Frattesina and the later Bronze Age – Early Iron Age metals trade: the absolute chronology of smelting sites in the Trentino – Alto Adige/Südtirol

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SUMMARY

We present 15 new ^{14}C dates for copper smelting sites in the Trentino, together with 31 published dates for smelting sites in the region. Smelting may have already begun in the sixteenth century cal BC and continued until the ninth century cal BC. This suggests a new historical model, in which the twelfth-ninth centuries BC site of Frattesina, an important trans-shipment node between continental Europe and the Mediterranean and manufacturing site, is at the centre of the metals trade of the final Bronze Age and early Iron Age, rather than subsidiary to *Etruria mineraria*. Frattesina uses copper from the southern Alps, which is traded to peninsular Italy but also to Greece (probably as finished artefacts), while the metal production of *Etruria mineraria* is seen to be rather less important.

RIASSUNTO

Sono presentate 15 nuove date per siti fusori del Trentino, in aggiunta alle 31 già edite. La riduzione del rame sud-alpino potrebbe essere già cominciata nel XVI sec a.C. e sarebbe continuata fino al IX sec. a.C. Si propone un nuovo scenario storico, nel quale l'abitato di Frattesina, databile al XII-IX sec. a.C. ed importante interporto tra l'Europa continentale e il Mediterraneo nonché centro manufatturiero, si trova al centro del commercio dei metalli del Bronzo Finale e dell'inizio età del Ferro, anziché dipendente dalla produzione dell'Etruria mineraria. Frattesina sfrutta il rame delle Alpi meridionali, che commercia verso l'Italia peninsulare ma anche verso la Grecia (verosimilmente come manufatti finiti), mentre viene ridimensionata l'importanza della produzione di rame dell'Etruria mineraria in questa fase.

INTRODUCTION

Frattesina (Fratta Polesine RO) is a key site datable to the transition from the Bronze Age to the Iron Age, twelfth-ninth centuries BC (most recently, see BALDO *et al.* 2018 and BIETTI SESTIERI *et al.* (eds) 2019). The complex consists of a settlement situated along a palaeo-channel of the river Po, close to the Adriatic Sea, and two cemeteries, Le Narde and Fondo Zanotto. Frattesina, despite its apparently marginal location at the head of the Adriatic, played an important role in Mediterranean commercial networks: it acted as a trans-shipment node between continental Europe and the Mediterranean for materials like bronze and amber, but was also a manufacturing centre, whose production seems to have been mostly for export. There is important documentation of glass-working (TOWLE *et al.* 2002; HENDERSON *et al.*

2015; ANGELINI 2019a; HENDERSON 2019), Baltic amber working (BIETTI SESTIERI *et al.* 2015, p. 429, fig 2.12; BELLINTANI 2015, p. 117; ANGELINI 2019b) and ivory and ostrich eggshell were imported as raw materials, worked on site and re-exported (BIETTI SESTIERI, DE GROSSI MAZZORIN 2005; BIETTI SESTIERI *et al.* 2015; ANGELINI 2019c). There is also extensive evidence for working of antler (BIETTI SESTIERI 1975, pp. 5-7; BELLATO, BELLINTANI 1975) and bronze working was carried out on an industrial scale: some 100 casting moulds are known (for 61 of which LE FÈVRE-LEHÖERFF 1994, pp. 171, 187-212, figs 4-8, 11-12, 19, 21-22, 24, 26, 28-29, 31-32, 37-38) as well as 4 founder's hoards (BIETTI SESTIERI 1975, pp. 5-7; BIETTI SESTIERI *et al.* 2015, pp. 433-435; BIETTI SESTIERI, GIARDINO 2019). Elsewhere, one of us has argued that in importing luxury raw materials and transforming them into finished goods, Frattesina can be said to have 'added value' (PEARCE 2019, p. 350).

Frattesina played a key role in the circulation of bronze in Italy and the Adriatic, but the source of its copper has long been debated. It has been posited that the Final Bronze Age saw south Alpine copper production cease, to be replaced by supplies from the area of west central Italy which was later Etruria (PEARCE 2000; cf. 2007, pp. 89-90, 101-107), and certainly there are clear indications of shared types, and probably a metal trade in finished objects between Frattesina and the mineral rich areas of southern Tuscany, the Colline Metallifere. This has long been interpreted as indicating a metals trade from present-day southern Tuscany to Frattesina and northern Italy more generally (e.g. BIETTI SESTIERI 1981, pp. 235-237; 1987, pp. 385-396). While the Final Bronze Age certainly sees an increase in the incidence of metalwork in south Etruria, and the region is certainly rich in copper resources, to date there is little or no evidence for their exploitation at this period.

The widely-accepted model for the chronology of metal production in the mining areas of the Trentino – Alto Adige/Südtirol Region dates the extraction and working of copper, after a phase of exploitation in the Copper and Early Bronze Ages, to the Recent Bronze Age and beginning of the Final Bronze Age, and, on the basis of the material culture record for the smelting sites, holds that it ends in the Luco/Laugen A phase.[1] The available typo-chronological data suggests that the Luco/Laugen A phase should be dated to the Bz D2 and Ha A1 chronological phases, between the thirteenth and twelfth centuries BC (MARZATICO *et al.* 2010, pp. 131-132). It is worth noting that Giovanni Leonardi (2010, p. 552) has proposed a much later date for the cessation of copper production in the southern Alps, revising his previous hypothesis (BAGOLAN, LEONARDI 2000, pp. 25-26), and now dates it towards the end of the eleventh century BC.

In this paper we present 15 new radiocarbon determinations for south Alpine copper smelting sites in the Trentino, in the context of the dates which are available in the literature for smelting sites in the Trentino – Alto Adige/Südtirol Region. To date, although we can suggest which ore bodies were exploited thanks to lead isotope analysis, we cannot securely identify those copper mine workings which were active in the later Bronze Age, even if some of the

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[1] PREUSCHEN 1973, pp. 130-150; PERINI 1989; 1992, pp. 55-57; ŠEBESTA 1992, pp. 100-109, 174-215; MARZATICO 1997; CIERNY, MARZATICO 2002, pp. 261-265; CIERNY *et al.* 1998, pp. 28-30; 2004, pp. 134-144; PEARCE, DE GUIO 1999.

extraction sites described in the literature are likely to be prehistoric, such as, for example, those on the slopes of Monte Fronte, Vetriolo (TN),[2] which means that smelting sites act as a proxy to both attest and date copper mining. The chronology which emerges from our review leads to some important considerations regarding the later Bronze – Early Iron Age circulation of copper both between north and central Italy but also at a European and Mediterranean scale, and also for the role of Frattesina, one of the most important Mediterranean sites at the end of the Bronze Age.

THE RADIOCARBON CHRONOLOGY

If we are to have a reliable historical picture of metal production in the south Alpine mining areas of the Trentino – Alto Adige/Südtirol Region, we need a large series of radiocarbon determinations. To date, there are 31 dates available in the literature; of these 13 are for the copper smelting furnaces facility at Acqua Fredda (also known in the literature as Passo del Redebus), at Bedollo (TN) and 18 for other smelting facilities in the region (Figure 1; Table 1). To these we now add 15 new radiocarbon determinations, for the Trentino smelting sites of Le Val (Sant'Orsola), Pezhe Alte (Transacqua), Platz von Motze[3] (Luserna), Valcava (Fierozzo), Peciapian (Segonzano), and Acquedotto del Faoro (Transacqua)[4] (Table 2).

The 13 determinations for Acqua Fredda, which is a fundamental site for the comprehension of copper smelting in the later Bronze Age in the Trentino, are the most important series of dates as they document long-term use of this smelting facility. Marzatico *et al.* (2010, fig. 4) present a Bayesian statistical model for 11 of the radiocarbon measurements constructed on the basis of the stratigraphy of the site (a so-called 'stratigraphic prior') (CIERNY 2008, pp. 68-70). According to their model, which has a relatively low index of agreement of 72.1% and so is not particularly reliable, smelting at the site comes to an end after the second activity phase, dated *1080-900 cal BC* (the first activity phase dates between *1220 and 1000 cal BC* circa, the second activity phase between *1080 and 900 cal BC* circa and the final phase of the site, documented by two dates and for which there is no secure evidence for smelting, between *1000 and 800 cal BC* circa – MARZATICO *et al.* 2010, p. 132). Alongside pottery which may be assigned to the Luco/Laugen A phase, finds at Acqua Fredda also include a fragment of a crescent-shaped handle (*ansa lunata*) with expanded tips (*lobi espansi*), which may be dated to the Recent Bronze Age, and a Final Bronze Age type Fontanella bronze pin with a thickened neck (*con collo ingrossato*).[5]

In Figure 2 we present a combined plot of the published and new radiocarbon dates for smelting sites in the south Alpine Trentino – Alto Adige / Südtirol region (excluding Acqua

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[2] PREUSCHEN 1962; 1973, pp. 121, 126, figs 4 & 7, tav. 1 & 2; ŠEBESTA 1992, p. 188; GRAMOLA 2000, pp. 229-238; DETOMASO 2005, pp. 99-100, 109-110; PEARCE 2007, p. 58; CIERNY 2008, pp. 38-39.

[3] This toponym has many variant spellings: Platz/Pletz/Plaz/Plez von Motze/Mozze.

[4] BELLINTANI *et al.* 2010, pp. 278-279, fig. 1; SILVESTRI *et al.* 2014, pp. 91-95; 2015a; 2015b; BELLINTANI, SILVESTRI 2018. Further information about the sites is available as follows - Pezhe Alte (Transacqua): PREUSCHEN 1973, p. 143; ŠEBESTA 1992, p. 193; Platz von Motze (Luserna): PREUSCHEN 1965, pp. 10-13; 1973, p, 134, tav. 3 (Site 2, named 'Tezze – Nord'); ŠEBESTA 1992, p. 203; CIERNY 2008, pp. 214-215 (Site D6-12); NICOLIS *et al.* 2012; Peciapian (Segonzano): CIERNY 2008, p. 111 (Site D1-18).

[5] CIERNY, MARZATICO 2002, figs 2.1, 4.1; CIERNY *et al.* 2004, pp. 134-136, figs 17.1, 27.4; CIERNY 2008, taf. 1:2, taf. 2:6; MARZATICO *et al.* 2010, p. 135; cf. CARANCINI 1975, pp. 200-202, taf.45.1389-46.1409.

Fredda), calibrated at 95.4% with the most up-to-date calibration curve (OxCal 4.3; BRONK RAMSEY 2009; REIMER *et al.* 2013). As can be clearly seen, smelting in the Trentino probably began in the fifteenth, maybe even the sixteenth century cal BC (Malga Trenca, Beta-101719 - 1670-1130 cal BC;[6] Malga Pontara 2, Beta-101717 - 1620-1220 cal BC; Val Morta, Beta-101724 - 1610-1110 cal BC; Brombisc, Beta-101712 - 1530-1120 cal BC). Lead isotope data from Scandinavian confirms the early date at which production begins: two swords and a hilt-plated dagger dated 1600-1500 are compatible with the South Alpine Alto Adige Trentino Veneto (AATV) field.[7] Moreover, a recent lead isotope and geochemical study of 97 copper-based artefacts from the Danish Bronze Age (MELHEIM *et al*. 2018), found that most of the 33 Period II (1500-1300 BC) artefacts analysed were compatible with copper sources in the Italian eastern Alps, both the South Alpine AATV and the Valsugana 'Vulcanogenic Massive Sulphide' (VMS) fields; a later study by the same group, which partly uses the same data, found that 24 of the 58 swords dated 1500-1300 BC from Scandinavia, Germany and Italy which they analysed are compatible with copper from the Trentino – Alto Adige/Südtirol region (LING *et al*. 2019, pp. 20-21), and they suggested that 'mines in the Italian Alps became a main supplier to central and northern Europe' around 1500 BC (LING *et al*. 2019, p. 32). However, their claim that there is 'no secure evidence of Middle Bronze Age[8] (1650/1600-1350/1300 BCE) smelting activities' in the Italian south-eastern Alps (MELHEIM *et al*. 2018, p. 102), repeated by Ling *et al*. (2019, p. 22: 'there is limited evidence of ore extraction and smelting in the region' 1500-1300 BC) is refuted by the evidence presented in our paper. The radiocarbon evidence clearly attests such activity in the fifteenth and fourteenth centuries, and possibly even the sixteenth century cal BC.

Furthermore, the calibrated dates suggest that smelting may well have continued until as late as the ninth century cal BC, as attested by the dates for Casara Conti Mirafiori - 1130-790 cal BC (Beta-101714), Le Val - 1000-820 cal BC (DSH8307_C), Platz von Motze XIX, context 53 - 1110-780 cal BC (Beta-101723) and above all Lodner Moor - 980-800 cal BC (ETH-25274). This latter date was obtained on a wooden *Picea* plank, which seems to have been part of a feature for washing slag sand (MARZATICO *et al.* 2010, p. 138). As such, the material dated may suffer from the 'old wood effect' and actually be somewhat older than the feature it dates. Even though the date for Lodner Moor is so late, the pottery at the site may be assigned to the Luco/Laugen A phase and not to phase B (*ibid*., p. 138, fig. 8).

DISCUSSION

Establishing that smelting, and therefore copper mining in the Trentino – Alto Adige/Südtirol Region, may have lasted even until the ninth century cal BC has some significant consequences for our historical and economic understanding, since, as we have seen, the conventional models for the circulation of copper in northeast Italy posit an interruption in the supply for copper from the Trentino, replaced at the beginning of the Final Bronze Age, in the twelfth or eleventh centuries BC, by copper originating from *Etruria mineraria*.

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[6] All radiocarbon dates are calibrated at 95.4% with OxCal 4.3.; BRONK RAMSEY 2009; REIMER *et al*. 2013.

[7] For the Valsugana 'Vulcanogenic Massive Sulphide' (VMS) and the South Alpine Alto Adige Trentino Veneto (AATV) fields, see ARTIOLI *et al.* 2016.

[8] That is, the 'Middle Bronze Age' in Scandinavian chronology.

The new chronology also raises some important problems regarding the local chrono-typology, in particular 1) the long-debated problem of the chronology of the Luco/Laugen A phase and 2) the fact that to date Luco/Laugen B pottery is absent from smelting contexts.

This hypothesis that metal supply was interrupted, as well as being based on the argument that pottery dated to the Luco/Laugen B phase is not to be found in south-Alpine copper-smelting contexts (as we have seen, the mines exploited have not yet been securely identified), is founded on the cultural connections, attested by pottery, amber and bronze artefacts of similar or even identical types, between *Etruria mineraria* and northeast Italy in the context of the Final Bronze Age Protovillanovan *koine*,[9] such as type Ponte San Giovanni winged axes, socketed shovels and pick-ingots (BIETTI SESTIERI 1997, pp. 387-392). Indeed, metallurgical activity in *Etruria mineraria* seems to increase from the thirteenth century BC (PELLEGRINI 1995, p. 512), showing strong links with northeast Italy, and its importance is shown by a series of hoards dated to the Final Bronze Age and Early Iron Age (BIETTI SESTIERI 1996, pp. 296-297; 1997, p. 385).

Two particular artefact classes, the socketed shovels and pick-ingots,[10] have long been considered as an index of a metals trade between the mining areas of Tuscany, around the Colline Metallifere, and the North-East.[11] A distribution map and a detailed classification of socketed shovels are provided by Bellintani and Stefan (2008, figs 3, 4; additional findspots in LEONARDI *et al.* 2015, pp. 411-413, fig. 3). The type Fondo Paviani shovels may be dated to the last phase of the Recent and beginning of the Final Bronze Age, while those assigned to type 'tra Manciano e Samprugnano' are considered a development of them, and appear in Final Bronze Age 2 (BELLINTANI, STEFAN 2008, pp. 313-317: LEONARDI *et al.* 2015, p. 412); pick-ingots are considered to be similar in date (twelfth-tenth centuries BC – PELLEGRINI 1992a; 1992b). At this stage in our discussion it is important to note that Elisabetta Borgna (1992, pp. 75-84) put forward a different hypothesis, according to which the pick-ingots were produced in northeast Italy, rather than the mining areas of Tuscany, and therefore document continued supply of south-Alpine copper to the Po plain and central and southern Italy. Moreover, the finding of a mould for the production of socketed shovels at Frattesina (BELLINTANI G.F., PERETTO 1972; most recently, BELLINTANI P., STEFAN 2008) and of another at Fondo Paviani (Legnago VR) (LEONARDI *et al.* 2015, p. 412) to date the only sites at which any moulds for the production of this class of artefact are known, confirms the production of these tools in eastern Po plain and therefore Borgna's (1992, pp. 75-84) hypothesis (assuming, as seems reasonable, that the moulds were used at the sites where they were found). In a recent article on the Italian Final Bronze Age, Anna Maria Bietti Sestieri has reconsidered some aspects of her previously-published historical reconstructions and classifies the type Ponte San Giovanni axes and the socketed shovels as metal types which were specific to Po valley metal production and in particular to Frattesina (BIETTI SESTIERI 2009, p. 14). In other words, according to Bietti Sestieri, in the Final Bronze Age, Etruria

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[9] BIANCHIN CITTON 1986; BIETTI SESTIERI 1997; NEGRONI CATACCHIO *et al.* 2000; BELLINTANI 2011, pp. 268-277.

[10] Most recently, LEONARDI *et al.* 2015, pp. 410-411, distribution in fig 1. Note however that LEONARDI *et al.* 2015, fig.1, place Larnaud and Lagnieu erroneously (and follow the incorrect spelling 'Laigneu', present in the literature since at least PELLEGRINI 1992a, p. 353, nota 44 – see BOCQUET, LEBASCLE 1983, p. 87).

[11] BIETTI SESTIERI 1973, pp. 410-412, fig. 23.10; 1981, pp. 235-237; 1997, pp. 387-392; BORGNA 1992, p. 52.

north of the River Fiora participated in the main metal exchange circuit active in central-southern Europe, centred on the Po valley site of Frattesina and its territory. Finally, Leonardi and colleagues argue that since the fragments of pick-ingots in the south Tuscan hoard found between Manciano and Samprugnano are on average smaller than those from Frattesina and Madriolo (Cividale del Friuli UD), this would support the hypothesis that these artefacts originate in north-eastern Italy rather than Tuscany (LEONARDI *et al.* 2015, p. 411).

However, even these recent contributions on the role of Frattesina and more in general on the metallurgy of northeast Italy at the turn of the second millennium BC do not necessarily contribute to the debate on the provenance of the *metal* used for their manufacture, since the copper cannot originate in the Po delta, where there are no ore deposits: it must necessarily originate elsewhere, as does the tin. It therefore cannot be used as proof of the use of copper from the North.

Analytical data

There are a number of published analyses for pick ingots (review in PEARCE 2000; 2007, pp. 90, 107; more recently, four pick-ingots were analysed by JUNG *et al.* 2011, p. 243, tab. 23.1, and 11 by GIARDINO, PATERNOSTER 2019, tab. 1). The four analysed from the Redipuglia hoard (Fogliano Redipuglia GO) have a relatively significant tin composition (respectively 3.2%, 4.2%, 4.8% e 4.8% – BORGNA 1992, pp. 29-30) while the two pick-ingots analysed from the Madriolo hoard (Cividale del Friuli UD) have a high tin content, reported as ‘12.27%’ and ‘14.77%’ (PIGORINI 1895, p. 18), as do the four pick-ingots from the second Frattesina hoard, analysed by Jung *et al.* (2011, p. 243, tab. 23.1), whose tin content is reported as varying between 10.2% and 14.7% (precise analytical data have not yet been published). The 11 pick-ingots from the Frattesina hoards (one from hoard 1, seven from hoard 2 and three from hoard 4) analysed by Giardino and Paternoster (2019, tab.1) have a tin content of around 10%, with a standard deviation of ±3% (*ibid.*, tab. 3); their lead contexnt averages 2.3% (s.d. ±2%) but two exemplars from the second hoard have higher lead contents, of 5% and 6%. On the other hand, only qualitative analyses of pick-ingots are published by Pellegrini (1992b; 1995; CASAGRANDE *et al.* 1993). An exemplar from the hoard discovered ‘between Manciano and Samprugnano’ (GR) has a copper matrix (PELLEGRINI 1992b, p. 597) but is characterised by a ‘considerable presence’ (‘*forte presenza*’) of antimony (PELLEGRINI 1992b, p. 593, cf. p. 597). On the other hand, two other qualitatively-analysed pick-ingots, from the Madriolo hoard and from a hoard from an ‘unknown locality in central Italy’, are bronze, but the Madriolo pick-ingot is characterised by a considerable and constant presence (‘*forte e costante presenza*’) of lead oxides (PELLEGRINI 1992b, p. 593; CASAGRANDE *et al.* 1993, p. 266). Finally, a second pick-ingot from Madriolo has a matrix of only copper (‘*matrice di solo rame*’) with traces of nickel and antimony (CASAGRANDE *et al.* 1993, p. 266). In contrast, a pick ingot from Porpetto (UD) has a low tin content (0.05%) but a lead content of 7.06% (TRAMPUŽ-OREL, HEATH 2001, fig. 17) and the five pick-ingots analysed from the Slovene hoards of Kanalski Vrh I and II and Veliki Otok I all have tin contents below 0.15% but contain high percentages of lead, varying between 17.70% and 36.87% (TRAMPUŽ-OREL 1996, pp. 227, 229-230, 234).

The compositional analyses for the pick-ingots available in the literature are not therefore useful in identifying a provenance for the copper used to make them, even if the 'considerable presence' (these are qualitative data) of antimony in the pick-ingot from the hoard found 'between Manciano and Samprugnano' (GR) could indicate the use of locally-occurring copper, given that the Manciano mining district is particularly rich in antimony (PELLEGRINI 1992b, p. 593). The Slovene pick-ingots and that from Porpetto (close to the Slovene border), with high lead contents, reflect a local metallurgical practice of the production of lead-rich alloys (HEATH *et al.* 2000), and since they are alloys, it is likely that neither these pick-ingots nor those in bronze found in modern-day Italy are primary products of copper ore smelting, but rather ingots made of material that has already been alloyed, and therefore may contain an unknown percentage of recycled copper. Leonardi and colleagues (2015, pp. 411, 416) suggest that the pick-ingots were manufactured in the eastern Alps, but they are more likely to have been made in a range of centres, following local alloying conventions – as attested, for example, by the high lead content of the Slovene and Porpetto examples. These analyses do not therefore contribute to resolving the question as to whether copper production continued in what is now Trentino – Alto Adige/Südtirol.

Federico Zaghis (2003; 2005; ZAGHIS *et al.* 2006) reports that he analysed 66 samples from the fourth hoard from Frattesina, and that as well as compositional analysis, he also obtained measurements for the lead isotope ratios for a lead ingot from the assemblage. Unfortunately the analytical data, regarding both the artefact composition and the lead isotope ratios for the ingot, are unpublished, but Zaghis (2003) argues that neither Alpine nor Tuscan lead was used for the ingot, and suggests a Sardinian origin, on the basis of the fact that the mineralisation is of a Variscan layer type which can be dated to 360-250 million years ago (but see below). Given the high percentage of lead in the pick ingots from the Kanalski Vrh I and II and Veliki Otok I hoards in Slovenia (TRAMPUŽ-OREL 1996, pp. 227, 229-230, 234), the presence of a lead ingot in the Frattesina hoard is extremely interesting. Angelini *et al.* (2015, p. 276) report that Zaghis also obtained lead isotope data for three pick-ingots (FR22, FR23 and FR28) and a socketed shovel (FR33) from Frattesina, and that they are all compatible with south-east Alpine copper sources apart from one of the pick-ingots (FR22); unfortunately they do not give further information and publish no analytical data, so that this cannot be verified.

Reinhard Jung and colleagues (JUNG *et al.* 2011, tab. 23.1) discuss analyses of 22 artefacts from the Veneto and from Lombardy (including two socketed shovels from the second Frattesina hoard), six ingots from the second Frattesina hoard (four of which are pick-ingots and two plano-convex bun ingots), and seven artefacts from southern Italy (Puglia and Calabria), for which they determined the composition and the lead isotope ratios; unfortunately the analytical data are still unpublished (cf. PEARCE 2016, pp. 49-50). Jung *et al.* (2011, pp. 236-238) report that a comparison with the data then available for the lead isotope ratios for Tuscan and Sardinian copper minerals allows them to exclude Tuscany and Sardinia as a provenance for the samples analysed, and that one of the pick ingots might originate from Cyprus (*ibid.*, p. 244), but until their data are published, it is not possible to verify any correlations with the published isotope data for Tuscany, Sardinia or Cyprus, or for the copper minerals of the southern Alps, which are now available (NIMIS *et al.* 2012, tab. 2; KÖPPEL, SCHROLL 1985, tab. 4). They also argue that the copper used for almost all the artefacts analysed came from the same mining district (JUNG *et al.* 2011, pp. 235, 238), and that comparison with compositional analyses for some droplets of copper from Acqua Fredda (METTEN 2003, pp. 61, 116, tab. 27) suggests an ore source in Trentino – Alto Adige/Südtirol (JUNG *et al.* 2011, p. 238). This interesting statement, and comparisons with analyses of material from the contemporary sites in the Marche of Moscosi di Cingoli (MC) and Cisterna di Tolentino (MC), which would confirm the circulation of south-Alpine copper in the middle Adriatic area (JUNG *et al.* 2011, pp. 239-240), can only be verified further when the analytical data have been published.

Jung and Mehofer (2013, p. 178) report further analyses and their corpus now consists of: 49 artefacts with an Italian provenance (of which 27 from the Veneto and Lombardy, 16 from Calabria and Puglia and six from southeast Sicily), 19 slag samples from Trentino, 89 artefacts from Greece, plus an unspecified number of artefacts from other areas of the Mediterranean; an important finding is that the lead isotope ratios of most of the analysed artefacts from Italy correspond to those of the Trentino slags (*ibid*., p. 178, fig. 5). Moreover, and it is an equally interesting finding, while the majority of the artefacts from Greece seem to be made from Cypriot copper, a few artefacts – all of Italian types – seem to be made of Trentino copper (*ibid*.). They note that the fact that two type Pertosa swords analysed, found in the Grotta Manaccora (Peschici FG) and at the Ipogeo dei bronzi at Trinitapoli (FG), are of a type which is not attested in north Italy suggests that they were made in south Italy with copper from Trentino (*ibid*., pp. 178-179). Unfortunately, again the analytical data are not included in this publication.

Villa and Giardino (2019, tab. C) present lead isotope analyses for 26 artefacts from the four Frattesina hoards, including 10 pick-ingots (seven from the second hoard and three from the fourth hoard); they assign four of the second hoard exemplars to the Valsugana VMS field and two to the South Alpine AATV field, while all three fourth hoard pick-ingots are assigned to the VMS field. They confirm the hypothesis of Jung *et al*. (2011, p. 244) that one of the pick-ingots from the second hoard is likely to be made of Cypriot copper and suggest that the lead ingot from the fourth hoard was in fact made of Alpine (AATV) metal (*contra* ZAGHIS 2003).

A recent lead isotope and geochemical study of 97 copper-based artefacts from the Danish Bronze Age, reported by Melheim *et al.* (2018), found an important presence of copper originating from the Italian Alps in bronzework dating 1500-900 BC. As we have seen, most of the 33 Period II (1500-1300 BC) artefacts analysed were compatible with Italian Alpine copper (AATV and VMS fields). The same pattern was found for the 18 Period IV (1300-1100 BC) artefacts, at least 12 of which were compatible with the AATV field. Period IV artefacts were largely consistent with the AATV field, while other ore sources are suggested for Periods V and VI (900-500 BC). The later lead isotope study on swords from Scandinavia, Germany and Italy by Ling *et al*. (2019), shows the presence of AATV copper in Scandinavia already in 1600-1500 BC and that 24 of the 58 swords dated 1500-1300 BC which they analysed are compatible with AATV copper (LING *et al*. 2019, pp. 20-21, 24).

Most of the 43 swords they analysed dating to 1300-1100 BC were compatible with Trentino Alto-Adige/Südtirol copper, though there are overlaps with other isotopic fields (LING *et al.* 2019, p. 24). Interestingly, Oscar Montelius (e.g. 1910) posited a model in which Italian metalwork flowed north in exchange for Baltic amber.

Finally, an abstract by Zofia Stos-Gale (2017, p.8) reports that lead isotope analysis of a selection of late Bronze Age tin bronze artefacts from Bulgaria, including all those from the thirteenth-twelfth centuries BC Varbitsa hoard "have lead isotope ratios … consistent with the lead isotope patterns formed by the data for ores from the Italian Eastern Alps Southalpine" AATV deposits. When this data is more fully published it will be possible to comment further.

The role of Frattesina

A later date for the end of metal production in Trentino provides a more convincing explanation for the prosperity of twelfth-ninth centuries BC trading and manufacturing site of Frattesina. According to our hypothesis, Trentino continued to be a source of copper for Frattesina even in phases 2 and probably 3 of the settlement. This 'commercial' site, located at the apex of what were then the northern branches of the Po delta (BALDO *et al.* 2018, p. 31, fig. 1), would thus have controlled the trade in south-Alpine metal via the long-distance networks as well. Otherwise, following the traditional model that sees *Etruria mineraria* as the only source of metal at the turn of the second millennium BC, it would be more logical for the Orientals (perhaps Cypriots, SHERRATT 2000, p. 87) with whom Frattesina traded, rather than sailing to the north-western coasts of the Adriatic, to have gone directly to the mineral-rich areas of the Tyrrhenian, as they did both in Mycenaean times (as suggested by the findings of Aegean-type sherds at Monte Rovello [Allumiere RM], Luni sul Mignone [Blera VT], San Giovenale [Blera VT] and Scarceta [Manciano GR]: most recently VAGNETTI *et al.* 2014, pp. 40-41, fig. 2.1; JONES, LEVI 2014, pp. 206-208, 263, figs 4.35, 4.85, 4.86]), and also in the period of Greek colonisation, as attested for example at Pithekoussai (Lacco Ameno NA) on the Island of Ischia (RIDGWAY 1984).[12]

Even if the later Bronze Age sees a flourishing of metal industry in *Etruria mineraria*, shown for example by the production of bronze tools at Scarceta (GIARDINO, POGGIANI KELLER 2012), we lack secure evidence for the contemporary exploitation of local copper ore resources (GIARDINO 2008, p. 75). Moreover, although there are a few artefacts in circulation in northern Italy for which lead isotope analysis indicates a probable use of Tuscan metal,[13] there is no evidence to date for artefacts in Tuscan metal in the eastern Mediterranean.[14] Indeed, the mine of Poggio Malinverno (Allumiere RM) in the Monti della Tolfa, the only prehistoric mine found so far, should probably be dated to the Copper Age thanks to the parallels for the hammerstones that have been found at the site (GIARDINO, STEINIGER 2011). Ingots of raw material whose form appears to be prehistoric are known from the Colline

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[12] We should not, however, underestimate the importance of other factors that favoured the Adriatic route, such as the amber trade.

[13] For example, an ingot from the final Bronze Age hoard from Muscoli (Cervignano del Friuli UD: CANOVARO *et al.* 2018, pp. 351-352) and perhaps a flat ingot from Frattesina hoard 1 (n.140) – VILLA, GIARDINO 2019, p. 259.

[14] We are most grateful to one of the anonymous referees for making this important point.

Metallifere area (e.g. ARANGUREN, SOZZI 2005) but these are mostly without a context. In the Monti della Tolfa, in South Etruria, the situation is substantially the same, apart from the report of iron-ore (limonite?) and copper slag from casting or smelting associated with worked quartz crystals in the Final Bronze Age layers of the settlement of Elceto (Allumiere RM) (ZIFFERERO 1992, p. 88), though no analyses are available. Even if it is likely that the local ore resources were exploited, and lead isotope evidence suggests that they were to some degree, it is therefore probable that this exploitation was still insubstantial, and that the well-known typological links of metal artefacts between Frattesina and Etruria are not necessarily an index of trade in metal originating in the area of Tuscany and Latium, as they have generally been considered; they could also attest to trade in copper from the southern Alps, as was already suggested by Elisabetta Borgna (1992, pp. 75-84). Cardarelli (2000, p. 95), Bietti Sestieri (2009, p.32) and Leonardi (2010, pp. 550-551), from different interpretative perspectives, have made suggestions concerning the origins and role of Frattesina, which now acquire new relevance. This 'proto-industrial' site in the Polesine 'drained' (or rather exploited) Alpine resources (copper) and those goods that passed through the Alps (like Baltic amber; BELLINTANI 2015). Frattesina was thus successor to the world of the lake-dwellings and Terramare, at the centre of a network of long-distance trade, and was a 'pole of attraction' for the Tyrrhenian world (rather than being on its periphery).

The chronology of Luco/Laugen A

As we have seen, there is no evidence to date for pottery of Luco/Laugen B type in the smelting sites of Trentino – Alto Adige/Südtirol, despite the fact that these continue into the Iron Age, perhaps until the ninth century BC.[15] This poses the problem of fixing the chronology of the end of the Luco/Laugen A phase, and could suggest that it has been assigned too early a date.[16]

Luco/Laugen A material, mostly pottery, has also been found to the south and west of the Alpine area considered to be its 'cultural territory' (see, for example, LEONARDI 2010, fig. 2). Recently Anna Angelini (2014) has reviewed this material, providing an updated list of findspots: in Lombardy at Parre (BG) in the Orobian Alps, at Dosso Castelli and Dosso Giroldo (Grosio SO) in the upper Valtellina and at Ponte San Marco (Calcinato BS), on the River Chiese, and in the Veneto pre-Alps at Custoza (Sommacampagna VR), Monte Casteggion[17] (Colognola ai Colli VR), Monte Castello (Magré VI) and Bostel (Rotzo VI); San Tomio (Malo VI) should be added to this list.[18] A vase-headed pin of alpine type was found at Montebello Vicentino (VI). The material excavated at Castel de Pedena (San Gregorio nelle Alpi BL), which controls the access routes to the Agordino mining district, is

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[15] Though given the poor state of our knowledge about Luco/Laugen phase B pottery, its similarity to phase A ceramics, and the general dearth of ceramic material at smelting sites, it is not impossible this absence of evidence is not in fact evidence of absence.

[16] The transition between Luco/Laugen phases A and B was traditionally assigned to the tenth century BC (MARZATICO 2001, p. 429; 2012, pp. 179-181), but more recently MARZATICO *et al.* (2010, p. 135) have suggested that Luco/Laugen B approximately dates 'to the 11th-10th/9th centuries BC (Ha A2-B1/B2)', which is supported by radiocarbon dates from the settlement at Vadena, where Luco B material already appears before c. 1000 cal BC (ALBERTI *et al.* 2005, p. 235).

[17] Also known as Castejon in the literature.

[18] MIGLIAVACCA 2015, p. 484, note 5, with previous bibliography.

particularly important (DONADEL 2012, pp. 99-100, figs 4.45, 4.46, 5; LEONARDI 2012, p. 159).

Luco/Laugen A pottery is also reported at various findspots in the northern Po plain: Cascina Montecchio (Vidolasco CR), Ca' Franchini (Sacca di Goito MN) and Casalmoro (MN)[19] (ANGELINI 2014). It has also been found in the Po delta: two sherds at Frattesina (Fratta Polesine RO) (BELLINTANI, SARACINO 2015, p. 82, fig. 4.1) and a sherd from Campestrin (Grignano Polesine RO) (BELLINTANI *et al*. 2019). One of the Luco/Laugen A sherds found at Frattesina seems to have been made with clay deriving from the Berici hills, outside the classic area of the Luco/Laugen culture (SARACINO *et al*. 2018, p. 112). The clay is petrographically similar to 4th century BC pottery from the settlement of Montebello Vicentino (SARACINO *et al*. 2018, p. 112; LEONARDI *et al*. 2013).

It is particularly interesting to note (not least in the light of our new model) that there are also a number of reports of pottery attributed to Luco/Laugen B outside its alpine 'cultural territory': Monte Summano – Valle del Castello (Santorso VI), the "casa gotica" at Asolo (TV) and at Castel de Pedena where there is also material from the later Luco/Laugen B-C phase (DONADEL 2012, pp. 99-100, figs 4.45, 4.46, 5; LEONARDI 2012, p. 159; ANGELINI 2014).

The presence of Luco/Laugen material in metallurgical sites outside its classic area of distribution could indicate that people from the Luco/Laugen area were brought in as specialised metallurgists, rather as in the late Middle Ages specialised miners, the Bergamaschi or 'Visentainer', moved around northern Italy. After the crisis of the Terramare world, we may be seeing a reorganisation of the system of exchange between the southern Alps and the Po plain, previously controlled by the communities of the plain, in which there was now participation of 'Luco/Laugen specialists', above all outside the sphere of Frattesina, as for example at Ponte San Marco (BELLINTANI 2015, p. 125).

The role of San Giorgio di Angarano

A historical and economic model which envisages continued metallurgical production in Trentino – Alto Adige/Südtirol into the first centuries of the first millennium also provides an explanation for the thirteenth to the beginning of the eighth century BC cemetery at San Giorgio di Angarano (Bassano del Grappa VI; BIANCHIN CITTON 1982), located close to the mouth of the Valsugana and thus ideally situated to control the flow of the metals trade along the River Brenta, and also across the Asiago plateau (*ibid*., pp. 196-197) (Fig. 3), towards the Veneto plain and the Po valley more widely. Even though the distribution of some of the grave goods found in the cemetery includes *Etruria mineraria* (*ibid*.), such as for example the type Croson di Bovolone razor in tomb 45 (BIANCHIN CITTON 1982, pp. 84-87, n. 3; cf. BIANCO PERONI 1979, pp. 17-18, 190, tav. 6, n. 81, tav. 112A), the type Fontanella razor in tomb 43 (BIANCHIN CITTON 1982, pp. 81-82, n. 2; cf. BIANCO PERONI 1979, pp. 58-60, tav. 24, n. 303, tav. 112B) or the two-piece serpentine fibulas of which one was found in tomb 42 and the other was a stray find (BIANCHIN CITTON 1982, pp. 79-80, n. 1, 186, n. 122; cf. VON

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[19] For the Luco/Laugen A sherd from Casalmoro see PAU 2015, p. 814, fig, 2.1.

ELES MASI 1986, pp. 210-211, tav. 163, n. 2133 & 2137), characteristic types of present-day Trentino – Alto Adige/Südtirol were also found, like the type Marco pin from tomb 42 (BIANCHIN CITTON 1982, pp. 79-80; cf. CARANCINI 1975, p. 204, n. 1424, tav. 46). The San Giorgio di Angarano cemetery, situated along some of the routes from the mining areas of the upper Valsugana towards the Po plain, therefore likely owed its location, prosperity and long period of use (from the thirteenth to the beginning of the eighth century BC – BAGOLAN, LEONARDI 2000, fig. 6b; BIANCHIN CITTON 1982, p. 194) to control of the metals trade.

CONCLUSIONS

The radiocarbon chronology for the smelting sites of the Trentino - Alto Adige / Südtirol region indicate that smelting may have already begun in the sixteenth century cal BC and continued until the ninth century cal BC. This copper is traded north as far as Bulgaria, Denmark, around Italy and, as finished artefacts, to Greece. The new model which emerges from our considerations begins to fill the gap between the mining activity in the Trentino and the start of exploitation of the mines in Lombardy, which is first documented at Silter di Campolungo (Bienno BS) in the Valcamonica – 830-540 cal BC and 750-400 cal BC – and at Campomoro (Lanzada SO) in the Valtellina – 800-400 cal BC (Table 3; Fig. 4; CASINI *et al.* 1999, p. 182; MORIN, TIZZONI 2009, pp. 122, 127), and is in full agreement with the continuity of copper mining elsewhere in the Alps (STÖLLNER 2010, pp. 302-303, fig. 2). Indeed, in the Tyrol we have a radiocarbon date for the 'Heidenzechen' (Schwaz) of 970-761 cal BC (ETH-10128: 2655±55 BP) (BREITENLECHNER *et al.* 2010, p. 1465) and dendrochronological dates for two sites: Schwarzenbergmoos (Radfeld/Brixlegg) – 900-869 BC circa (NICOLUSSI *et al.* 2010) and Mauk E (Schwaz/Brixlegg) – 707 BC (PICHLER *et al.* 2010). There are two similar dates from the Mitterberg main lode (Bischofshofen, Salzburg): 921–831 cal BC (GrN-25383: 2740±20 BP) and 1002-846 cal BC (GrN-25383: 2780±25 BP) (BREITENLECHNER *et al.* 2014, p. 121, tab. 5). Moreover, we have radiocarbon dates for two sites further East in the Neuenkirchen district, in southeast Lower Austria (TREBSCHE 2015, tab. 2): at smelting site P III at Prein an der Rax, 995-825 cal BC (Poz-54655: 2755±35 BP, calibrated at 95.4%),[20] and at Prigglitz-Gasteil, with seven determinations which calibrate at 95.4% in the twelfth to ninth centuries cal BC. Further West, in the Oberhalbstein mining district in Switzerland, two radiocarbon dates for the smelting site of 'Ried südlich Gruba I' at Marmorera (GR) calibrate to 1020-840 cal BC and 910-800 cal BC (TURCK *et al.* 2014, pp. 222-224, fig. 7).

We can also propose a simple explanation for the location, wealth and long period of use of the San Giorgio di Angarano cemetery, situated to control the routes between the mining areas of the Valsugana and the Po delta.

That metallurgical production continued in Trentino – Alto Adige/Südtirol until the ninth century BC, as documented by the radiocarbon dates, throws into crisis our understanding of the chronology of the Luco/Laugen A phase, and in particular the transition to phase B, since

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[20] NB there is a transcription error in table 2 of TREBSCHE 2015.

pottery which may be assigned to the second phase is so far absent from smelting sites. However, this continuing activity allows us to propose a new historical model, in which Frattesina is at the centre of the metals trade of the final Bronze Age and early Iron Age, rather than subsidiary to *Etruria mineraria*. Frattesina exploits the copper from Trentino – Alto Adige/Südtirol, which is traded to peninsular Italy but also to Greece (probably in the form of finished artefacts), and where the metallurgical production of *Etruria mineraria* is seen to be rather less important.

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Tables & Figures

Site	**Comments**	**Lab n.**	**^{14}C age BP**	**Calibrated age BC**	**Confidence**	**Source**
Malga Trenca		Beta-101719	3160±100	1664-1131	95.3%	CIERNY 2008, tab. 3
Malga Pontara 2		Beta-101717	3150±80	1613-1223	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF I, context 30	Beta-101699	3130±90	1614-1131	95.4%	CIERNY 2008, tab. 3
Val Morta		Beta-101724	3100±90	1608-1113	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF VI-B, furnace 9	Beta-101705	3100±80	1529-1125	95.4%	CIERNY 2008, tab. 3
Brombisc		Beta-101712	3100±80	1529-1125	95.4%	CIERNY 2008, tab. 3
Lodner Moor	Context 2b, Grid sq. B10	ETH-25272	3100±45	1492-1232	95.4%	MARZATICO *et al.* 2010, p. 138, fig. 7
Malga Stramaiolo		Beta-101718	3060±70	1495-1116	95.4%	CIERNY 2008, tab. 3
Bedelar		Beta-101711	3050±90	1501-1043	95.4%	CIERNY 2008, tab. 3
Cambroncoi	Test pit 2, 3	Beta-126098	3040±130	1607-928	95.3%	CIERNY 2008, tab. 3
Acqua Fredda	AcF I, layer C	Beta-126096	3040±60	1431-1119	95.4%	CIERNY 2008, tab. 3
Platz von Motze	XI, context 45	Beta-101720	3020±80	1436-1022	95.4%	CIERNY 2008, tab. 3
Peciapian (Segonzano)	N.18, context 15 SEPE	LTL-2791A	3019±45	1401-1126	95.4%	SILVESTRI *et al.* 2015a, tab. 1
Peciapian (Segonzano)	N.13, context 6 BASE SEPE	LTL-2790A	2996±45	1393-1059	95.4%	SILVESTRI *et al.* 2015a, tab. 1

Malga Millegrobbe		Beta-101715	2990±50	1391-1054	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF I, furnace 1	Beta-126099	2980±50	1387-1047	95.4%	CIERNY 2008, tab. 3
Peciapian (Segonzano)	N.92, context 15 SEPE	LTL-2792A	2969±45	1376-1041	95.4%	SILVESTRI *et al.* 2015a, tab. 1
Platz von Motze	XIX, context 57	Beta-101722	2930±70	1376-929	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF I, furnace 5	Beta-101700	2880±100	1376-831	95.4%	CIERNY 2008, tab. 3
Prati di Montagna		Beta-101723	2880±70	1266-856	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF VI-B, F2	Beta-101708	2880±70	1266-856	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF VI-B, furnace 8	Beta-101704	2830±80	1212-827	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF VI, F1	Beta-101703	2850±40	1127-906	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF IV, context 411/412	Beta-101702	2830±70	1207-833	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF VI-A, furnace 7	Beta-101706	2830±70	1207-833	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF VI-C, context 686, Brett	Beta-101709	2790±60	1110-818	95.4%	CIERNY 2008, tab. 3
Casara Conti Mirafiori		Beta-101714	2770±80	1127-798	95.4%	CIERNY 2008, tab. 3
Platz von Motze	XIX, context 53	Beta-101723	2730±80	1109-788	95.4%	CIERNY 2008, tab. 3
Lodner Moor	Context 3, Grid sq. B9	ETH-25274	2715±45	974 -801	95.4%	MARZATICO *et al.* 2010, p. 138, fig. 7
Acqua Fredda	AcF IV, context 403	Beta-101701	2680±90	1084-544	95.4%	CIERNY 2008, tab. 3
Acqua Fredda	AcF VII, context 704	Beta-111571	2660±80	1014-544	95.4%	CIERNY 2008, tab. 3

Table 1. Published radiocarbon determinations for smelting sites in Trentino – Alto Adige/Südtirol (note that CIERNY [2008, tab. 3] assigns the lab n. Beta-101723 to two samples). Calibrated at 95.4% with OxCal 4.3.2; BRONK RAMSEY 2009; REIMER *et al.* 2013.

Site	**Comments**	**Lab n.**	**^{14}C age BP**	**Calibrated age BC**	**Confidence**
Le Val (Sant'Orsola)	Context 17	DSH8303_C	3127±31	1494-1297	95.4%

Pezhe Alte (Transacqua)	Trench 3, context 515	DSH8296_C	3114±25	1437-1299	95.4%
Platz von Motze (Luserna)	2005 sector B, context 86, section 3	DSH8294_C	3080±33	1426-1261	95.4%
Pezhe Alte (Transacqua)	Trench 2, context 303 base	DSH8310_C	3039±27	1395-1216	95.4%
Valcava (Fierozzo)	Context 6	DSH8299_C	3038±25	1393-1218	95.4%
Platz von Motze (Luserna)	2009 sector B, context 84, Grid sq. C11	DSH8308_C	3028±30	1395-1134	95.4%
Valcava (Fierozzo)	Context 13	UBA-25284	3017±29	1389-1131	95.4%
Platz von Motze (Luserna)	2006, context 73, Grid sq.B5	DSH8293_C	3111±28	1436-1292	95.4%
Le Val (Sant'Orsola)	Trench 1 context 28	DSH8315_C	2975±32	1369-1057	95.5%
Acquedotto del Faoro (Transacqua)	Context 1005	DSH8317_C	2972±50	1382-1027	95.4%
Peciapian (Segonzano)	SEG_13_83_260	DSH8267_W	2942±35	1260-1028	95.4%
Valcava (Fierozzo)	Context 6	UBA-25282	2940±34	1258-1028	95.4%
Peciapian (Segonzano)	SEG_13_83_255	DSH8266_W	2906±34	1211-1005	95.4%
Valcava (Fierozzo)	Context 16	DSH8304_C	2903±45	1222-941	95.4%
Le Val (Sant'Orsola)	Trench 1 context 27	DSH8307_C	2757±32	994-827	95.4%

Table 2. New radiocarbon determinations for smelting sites in the Trentino (calibrated at 95.4% with OxCal 4.3.2; BRONK RAMSEY 2009; REIMER *et al.* 2013).

Site	**Lab n.**	**^{14}C age BP**	**Calibrated age BC**	**Confidence**	**Source**
Silter di Campolungo	BM-3016	2580±45	831-544	95.4%	MORIN, TIZZONI 2009, p. 122
Silter di Campolungo	BM-3054	2410±35	748-398	95.4%	MORIN, TIZZONI 2009, p. 127
Campomoro	Geochron-?	2490±95	802-403	95.4%	CASINI *et al.* 1999, p. 182
Campomoro	BM-3038	2230±45	394-197	95.4%	CASINI *et al.* 1999, p. 182

Table 3. Radiocarbon determinations for Silter di Campolongo (Bienno BS) and Campomoro (Lanzada SO). Calibrated at 95.4% with OxCal 4.3.2; Bronk Ramsey 2009; Reimer *et al.* 2013.

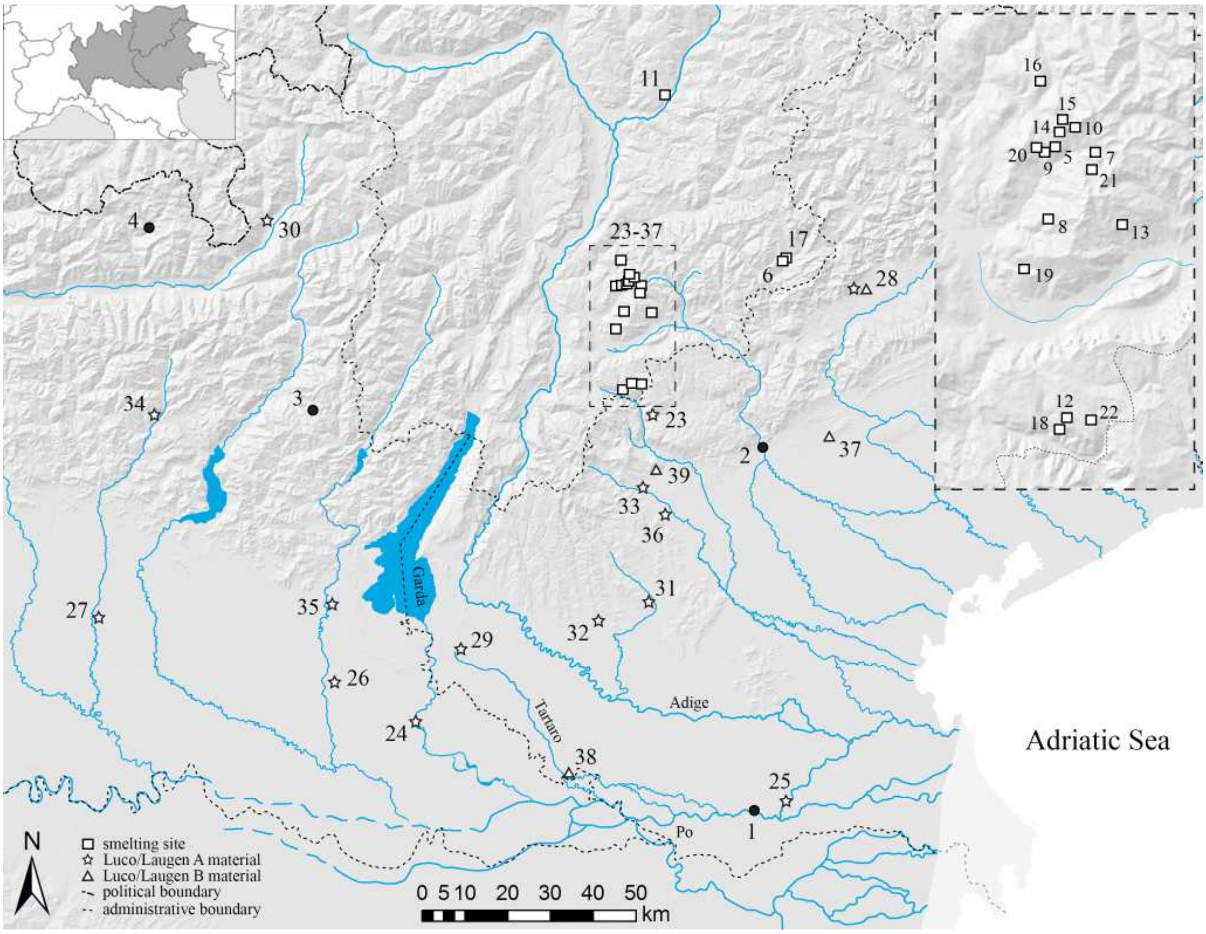

Figure 1. Sites mentioned in the text (map by Fabio Saccoccio using data from Balista 2009; 2018; Farr *et al.* 2007; Piovan *et al.* 2012; Ravazzi *et al.* 2013).

1. Frattesina, Le Narde, Fondo Zanotto (Fratta Polesine RO); 2. San Giorgio di Angarano (Bassano del Grappa VI); 3. Silter di Campolungo (Bienno BS); 4. Campomoro (Lanzada SO).

Trentino – Alto Adige/Südtirol smelting sites: 5. Acqua Fredda / Passo del Redebus (Bedollo TN); 6. Acquedotto del Faoro (Transacqua TN); 7. Bedelar (Palù de Fersina TN); 8. Brombisc (Frassilongo TN); 9. Cambroncoi (Sant'Orsola Terme TN); 10. Casara Conti Mirafiori (Bedollo TN); 11. Lodner Moor (Renon / Ritten BZ); 12. Malga Millegrobbe (Lavarone TN); 13. Malga Trenca (Roncegno TN); 14. Malga Pontara 2 (Bedollo TN); 15. Malga Stramaiolo (Bedollo TN); 16. Peciapian (Segonzano TN); 17. Pezhe Alte (Transacqua TN); 18. Platz von Motze (Luserna TN); 19. Prati di Montagna / Bergwiesen (Fierozzo TN); 20. Le Val (Sant'Orsola TN); 21. Valcava (Fierozzo TN); 22. Val Morta (Luserna TN).

Luco/Laugen A material outside its 'cultural territory': 23. Bostel (Rotzo VI); 24. Ca' Franchini (Sacca di Goito MN); 25. Campestrin (Grignano Polesine RO); 26. Casalmoro

(MN); 27. Cascina Montecchio (Vidolasco CR); 28. Castel de Pedena (San Gregorio nelle Alpi BL); 29. Custoza (Sommacampagna VR); 30. Dosso Castelli and Dosso Giroldo (Grosio SO); 1. Frattesina (Fratta Polesine RO); 31. Montebello Vicentino (VI); 32. Monte Casteggion / Castejon (Colognola ai Colli VR); 33. Monte Castello (Magré VI); 34. Parre (BG); 35. Ponte San Marco (Calcinato BS); 36. San Tomio (Malo VI).

Luco/Laugen B outside its 'cultural territory': 37. "casa gotica" (Asolo TV); 28. Castel de Pedena (San Gregorio nelle Alpi BL); 38. Coazze (Gazzo Veronese VR); 39. Monte Summano – Valle del Castello (Santorso VI).

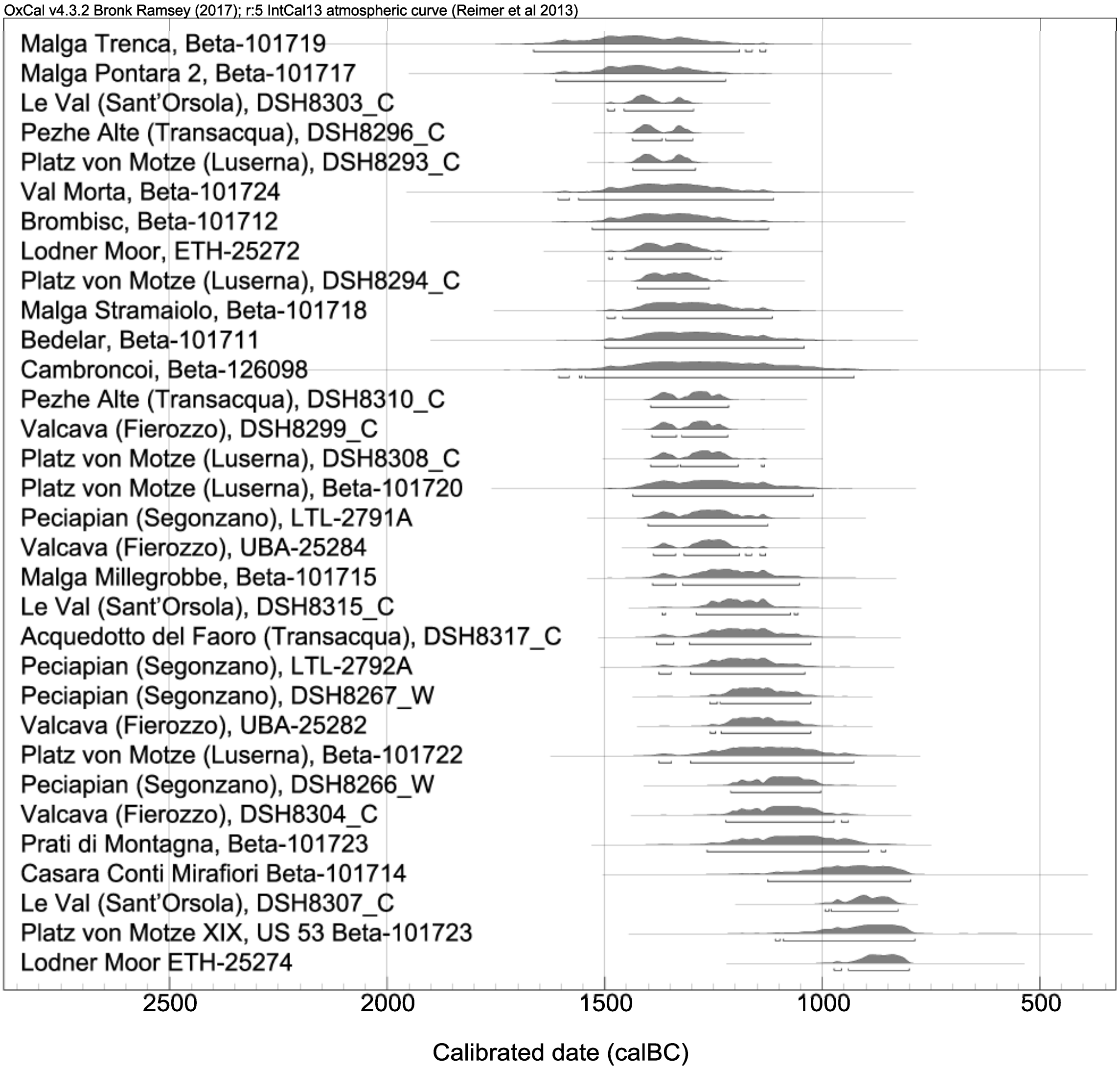

Figure 2. Published radiocarbon dates for smelting sites in Trentino – Alto Adige/Südtirol, excluding Acqua Fredda; calibrated at 95.4% with OxCal 4.3.2; BRONK RAMSEY 2009; REIMER *et al.* 2013.

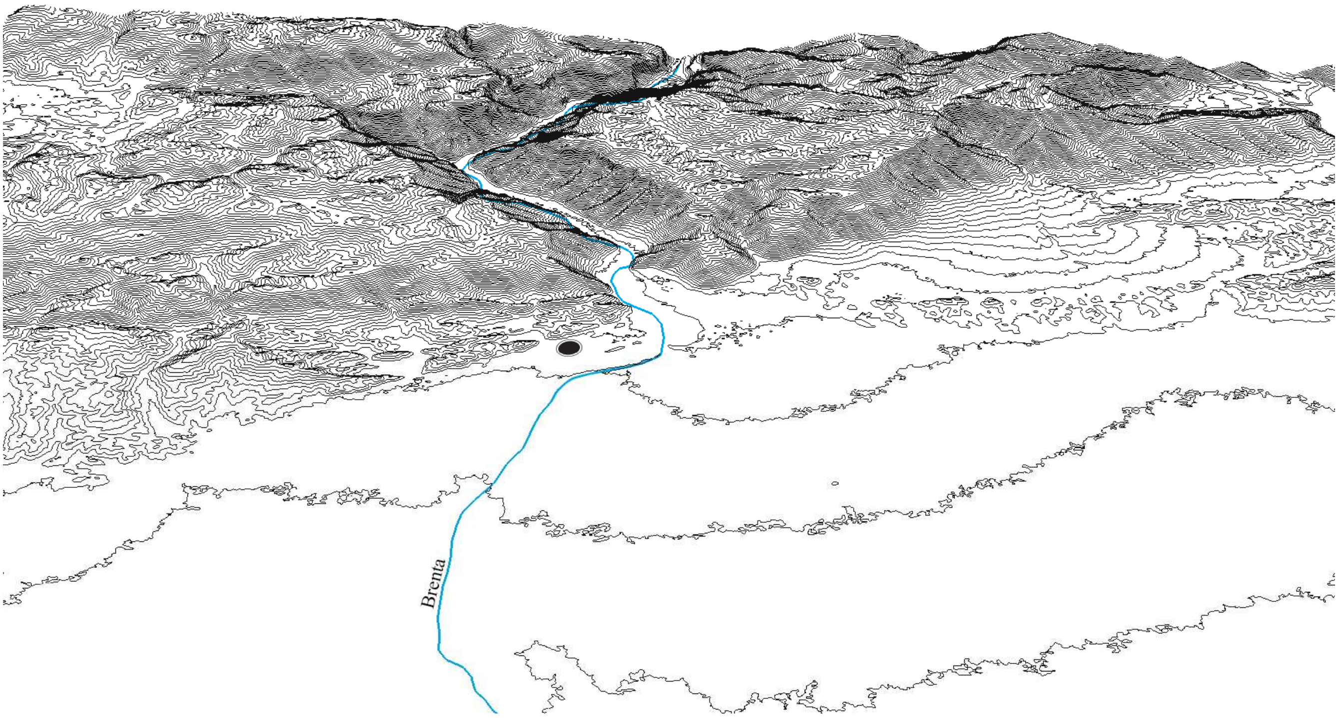

Figure 3. Setting of the San Giorgio di Angarano cemetery (Bassano del Grappa VI), close to the mouth of the Valsugana (contours at 30m intervals; image generated by Fabio Saccoccio using data from Farr et al. 2007).

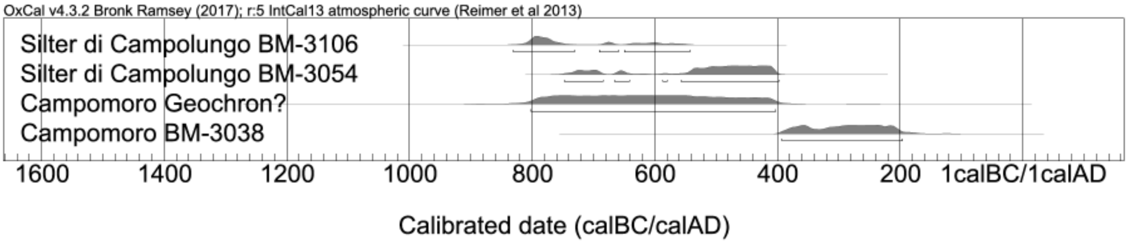

Figure 4. Radiocarbon dates for Silter di Campolungo (Bienno BS) and Campomoro (Lanzada SO) (cf. Table 3); calibrated at 95.4% with OxCal 4.3.2; Bronk Ramsey 2009; Reimer *et al.* 2013.