
<thead>
<tr>
<th>Chronology</th>
<th>Short triangular axes (type i)</th>
<th>Elongated triangular axes (type ii)</th>
<th>Archaic trapezoidal axes (type iii)</th>
<th>'Bocca Lorenza' axes (type iv)</th>
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<tr>
<td>4500–4250 cal BC</td>
<td>?</td>
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Table 4  Chronology of early copper axes from the central Mediterranean region proposed in this paper
COPPER AGE DEVELOPMENTS OF CENTRAL MEDITERRANEAN METALLURGY

The Copper Age developments of Neolithic metallurgy have been the subject of recent works of mine (Dolfini 2010; 2011; 2013; 2014; Dolfini et al. 2011), and I shall summarise the principal results here. First, long-standing claims for the gradual development of metalworking and metal-using in the course of the Copper Age are to be rejected. Indeed, quite the opposite holds true: all stages of the metallurgical chaîne opératoire are now unequivocally documented at the very beginning of this period (c.3600–3300 cal BC), and were probably carried out with little variation until the introduction of tin-bronze technology. Copper Age ore mining has been brought to light at several sites including Monte Loretto in Liguria and Saint Véran in the French Alps (Bourgarit et al. 2008; Maggi & Pearce 2005); copper smelting is attested at open settlements such as Terrina IV in Corsica, San Carlo in the Tuscan Colline Metallifere and Neto-Via Verga north of Florence, but also at numerous rock shelters in the eastern Alps (Camps 1988; Fedeli 1995; Pearce 2007; Pedrotti 2001; Perini 2001; Sarti & Volante 2002); casting and smithing were probably carried out in most of the central Mediterranean region as the widespread crucibles, tuyères, and casting residues would suggest (Dolfini 2014: table 3); and metal objects were frequently deposited in burials following utilisation in a wide range of tasks including tree-felling, wood-working and possibly combat (Dolfini 2011).

Furthermore, mastery of polymetallic technology was perfected during this time period. Sulphidic ores were routinely smelted including iron-copper compounds and fahlores, from which arsenical and arsenical/antimonial alloys were naturally obtained. Metals other than copper were also exploited based on locally available sources. These encompassed silver, either from galena or argentiferous fahlores, lead (in Sardinia), and the rare antimony (in Tuscany). Gold was also used in Sardinia and possibly Malta during the 3rd millennium cal BC, but it is doubtful whether it was sourced locally (Atzeni et al. 2005; Giardino 2000; Trump 2004: 233; Valera et al. 2005). Importantly, claims for the gradual transition from an allegedly simpler arsenical-copper technology to allegedly more advanced ternary (copper-arsenic-antimony) alloys in central Italy have been disproved (De Marinis 2006). On the contrary, objects with both alloys (as well as pure copper) were cast from the beginning of the Copper Age, thus further demonstrating the rapid and precocious developments of metal technology in this area (Dolfini 2010; Dolfini et al. 2011).

Finally, it has been demonstrated that large implements including axes, daggers and possibly halberds were manufactured in Italy from the Early Copper Age, and that bivalve moulds were first employed in the casting of axes as early as the Late Neolithic (Giardino 2009-2012: 19). Metal objects were also frequently worked by complex (although somewhat incomplete: Artioli 2007) cycles of cold-hammering and annealing in the Copper Age. Strikingly, it would now appear that these objects were manufactured with little variation, either in shape or chemical make-up, until the advanced Copper Age. This is certainly the case for the Guardistallo-type daggers, which were first fashioned in the mid-4th millennium cal BC (Dolfini 2010). I would tentatively argue that the same holds true for most types of Copper Age trapezoidal axes, although interpretation is impeded by the insufficient number of radiocarbon dates. Certainly, current typologies based on the assumed gradual evolution of shapes and technological features are to be completely revised (Bianco Peroni 1994; Carancini 1993; 1999; 2001; 2006).

If we consider the stark contrast highlighted in this paper between emerging metallurgical practices in the Late/Final Neolithic (c.4500–3600 cal BC) and the appearance of fully fledged metal-working and metal-using in the Early Copper Age (c.3600–3300 cal BC), it would be almost unthinkable not to presume that some kind of technological intensification had occurred at the transition between the two horizons. This must have been sustained enough to account for the quasi-simultaneous upsurge of complex polymetallic technology in most of the Central Mediterranean region (although developments in southern Italy are probably later: Dolfini 2013), but also rapid enough not to leave any recognisable fingerprint
in the record: punctuation, not gradualism, was its main feature; generations of human lives, not the anonymous rolling of centuries and millennia, was its time-scale.

It is my contention that metal-working and metal-using intensified during the Final Neolithic c.3800–3600 cal BC. This is a short-lived and as yet poorly understood transitional phase in which the Late Neolithic world and some of its most distinctive practices (e.g. the use of portable figurines and the exchange of obsidian) dwindled and finally disappeared, or at any rate lost their prior centrality. New practices and spheres of action emerged in their place, in which the central Mediterranean communities rooted a novel sense of belonging and being in the world. Most prominently, these encompassed formalised burial practices and ancestor rituals in which new concepts of gender and personhood were brought about, and new artefacts were employed in their materialisation (Barfield 1998; Robb 2009; Whitehouse 1992a; 1992b). Interestingly, radiocarbon dating now indicates that Copper Age funerary customs were first elaborated in the centuries 3800–3600 cal BC (Cazzella & Silvestrini 2005). New ways of making and decorating ceramics also emerged in this time period from the pulverisation of the wide-ranging pottery styles of the Late Neolithic. In all likelihood, metalworking partook in the same, fast-changing technological and cultural milieu.

It is not difficult to imagine how, at a time when long-established skills, networks and allegiances (e.g. for the procurement, working and exchange of Alpine greenstone) were rapidly losing ground, new actors would have stepped forward who could take advantage from the stretching and tearing of the fabric of Neolithic society. Communities strategically located near the previously unimportant copper sources must have become indispensable intermediaries for the procurement of the bright-coloured ore; smelters and smiths, who mastered the potent rituals and magic required for turning crushed rocks into molten metal, and nondescript copper prills into shiny weapons, must have acquired unprecedented standing within their communities; and those with the ability to broker new alliances for the exchange of the finished objects must have won for themselves and their kin a new reputation and indeed a new power. In a matter of generations, these actors would have rearticulated metal and metalwork into a new material language, which would have newly defined that messy tangle of objects, relations and practices which we now call Copper Age society.

**CONCLUSIONS**

For a long time, early central Mediterranean metallurgy stood in splendid if rather uncomfortable isolation. This was due to two contrasting forces that pulled the subject, and especially its chronology, in opposite directions. On the one hand, it was argued that the first metal objects would have made their appearance in the early to mid 5th millennium cal BC – a time when most European societies had not yet made their first encounters with metalwork. On the other hand, it was claimed that metallurgical practices and products did not significantly spread through the Italian peninsula until the developed Copper Age – much later than in neighbouring areas north and east of the Alps. The evidence discussed in this paper has disproved both claims. As for now, not a single metal artefact can be securely assigned to as early a time as the Middle Neolithic (c.5000–4500 cal BC). At the same time, it is now evident that not only did the first metal objects appear south of the Alps in the ensuing Late Neolithic (c.4500–3800 cal BC), but also that the technology to make them spread in the same time-span. Crucially, this enabled the earliest smiths to locally cast large implements including axes, and to extend the then-developing extractive technology of copper to new ores and metals including lead, silver and antimony. Such an upsurge in metal-working and metal-using, which probably took place in northern Italy, west-central Italy and Sardinia in the Final Neolithic (c.3800–3600 cal BC), created the technological and social condition for metal to be fully incorporated into central Mediterranean society – with the notable exception of southernmost Italy, Sicily and the Maltese archipelago – from the Early Copper Age (c.3600–3300 cal BC).
ACKNOWLEDGEMENTS

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NOTE

1 For the sake of consistency, all radiocarbon dates cited in this work have been newly calibrated with OxCal 4.1 using IntCal 09 as a calibration curve (Bronk Ramsey 2009). The two confidence interval is in excess of 95% for all dates.
BIBLIOGRAPHY


