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The tin of Campigliese: 40 centuries of usage

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Abstract

In the past, many scholars have attempted to find tin sources, in the central Mediterranean area, for bronze production, mostly between the Medium Bronze and Recent Bronze Age (1,700 - 1,200 BC[1]).

In this period we can find, in the entire Mediterranean, a series of critical events such as the depletion of the Anatolian tin ores; the advent and rise of the long-distance Cypriot trades; the "Bronze-Age collapse"; the arrival of intra-European and intra-Mediterranean central production&trade places.

With regard to the discussion of tin sources, scholars have fluctuated between recourse to the commonplace of "absence of prehistoric exploitation" or to the Cassiterides myth.

In this paper, I will attempt to demonstrate that the tin from the Campiglia area (i.e. from the Campigliese) was available in such quantity to meet, for some centuries, the needs of the central Mediterranean and was of exceptional quality, allowing it to be easily extracted and worked quickly.

This paper will also underline that the Cornwall mines have stocked tin in large quantities only after the Roman conquest and that the oldest dating of Erzgebirge mining is medieval.

1 These dates only meant for central Tyrrhenian Italy, indicating the beginning of the Middle Bronze and the end of the Recent Bronze, that is, between the advent of the *Grotta Nuova* facies and the beginning of Protovillanovian culture.

2 http://www.openstreetmap.org

3 http://opendatacommons.org e http://creativecommons.org

Introduction

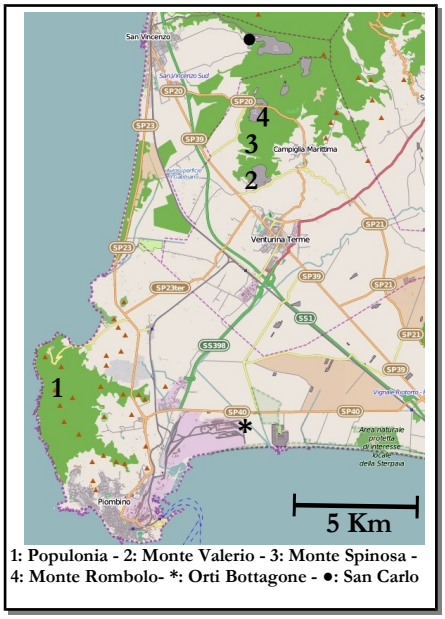
The places

A few kilometres north-east of Populonia on the Tyrrhenian coast, rise from the plain of northern Maremma the hills of Campigliese, still today totally covered with vegetation and spotted by the quarries of shale and feldspars.

Campiglia Marittima is at a height of 230 m s.l.m. while the hills that stand towards the sea are (from south to north): Monte Valerio (245 m), Monte Spinosa (386 m) and Monte Rombolo (390 m).

On the south-eastern side of Monte Valerio there was once Monte Fumacchio, now totally disappeared due mainly to metal excavation undertaken since the last few years of the nineteenth century until the end of World War II.

On the map you can see the OB[4] site (*) where are the remains of the most ancient (4,200 - 4,100 BC) metallurgical site of the whole Italy, as well as that of San Carlo (●) a little more recent (3,400 - 3,100 BC) both with very advanced copper fusion techniques[5].



1: Populonia - 2: Monte Valerio - 3: Monte Spinosa - 4: Monte Rombolo- *: Orti Bottagone - ●: San Carlo

The rediscovery of cassiterite

Today, there is no evidence of the mines that existed in the Bronze Age, because the hills have undergone mining operations in modern times so invasive that their entire appearance has drastically changed. However are documented[6] the inspections carried out in the second half of the nineteenth century by Simonin and Blanchard which give little scientific guidance but are still interesting regarding the state of the old mines.

	1	2	3
$Sn\ O_2$	92.40	75.18	89.94
$Fe_2\ O_3$	3.49	4.—	9.13
$Mn_2\ O_3$	—	—	0.93
Cale O_3	3.34	19.64	—
Pb e Bi	—	tr	—
Materie indeter.	0.77	1.18	—
	100.00	100.00	100.00
Stagno Met:	72. 4	58. 9	70. 7

tout venant analysis at Cento Camerelle (late '800)

It should be remembered that at that time it was not known at all that in Monte Valerio was the tin and that the area was worked only for copper and iron. In fact, the Targioni Tozzetti in the middle of the eighteenth century[7] writes: "*In Monte Valerio, therefore, of the Captained of Campiglia, iron is hollowed out, which is very raw and consumes too much coal to merge. Of this one finds a vein that is very thick, others that are all porous...* "

Following Blanchard's investigations, at the end of the 19th century, he discovered cassiterite also at Fumacchio[8]

4 OB: Orti Bottagone with a chronology about 4100-4200 BC. Cf. F. Fedeli (1995)
5 Artioli (2007) says: *"the samples from Tuscany (CS1 from San Carlo and OB1 from Orti Bottagone) contain iron phase that may be the product of metallurgical processes."*
6 See the Annex A containing the chronicle of the "rediscovery".
7 Targioni Tozzetti (1754)
8 Average metal tin percentage: 47%

and Cavina[9]. Lastly, he found cassiterite at Monte Rombolo[10], even in veins where Fe, As, Pb and Ca. are prevalent. Evidence of ancient excavations for the tin brings us back to Blanchard[11], who discovered in 1873 the mine of Cento Camerelle and confirmed that there were ancient metal mining operations, but only for the part inherent the superficial veins of cassiterite, without affecting the deeper ones of ferrous metals.

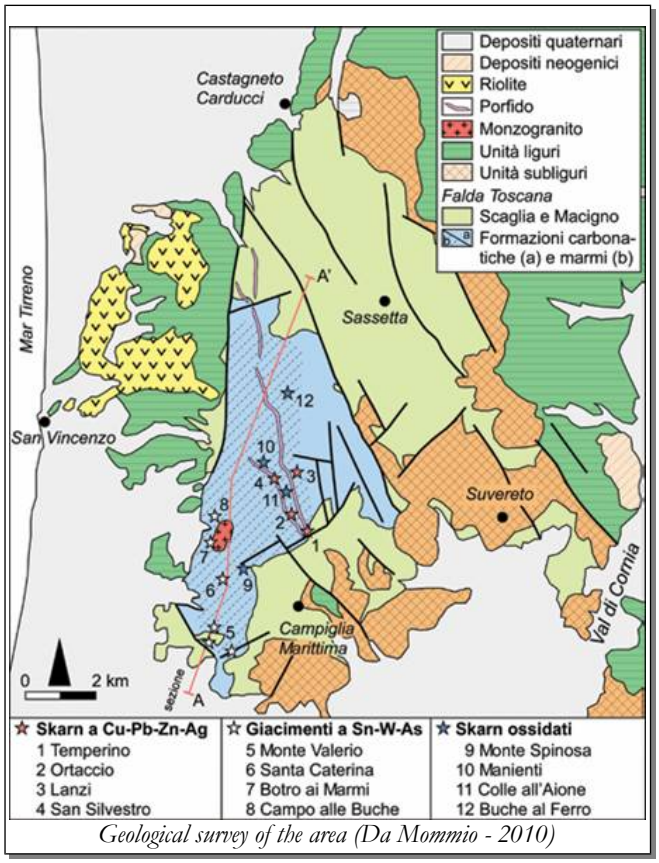
Blanchard then discovered the cassiterite in pre-existing iron mines, also referring to the old excavations of Campo alle Buche, where, due to the size and type of wells found[12], it is concluded that in ancient times they also extracted cassiterite there.

The Cento Camerelle tin field, on the western slope of Monte Fumacchio, consisted of irregular limonite veins cut into limestone, containing nearly granular cassiterite. The fact that the thread was worked in ancient times is witnessed, in addition to the archaeological evidence discovered in the last century, also by the name of Cento Camerelle (*Hundred little rooms*), to indicate the large number of old excavations.

Even from the nearby Mount Valerio comes cassiterite, though poorer and more impure[13] than that of the Fumacchio.

Unlike the first two is the outcrop of Monte Rombolo, where cassiterite is mixed with lead arsenate: the limonite lines seem to bend to Campo alle Buche. Both at the Cento Camerelle and in the neighbouring resort of Cavina and Campo alle Buche at Monte Rombolo, the ancient wells had been excavated to follow the veins.

The shape of the wells and the complete ignorance of tin deposits before their rediscovery at the end of the nineteenth century suggest that they may be prior to the medieval age.



Geological survey of the area (Da Mommio - 2010)

The wells are, in fact, narrow and deep, differing somewhat from the typology of the medieval ones of Massetano[14], which were regulated by a special municipal legislation[15], were, however, suitable for the

9 Average metal tin percentage: 11%

10 Average metal tin percentage: 2%

11 As Strobel reports in the *Bollettino di Paletnologia* year 1879

12 From the Sheet 63 (Monte Rombolo, Campo alle Buche, Botro ai Marmi, Monte Spinosa) of "Mining and Mineralogy Heritage in Tuscany - Naturalistic and Historical Archaeological Aspects" - Tuscany Region Government - 1991": "*The remains of a multitude of wells and downs were still seen until the middle of the last century* "

13 The percentage of cassiterite on the *tout venant* varies from 7 to 63% with an average of 25%. The presence of iron sesquioxides is high. The sum of Cu, Pb and Bi oxides does not reach 1% with an average value of about half.

14 Territory around the city of Massa Marittima

15 "The law of Massa Marittima *Ordinamenta super artem fossarum rameriae et argenteriae civitatis Massae* was definitively promulgated by the Sieneses in 1325, but it was already completed in 1294, having gone to Massa, then free commune, between 1138 and 1225 when the silver extraction was at its height. It is one of the most important contributions to the advancement of science and technology in a sector of primary economy in which Italy played a central role throughout the Middle Ages and explains, at least in part, the flourishing of Tuscany at that time" (A. Mottana - "Oggetti e concetti

use of mineral lifting winches, generally masonry-coated with a large entrance.

The old Blanchard[16] analyses, which archaeologists criticize because they are not adequately documented, are, however, in tune with both medieval documentation that does not point to the metal and the logic of the excavation economy.

It is assumed that the *Cento Camerelle* toponym is to be identified in the area where the extractive effort of cassiterite was the lowest and the tin yield[17] was the highest possible.

We also note that in the first year[18] of re-activation of the mine in modern times (1876), only a few tonnes of minerals from the Cento Camerelle were excavated but produced 8 tons of metallic tin.

This is how this should be the productivity of the mine in the last days of its ancient life.

So without any certainty, but with a very high probability level, we determined that:

- In the three areas of Monte Valerio (Cento Camerelle, Fumacchio and Cavina) as well as in one of Monte Rombolo (Campo alle Buche) there were evidence of ancient cultivations;
- These ancient cultivations, always in the nineteenth-century observations, had wells not certainly of medieval origin;
- In no medieval document you find mention about the Tin processing, but only that of Copper, Silver, Lead, Zinc and their different minerals. However it should be recalled that there was a need for Tin for the production of glazed ceramic for which Pisa was famous and at the same time, Pisa itself had the right to exploit the Campigliese.

Quantities excavated

From many documents recovered from the University of Siena and available online for consultation[19], there are those retrieved from the former-archive RIMIN, a mining research company belonging to the ENI group.

From these documents one can deduce, albeit in the presence of sometimes unclear information, that the area of Monte Valerio with the mining fields of Monte Fumacchio and Cento Camerelle in the East; Cavina to the South and Santa Barbara to the West; as well as the area of Monte Rombolo with its mine at Campo alle Buche, have produced metallic tin in two periods:

1. from 1876 to 1914 for a total of 104 tonnes[20];

2. from 1936 to 1943 for a total of 1,533 tonnes[21].

For a total of 1,637 tons since, in 1875, Blanchard discovered cassiterite to date. Mr. Benedettini (1983) pointing out that, in the period 1936-1947, *"2,555 tons of cassiterite were processed at 60% of tin"*.

This may mean that the cassiterite contained in the selected and washed mineral was 77.5%, or that someone was confused as the value of 77.5% corresponds[22] to the percentage of tin contained in the cassiterite.

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inerenti le Scienze Mineralogiche ne *La composizione del mondo con le sue cascioni* di Restoro d'Arezzo (anno 1282)" - Rend. Fis. Accademia dei Lincei - 1999.

16 Not only but also Simonin 1858; Coquand 1876; Church 1879; Stroebel 1879

17 The first analysis of the *tout venant* made by Blanchard gave: about 90% cassiterite, 9% Fe sesquioxides, 1% Mn sesquioxides

18 Without any modern facilities. The first implants of ore dressing of Fumacchio veins started from 1877.

19 http://www.neogeo.unisi.it/dbgmnew/

20 See the page 27 of the document "L'unica miniera di stagno in Italia" (1933)

21 Cf. Benedettini (1983) page 9.

22 The figure is in practice in Campiglia. The theoretical value is 78.62%.

But there is more.

Later, the same author, perhaps to give more credibility to the figures, reports the steps of the "Memoria illustrativa della carta mineraria d'Italia"[23] where it is said that "*during the last period of mine activity between 1936 and 1947, little more than 1,500 tons of metallic tin were produced, containing about 400,000 tons of stanniferous mineral.*"

The figures seem to match.

But shortly thereafter, we read: "*Towards the end of the last century, there was a resumption of growing crops that diminished at the end of the First World War: at this time about 200 kg of starch ore was produced in Sn at 29%, 700 Kg in Sn content of 5-3%, and 850 tonnes with 2% content* ".

In fact, they were all tons and not Kg, as shown by the detailed statistics on p. 27 of the 1933 document cited above.

Another confusion?

It is in the Internal Report No. 14749 RIMIN s.p.a. Titled "*Monte Valerio's tin mine: mining statistics and researches extracted from the Mining Service reports from 1936 to 1943" (1975)* which reveals a very different truth.

In 1936 AMMI (Italian Minerals Metallic Company) received a request to investigate all potential mineralization of the territory as a response to the economic sanctions imposed on Italy by the Society of Nations at the end of 1935.

AMMI produced in 1936 some documents, then converged in the RIMIN Library and labelled as T-410, T-490 and T-491. In May of 1936, the mine was reactivated by AMMI.

The above cited internal Report 14749 says:

Year	Tin (ton.)	Activity	Works (Cento Camerelle = CC; Cavina= CA; Santa Barbara= SB)
1936	11.71	445 ton. At 2.63% of tin probably from Cento Camerelle e Cavina	170 m long stretch of CC and CA railways + 80 m of new mineral attack tunnels. SB was re-armed by the Cortese well, reopened a new gallery "Hail of the Falcons" as the old one was sunk and opened the new Vittorio well. At the end of the year begins the construction of the new ore dressing plant.
1937	? (1)	tout-venant at 0.25% – 0.35% of tin	CC and CA: 3,129 m of galleries, 31 m of wells and 445 m of wells were excavated. SB: Not cultivated, pending completion of the planting. 1,536 m of galleries, 70 m of wells and 119 m of wells were excavated. At the end of August, the new ore dressing will be in operation.
1938	300.7	108,554 ton. from three mines at 0.28% of tin.	CC and CA: 2,895 m of galleries and 458 m of wells and stoves were excavated. SB: 897 m of galleries and 181 m of wells and stoves were excavated.
1939	n.d. (2)	n.d.	CC and CA: Thirteen new wells entered service. SB: The Cortese well (Olivastrino area) is deep.
1940	n.d.	n.d.	Added 3rd wash section and new sterile enrichment section.
1941	n.d.	n.d.	CC Cultivation hindered by the presence of water. Install new enrichment sections and built a small flotation plant for the elimination of pyrite.
1942	159.7 (3)	57,647 ton. from three mines	Install new enrichment sections
1943	n.d.		
TOT.	472.1		

(1) It is assumed that the failure to produce the product was due to the fact that the ore dressing new plant was only put into service in August and therefore the tout-venant was stored in the yards to be processed the following year.
(2) The lack of indication of production for the years 1939-1941, that is, of the most important issue of a Mining Journal, is inexplicable.
(3) There is no indication of the production of Sn. It is assumed that the average percentage on the venous site was equal to that of 1938, i.e. 0.28%.

23 Volume XIV of the Italian Geological Service (1975)

Who do you believe so?

To the exact, though incomplete, mining reports of the AMMI report, or to Benedettini's general indications?

The difference is not small: compared to 472 tons really and officially documented there is a triple amount.

It should be noted that the extensors of the AMMI report certainly did not have the interest in overtaking production or lowering it, but I did the opposite.

We are therefore more likely to believe in these relationships, which leads us to evaluate the tin extracted in modern times around 600 tonnes[24].

Considering that the estimation of Venerandi-Pirri and Zuffardi of 1981 indicates the mineralization of Monte Valerio with a cut-off of 0.3% [25] in 4,000 tonnes we can safely estimate in about 3,400 tons of tin the quantity excavated in ancient times at Monte Valerio.

24 Exactly 576.1 = 104 + 472.1 tonnes

25 Against even lower values (0.28%) excavated in modern times

The tin problem

It would be too simplistic to say that the spring that made the Eastern metallurgists move from the Aegean Sea and make them enter in the Adriatic and in Tyrrhenian sea was the need to expand their markets.

The primary thrust was, in all likelihood, the necessity: the Taurus Mountain Tin was out of stock, and alternative sources had to be found.

Who were these metal seekers if Cypriots or Syrians, if Anatolian or Philistine we are not able to determine it. We only know, extrapolating from the wrecks of Uluburun and Cape Gelidonia, that one of their metal sources was the Cypriot copper mines.

In the past it was said that they had found it in Afghanistan[26], Cornwall, Erzgebirge, Iberian peninsula etc. Indeed today we know that the tin of the Cornwall seems to have been extracted in quantities only since the 1st century AD[27], and the mines of Extremadura and Brittany are certain that they have been exploited massively only starting from the Bronze Finale and finally that many supposed fields that could be theoretically usable could not be due to the low percentage of cassiterite in the rock[28].

The only tin mines available between the 17th and the 13th centuries BC were those of the steppes of Kazakhstan[29] and those of the Campigliese.

If, as previously analyzed, it was possible to calculate that at least 3,400 tons of metallic tin could be extracted in antiquity from Monte Valerio[30] only on a material which could on average contain up to two-thirds of the weight of the excavated material[31].

It can therefore roughly be estimated that the tin extracted in antiquity from Monte Valerio and put into circulation could have generated up to 40,000 tons of bronze with an annual output of 100 tons of bronze if limited to only 400 years in question[32].

That's a lot, but much more than what the Muhly[33] told us, indicating in 11 tons per century the tin import of the entire Anatolia.

But Muhly could not know anything about the wreck of Uluburun[34] and the much larger quantities of copper and tin found there and that the Cypriot ships sped across the Mediterranean exchanging processed products like copper and tin.

26 See Cleuziou-Berthoud (1982), but with little certainty about the tin. Even recent surveys (the Sistan basin) indicate tin only in ppm.

27 Investigation of the source of the tin based on lead isotopes is not applicable to bronze artifacts: many cassiterite deposits have no lead in fractions of ppm. As a result, the lead found is only copper. The only scientifically valid analyzes appear to be just those on the tin isotopes. See Haustein.

28 Like in the other mines of Anatolia and those of Sardinia. See Valera: *"cassiterite is finely intergrown with major zinc and lead sulfides, and it is only visible under the microscope"* (2005).

29 See Stollner (2011). Previously, Cierny (2003) had indicated Tajikistan and Uzbekistan as possible sources of tin by quantifying only one tonne extracted in the old.

30 It was not taken into account in the calculation of the mine at Campo alle Buche, although excavated in ancient times, in the area of Monte Rombolo.

31 From the analyzes carried out at the end of the nineteenth century, the average content of cassiterites in the rock of the Cento Camerelle mine was 85%, with a metallic tin content of 66% of the extracted material, therefore of exceptional quality.

32 More than half of Elbe's iron production estimated by Mommersteeg in a defined industrial context to approx. 150 tons annually for five centuries from the 7th to the 2nd century BC

33 J. D. Mulhy - *"Sources of Tin and the Beginning of Bronze Metallurgy"* - American Journal of Archaeology 89 - 1985

34 The first wreck publications are after 1985.

We know that they sold[35] *oxhide copper ingots* in Sardinia[36], produced by Cypriot mines, but not in Etruria where the metallurgy was truly alive from the Eneolithic and starting from the EBA[37] already circulated the locally produced convex-plan ingots[38] and the axes, then the pick-ingots as well as the always local production palettes[39].

It is therefore reasonable to suppose that the Cypriots[40] sailed the Tyrrhenian Sea, unloading the *oxhide* in Sardinia and then[41] loading the Etruria tin to work it and distribute it to the eastern circuit.

Although it does not emphasize literature on significant archaeological trails[42] of ports or moorings on the islands[43] or the coasts of northern Tyrrhenian[44] for the period in question[45], however, some recent findings[46] suggest that the hypothesis should be verified in this direction[47].

In Sardinia there are modest veins of cassiterite[48], but such that they can not be recognized or even exploited in pre-industrial times.

In fact the investigations carried out by AMMI just before World War II did not bring anything. We only know that they opened the mine, attempt to install some ore dressing plant and then nothing more. It does not seem that a kilo of tout-venant was dug, not even the tin.

We do not know if this is due to the loss of documents or for other reasons, so we can not conclude anything for sure.

However it is highly probable that the cassiterite of Sardinia is essentially of mineralogical interest.

From Gale e Stos-Gale (1987): *"We visited this ore deposit in 1984, noting that the chief ore is a finely and intimately intergrown mixture of sphalerite, galena, pyrite and cassiterite, in which the cassiterite can be recognized only under the microscope, so that it is most unlikely that cassiterite could even have been recognized in it in the Bronze Age, far less separated or utilized. Botti (1936) confirms all our observations, whilst Valera et al. (2005) in their review of tin deposits in Sardinia write of Canali Serci that "Minor cassiterite is finely intergrown with major zinc and lead sulphides, and it is only visible under the microscope. Again the same questions arise: was a primitive tin metallurgy viable for such a primary ore association? Was a cassiterite placer*

35 Selling means any old economic transaction, including the barter with goods and / or services.

36 At least since the 12th century BC

37 See F. Cattin et alii (2010): Copper finds (3 by Ayent / Les Places in the Canton of Valais - Switzerland) and belonging to the EBA (2,200 to 2,000 BC) were made with copper from the mines in the area Campiglia-Massa Marittima.

38 See Aranguren (2005, 2011) which also reports the latest finds at the copper mines of Massa Marittima (La Speziala and Serrabottini).

39 Not to mention the first small weight ingots defined as the one found at Serrabottini (Aranguren 2005) almost certainly of the Bronze Age and weighing 338 grams, that is close to the so-called italic pound (341 gr.) and the oldest Roman (from the IV century BC with the value of 327 grams), but far enough from the Etruscan pound (358 gr). Cf. Maggiani 2002

40 Cypriots are the middle-east metallurgists. Probably Cypriots but along with not better identified "Levantines" (Syrians?).

41 Since the currents in the Tyrrhenian Sea are anti-clockwise, at least in the months in which they sailed in ancient times, it is most likely the opposite.

42 Grifoni Cremonesi says: *"At the Giglio Island there were structures with pole holes excavated in the rock and also in Pianosa a large hut was found enclosed by stone blocks, on a rocky spur that controlled the sea routes between Corsica and Tuscany. Also on the island of Elba there are fortified sites on the slopes of Mount Jupiter. "*

43 See B. M. Aranguren et al. (1992) where reference is made to finds dated to the 15th century BC.

44 It is also possible that the new coastal lines have saturated the old landings or, even rarer, that the sea has flooded them.

45 In the interval between the LH I period and the LH III A.

46 See Aranguren (2011) and the metallurgical site of Capo Sparviero (Punta Troia) in Punta Ala radiocarbon dated at the XVII century BC (range XVIII-XVI century)

47 See Andrea Dolfini (2013, 2014) proposing a new model for the diffusion of copper metallurgy in the peninsula and the islands from the Eneolithic communities of Central Tyrrhenian Italy.

48 Mineralogical site of Canale Serci, Perdu Cara

concentration possible in the local morphology? Both answers are negative, because only a modern flotation process can separate and concentrate each ore mineral from such a primary mixture, and only a weak geochemical increase may be expected in the stream sediments derived from the erosion of the Canali Serci lode.

Valera et al. (2005) confirm our own observations that there is no source of lead containing tin in Sardinia available in the Bronze Age, and indeed that the tin occurrences in Sardinia are mostly mineralogical occurrences only,'with the only hypothetical possibility, though very weak, of a Sardinian tin beneficiation being offered by an eventual small placer *from the Perdu Cara mineralisation'".*

The tin of Campigliese

Monte Valerio's tin deposits were evaluated numerically by the University of Milan[49].

Monte Rombolo and Monte Spinosa today: on the background Populonia

The potency of cassiterite strands was estimated at about 4,000 tonnes, of course all extracted.

Of these, about 600 have been counted in modern times since it was discovered that the mountain had not only copper and iron deposits, but also tin deposits.

There are about 3,400 tonnes missing, almost certainly excavated in ancient times.

However, the above mentioned work contains some omissions.

The authors did not say that Monte Valerio (with a range of 3.5 km2) includes Monte Fumacchio, Cento Camerelle and Cavina.

Moreover, they did not mention the other stanniferous area made up of Monte Rombolo and Campo alle Buche, away from Monte Valerio over 3 km.

We do not consider it a mistake not to mention Monte Spinosa, since tin mineralization is a recent discovery.

The second omission relates to the potential of the field, estimated at ca. 1 million tonnes to 5.2% Cassiterite[50], all extracted.

The situation of the tin in Campigliese must be fully defined as follows:

49 I. Venerandi-Pirri, P. Zuffardi - 1981

50 The pure cassiterite gives a metallic tin in an average ratio of 1: 0.77, so in total we talk about 4,000 tons.

Mine	Ore	Quantity extracted	Quantity in situ
Monte Valerio	Santa Barbara Cavina Cento Camerelle	ca. 600 tons in modern times (from the late 19th century to 1947) including Cento Camerelle. ca. 3,400 in ancient times[51] as the difference between the potential of Monte Valerio (4,000 tons) and how much excavated (and documented) in modern times.	20.000[52]
Monte Rombolo	Campo alle Buche	Certain quantities[53] but entirely to be determined. Francovich[54] attributes it to the Etruscan period. However, the excavation technique is different from the Cento Camerelle.[55]	
Monte Spinosa	Monte Spinosa	None	Found tin in the 1991 survey[56]

The beginning of the Etruscan industrial production of iron began in the 7th century BC: on this date the iron squashed the bronze for both weapons and household utensils and for those intended for agriculture, while bronze was left for statuary and ritual objects and furnishings.

It is difficult to argue that in the 500 years (from the VII to the II century BC[57]) during which the areas of Elba, Populonia, Campigliese, Massetano, Vetulonia were entirely devoted to such an industrial effort so high to produce up to a maximum of 200[58] tons of iron ingots per year[59], they were also able to dedicate to extracting the tin. However we can not rule out that a limited production for statuary has been there.

This production can not weigh more than 400 tons of tin throughout the whole period, although we can not rule out imports from Iberia or from Brittany.

In the opinion of the writer, considering that some Blanchard's analysis of the Cento Camerelle mineral showed that they were of almost pure cassiterite[60], they are very likely to have been exploited from far away.

If bronze plates have been found in western Etruria since the XXII century BC, evidence of local bronze metallurgy are only from the XVIII century BC.

In addition to Scarceta[61], which was a small village entirely dedicated to Bronze metallurgy, also at Capo Sparviero (Punta Ala) archaeologists have recently[62] found the remains of metallurgical activities, dating from the first radiometric surveys at a time between the XVIII and XVI centuries BC. [63]

51 According to Blanchard's analysis, the "ancient" thread had to have an average metal content of not less than 70%.

52 It is meant by modern industrial techniques. See the report by Eng. V. Ticino of Rimin s.p.a. (ENI group) which estimates 2 tonnes of metallic tin per day for 30 years. This report is in contrast to that of November 43, which estimates a total of 93,500 tons of tin. It seems that both refer to Monte Valerio / Santa Barbara with the exclusion of Cento Camerelle / Cavina. But while Ticino report says it explicitly, it is not for the other report that cites only the excavation permit and relative tables.

53 See Chart 63 (M. Rombolo - Campo alle Buche) from "Inventory of Mining and Mineralogy in Tuscany - Naturalistic and Historical-Archaeological Aspects" - Tuscany Region - Environment Department - October 1991

54 https://en.wikipedia.org/wiki/Riccardo_Francovich

55 The Cassiterite of Campo alle Buche was very different from that of Cento Camerelle. Mixture of arsenic iron, appeared red, with a metal tin content in the fragments of about 40-50%. No veins were traced.

56 See Report T-1404 (Rimin Library) on behalf of the Mining Directorate of the Ministry of Industry, Commerce and Crafts.

57 L. Chiarantini, M.Benvenuti - "I bacini di approvvigionamento dei minerali metalliferi e le tecnologie produttive del rame e del ferro" - Edipuglia - 2009

58 With peaks up to 400 tons in one year.

59 With a total output of 5 centuries, certainly not less than 50,000 tons.

60 On a Kg of crude mineral, the first sample yielded 92% Cassiterite, while the third was 90%.

61 Cf. Claudio Giardino, Raffaella Poggiani Keller - *Le produzioni metallurgiche del Bronzo Tardo in Maremma: nuove evidenze da Scarceta* - X Incontro di studi Preistoria e Protostoria in Etruria - Settembre 2010

62 2010

63 Cf. Biancamaria Aranguren, Luca Cappuccini, Mario Cygielman, Pasquino Pallecchi *Attività metallurgiche nell'Età del Bronzo: primi dati dal sito di Capo Sparviero (Punta Ala, GR)* - X Incontro di studi Preistoria e Protostoria in Etruria -

At Capo Sparviero, the earliest observations documented a ditch filled with copper processing scraps and bronze fragments and a jar in a dough, buried at a depth of about 30 cm and "fired" by a series of stones, large pieces of refractory clay and pieces of mineral. The vessel retained its original content, consisting of mineral aggregates; the "charge" of a ready-to-cast mineral that are characterized by the presence of carbonate and silicone elements, fragments of cupriferes and slags.[64]

Of the same period of the Antique Bronze (XXII - XVII century BC.) are the bronze panels found in San Vincenzo and Campiglia Marittima: this shows no doubt that in all Campigliese, probably due to the tin mines on the place, bronze metallurgy was thriving.

However, at the same time:

"The brass hoards are 11, located along the communication paths (the so-called locker ways); the most important is that: Albegna, Fiora valley, Mount Amiata, which leads to the Val d'Orcia and Amiata. Another set of hoards is located along the coast from Livorno to Campiglia and both clearly indicate routes between mining areas. Two isolated deposits are instead on Monte Verruca (Pisa) and Lucca. "[65]

During the Middle Bronze sites increase and are all located on the waterways i.e. in the valleys near the rivers and along the coast near golf courses and landing places. The islands are also occupied with rocks on the heights dominating the sea as at Giglio, Pianosa and Elba.

"At the Giglio Island there were structures with pole holes excavated in the rock and also in Pianosa there was a large hut bounded by stone blocks on a rocky spur that controlled the sea routes between Corsica and Tuscany. Also on the island of Elba are fortified sites on the slopes of Mount Jupiter. These settlement choices therefore indicate a strong organization of the land that controlled the landings and routes, probably linked to copper and tin exchange with sites in a strategic control and defense position.[66]*"*

During this period the presence of metallurgy is documented by the fragments of mantis nozzles found in the Paduletto di Coltano site.

Updated mineralogical genesis (2013)

Recently, a research group led by Andrea Dini of the Institute of Geosciences and Georesources of the CNR (National Research Council) of Pisa has produced a series of documents including an updated vision of the genesis of the Campigliese tin.

Dini says: *"Monte Valerio, since its discovery in 1876, is considered an anomalous reservoir due to the considerable distance from the intrusion of Botro ai Marmi. The new geological and mineralogical data indicate that the mineralization of Monte Valerio, Pozzatello, Santa Caterina, Botro ai Marmi and Campo alle Buche, despite small local differences, belong to the same type (tin-tungsten-arsenic) and are genetically linked to granite of Botro ai Marmi. From those in direct contact with granite (Botro ai Marmi) to the slightly distant ones (Campo alle Buche and Valle Santa Caterina), to the much farther ones (Monte Valerio and Valle Pozzatello), similar mineral primary paragenesis (cassiterite, scheelite, arsenopyrite, pyrite, bismutinite, etc.), accompanied by interesting alteration paragenesis with numerous arsenates (mimetic, adamite, scorodite, edifane, arseniosiderite, etc.). The study of these arsenates is still ongoing and the discovery of rare species (e.g. bismuth arsenic, pre-altered, in Monte Valerio, lead and aluminium arsenic sulphate, hidalgoite and lead arsenate-chromate and copper, kennels, at Campo alle Buche) are hoping for future research. "*

Settembre 2010

64 See also: B. Aranguren, L. Cappuccini, M. Cygielman, P. Pallecchi, *Castiglione della pescaia – Punta Ala loc. Capo Sparviero: un sito metallurgico dell'Età del Bronzo,* in Notiziario della Soprintendenza per i Beni Archeologici della Toscana, 6/2010, Firenze 2011

65 Grifoni Cremonesi

66 Grifoni Cremonesi

The tin of Campigliese in Sardinia

It is very interesting to read the volume "Archaeometallurgy in Sardinia" in 2005, curated by F. Lo Schiavo, A. Giumlia Mair and R. Valera. In particular, the curated contributions of the exact sciences specialists Giumlia Mair and Valera give us a somewhat different look than what we read about the same theme by international researchers quoting dated sources (typically Muhly and Penhallurick).

It should also be said that even Lo Schiavo does not fully grasp the suggestions of the exact sciences and prefers to leave the problem unresolved. We read from Valera's contribution about the tin found in Villagrande:

"Each analysed cassiterite showed a fairly distinct "personality" with peculiar trace element patterns. However only one sufficiently reliable conclusion can be drawn: i.e., the lack of any link between the Villagrande tin and the Sardinian cassiterite. In fact the Cd-Sb couple has very low values in the Sardinian (Perdu Cara) cassiterite, and the same result is shown by the other cassiterites (Erzgebirge, Nigeria, Spain, China), except for the Monte Valerio sample. In conclusion, the above data bring additional support to the exclusion of Sardinia as mother land of the Villagrande tin. The few samples of other districts we analysed seem to point rather to Tuscany, but the problem is completely open."

From the strictly scientific point of view, the last 5 words of the citation are correct: only a chemical analysis has been conducted on what has been found and this is not sufficient to be certain. Also because of the need for the isotope analyzes on the tin (Haustein - 2010), other tin samples (Portugal, Cornwall, Brittany) would be needed to avoid the risk of having an incomplete database[67] and suggest misleading conclusions as unfortunately also in recent times has happened and not rarely.

67 Cfr. A. Pampaloni ("Lead Isotopes Analysis: risks and errors"- 2016)

The other sources of tin

Cornwall

That the Tin from Cornwall has been extracted and used since the Bronze Age is an indisputable fact. Tin quantities found in relics such as Salcombe's as well as analyzes on Nebra[68] disk isotopes speak alone. But the Meharg[69] surveys have made us think about the quantities in use. The Meharg coordinated a research group that made use of measurements made on peat cores extracted in southwest England including Cornwall. The measurements concerned Copper and Lead, but in particular the Tin. On the theme Meharg says:

"*There is no prolonged elevation of tin inputs at Tor Royal before cal. AD 100, although isolated 'spikes' in concentration are evident. These spikes may represent* ***sporadic tin smelting activity during the pre-Roman period****, rather than 'noise' within the dataset, as lower and more stable tin levels are recorded for cal. AD 400–700 and 1000–1400. A sustained rise in tin deposition is observed from ~cal. AD 100, declining to a smooth baseline ~cal. AD 400 (the latter date would be close to the time of departure of the Roman army from Britain). Material evidence for early Roman exploitation of tin is scarce. Rather, it has been argued that the Romans only became interested in British tin following the exhaustion of supplies from Spanish mines by the middle of the 3rd century AD. The data presented here suggest that British tin was continuously exploited earlier in the Roman period than has previously been surmised and that smelting was located close to Tor Royal.*" With some conclusions worth reporting:

1. *Investigations in SW Britain have provided detailed chronological and geochemical profiles which for the first time enable us to address with confidence many issues surrounding tin in antiquity.*
2. *The first prolonged elevation of tin influx to a peat profile occurs from ~cal AD 100, declining to a smooth baseline ~cal AD 400. Given dating uncertainties, this would seem to correspond well to the period of Roman occupation in Britain and would conflict with suggestions that the Romans only became interested in British tin following the exhaustion of supplies from Spanish mines by the middle of the 3rd century AD.*
5. *Given the lead–copper relationship, this suggests that any copper mining in this region outwith these periods was not on a substantial scale. At their highest, the figures for lead concentration on Dartmoor for the Roman period are as high, or higher, than for other European sites (including Spain). This is further evidence for local SW British sources dominating the lead deposition, with copper smelting the most probable explanation.*
6. *Our data may provide the first supportive 'direct evidence' for the expansion of SW British tin and copper production during the Iron Age.*

Erzgebirge

For the dating of tin mines in the Erzgebirge, it is enough to mention two recent works. [70] [71]

68 M. Haustein (2010)

69 A. Meharg (2012)

70 G. Rapp (2009): *"The first direct evidence for mining in the Erzgebirge dates to the close of the 12th century. Penhallurick (1986) addresses the question by stating, '...but tin mining there must have been in the Erzgebirge during the Bronze Age, for without it, the achievements of Europeans metallurgist before the discovery of Cornish ores cannot be explained'"-*

71 Cfr. E. Niederschlag, E. Pernicka, T. Seifert, M. Bartelheim - *"Early Bronze Age tin and copper production in the Erzgebirge?*" - 33rd International Symposium on Archeometry, 22-26 April, Amsterdam - 2002.

Conclusions

We determined that the tin of Campigliese was extracted and used throughout the Bronze Age in a fair amount. This amount, comparable over time to that of the Kestel mine in Tauro, which produced 5,000 tons of tin for 1,000 years, can be estimated at about 3,400 tons very hypothetically[72] as follows:

- EBA[73] (2,300 - 1,700 BC) use only local: 300 tons for 600 years (50 t/century);
- MBA (1,700 - 1,300 BC) local use and possibly eastward exports through Cypriot / Levantine mining: 600 tons for 400 years (150 t/century);
- RBA-FBA (1,300 - 1,000 BC) local and Mediterranean area: 900 tons for 300 years (300t/ century);
- EIA (1,000 to 700 BC) local and Mediterranean-centered area: 600 tons for 300 years (200t/ century);
- Etruscan and Roman period (700 - 100 BC[74]) only for figurative bronzes production: 1000 tons for 600 years (166 t/century);

So we have basically two periods: the first one in which bronze (and consequently the tin) represents the primary metal for any metallic object whether it is for civil, military or artistic use whether it is figured or not. In the second, which coincides with Iron Age, where all the objects of civil and military use are iron made, the bronze will only serve for figurative bronzes.

During the EBA the tin was still available for the Middle East from the Taurus mountains, while Kazakhstan, Monte Cer in Serbia and southwest England were probably available from the MBA.

How much tin would be extracted from these mines and where it would be marketed is very difficult and other imaginative hypotheses would be needed than the one mentioned above.

In the field of certainties, we can only say that the 3,400 tons rating is highly conservative for the following reasons:

- The estimate of 4,000 tons of useful pool for Monte Valerio made by the University of Milan foresees a cut-off of 0.3% when volumes were extracted with a cut-off of 0.28%[75];
- Monte Rombolo is not considered with the ancient excavation site of Campo alle Buche[76];
- All the medieval excavation assumptions[77] have been eliminated, both as regards the typology of the excavations found and the news in the medieval documentation.

72 I apologize for the absurdity of the idea. But it was important to imagine a semblance of fruition even if free. When I came to know about the origins of Otzi's ax copper (the Similaun mummy), I realized that perhaps even though the hypothesis was free, it could also be less absurd than when I first assumed it. In any case, it is still much more realistic than the myth of Cassiterides.

73 The first finding of stannic bronze in the center of Tyrrhenian area is the bronze ring from Poggio Olivastro (Vulci) dated to the late Eneolithic

74 The news of Pliny the Elder and of the *senatus consultum* forbidding the extraction of minerals in Italian territory is well known: *"Haec est Italia diis sacra ... metallorum omnium fertilitate nullis cedit terris; Sed interdictum id vetere consultant patrum Italiae parci iubentium. "*

75 Which means a greater value of the quantity to be subtracted or a recalculation of the total

76 Considering the number, the width, the depth of the wells and the average value of the cassiterite as we are told by the end of the eighteenth century, we can estimate the ancient production of Campo alle Buche not less of 500 and not more than 1,500 tons.

77 Also in Sheet 64 (Monte Valerio, Cento Camerelle, Cavina) of the Tuscany Regional Inventory (1991) concerning the tin it is said that *"there is no trace of cultivation of this metal in the period between the Etruscan age and the second half of the nineteenth century "*

Annex A: A. Church (1879)

"At the beginning of 1875 in the continuation of some excavations of hematite, in the vicinity of Campiglia Marittima, some boulders of a heavy, gray-gray mineral attracted the attention of the assistant to the works, which apart from a piece of stone to cause of its uncommon weight.

Mr Blanchard, a mining engineer, frequently visited those excavations, learned some fragments of the ore, sent them to London, where in October 1875 they were found to be cassiterite with a small amount of sesquioxide of iron and calcium carbonate ...[78]

It was in one of the ancient excavations made by the Etruscans or the Romans two miles southwest of Campiglia, which was discovered the cassiterite.

The ancient mine, now known as Cento Camerelle, consists of a number of small excavations connected by galleries cut into hematite and limestone in the hillsides of the hill called Monte Fumacchio.

Limestone infiltration over a period of more than two thousand years has deposited a 5 to 6 inches thick stalagmite crust over the walls of the old tunnels that were probably abandoned before or during the demolition of Populonia by Silla during the proscriptions.

In the Middle Ages and in later periods it seems that the excavations were little or nothing in Campigliese, although they continued actively in the nearby Massetano; so that the Cento Camerellle were no longer disturbed until the recent times.

In 1858, Mr Blanchard, who resided nearby as a manager and engineer at the Temperino copper mine, visited the ancient mine in the company of Mr. Simonin and found him inhabited by legions of batons from which he had accumulated a sufficient amount of guano, they thought, forming a subject of profitable speculation.

The modern history of the mine begins from this date. In 1872, Mr. Charlon began digging for hematite by removing the limestone concretions that had formed over the veins. In 1873 it came into the hands of its current owners and was worked for iron ore.

The cassiterite vein was discovered about 15 meters to the west of the ancient workings, its direction was first east-west. It varied greatly in size and direction, being sometimes 5 to 7 meters wide and from time to time shrinking to a few inches.

Sometimes the cassiterite was completely replaced by the hematite with which it was associated.

The surrounding limestone belongs to the lower Lias.

As the excavation proceeded, it was found that the cassiterite came from the horizontal bed of the mineral in which the Cento Camerelle were excavated on the outer edges of which appeared in irregular pockets and slits in the limestone.

It became apparent that the old works had to be done for the extraction of the cassiterite and when, following the fissures these were reached, he found himself removing the concretions from the walls of the vein, more or less abundant traces of that mineral.

Monte Fumacchio, where these excavations were made, is in itself an object of great geological interest.

It takes its name from vapors that can be seen during the winter months, leaving cracks in limestone. This

78 The Church reports the first analyzes carried out by Rosenthal in London on samples sent by Blanchard. The first reported cassiterite at 92.4% (metallic tin at 72.5%) while the second yielded cassiterite at 75.18% (metallic tin at 59.15%).

phenomenon is observed in other hills of Campigliese, especially in a resort about two miles west of the village of Suvereto, called the Buca del Fico, where there is now a cave with a humid and warm atmosphere, evidently caused by an underground course of hot water through the mountain …

The tin ore extracted from the Cento Camerelle mine contained a considerable amount of iron peroxide, which was in fact the main ganga of the strand.

The look of the richest mineral samples obtained was gray with only a slight metallic luster. The crystals are very small and the most commonly observed forms, the diatomic prisms with octahedral tops.

This is the first discovery of cassiterite in Italy, except for small and rare gemini crystals that were associated with beryllium and lupidolite in the Elba island truncated granite.

Closer to the sea than Monte Fumacchio, continuing along the same line of hills, rises with a slope of Monte Valerio between the road and the groves of the olive trees lying south and southeast of its base. Down from this slope of the hill flows a canal and the rock is denuded.

The limestone is sprinkled with rocky rock: on the south slopes there is a considerable height of alluvial clay.

Rock fragments are found on the surface, more or less worn out by water, and others enclosed in clay.

There are considerable veins of hematite in the limestone near the base of the hill, especially in a place where the Romans or the Etruscans made considerable excavations and is known as Cava Vecchia, where ancient picks and copper and bronze lamps were found.

Modern excavators, following the traces of these early miners, extracted considerable amounts of iron from these veins and extended the workings to the place long since abandoned by them.

The old works are more rude than the Cento Camerelle and have no galleries or rooms but simply consist of a sloping slope that follows the course of the settlement and is evidently made for extracting the hematite …

Recent explorations at the Cava Vecchia were found in the clay of disassembled rock pieces, and among them, at the depth of 30 or 40 feet they met cassiterite pieces during the spring of 1876.

They were different in appearance from those of the Cento Camerelle: of red color similar to hematite, but containing 40 to 50% of tin.

By carefully examining the slopes of the hill above the mine, no mineral vein could be discovered to justify the broken boulders scattered below, but in the field at the left of the channel discovery of fragments of tin mineral very similar to appearing at the rocky rock more copiously scattered around but not containing cassiterite.

In the Cava Vecchia the fragments of cassiterite that were frequently found scattered in the clay contained 61% of tin but did not provide, for their position, a clue to discover the origin of the tin mineral fragments …

Continuing the exploration in the vicinity was an examination at the east of Monte Fumacchio in the place called La Cavina, where a small vein of hematite had been discovered in 1875 and abandoned for its minor importance.

A little above this small excavation, a servant observed the principle of an ancient work in the same vein, the outer walls of which had traces of cassiterite.

The work here first consisted in the removal of limestone containing traces of tin ore until the tunnel reached an opening in the rock whose walls were covered with limestone concretes.

There was some amount of red-light amorphous ground, containing iron arsenic associated with cassiterite. They accompanied the copper, bismuth, and lead cassiterite in small quantities like the Cento Camerelle …

At the beginning of 1878 a new three-mile trench mine was opened in the North and another chain of hills at Monte Rombolo, mentioned above.

This place is known as Botro ai Marmi, from the ancient Etruscan quarry now very little worked.

There are a lot of hematite veins around the limestone.

On the side of Monte Calvi, the old mines are numerous and large, some of which are probably unexplored by modern and other soldiers by the primitive workers.

Deep wells performed with great care sometimes occur in the woods that cover the hillsides, others such as the Buca del Colombo and the Buca del Serpente penetrate vertically at the top of the hill …

In Ponente there is a stretch of land covered with bushes called Campo alle Buche for the number of ditches and wells excavated by the ancients.

The vigor with which these excavations were carried out by those first workers, without dust, without dynamite and without the force of steam, is truly remarkable; those abundant remains of their industry would show that the minerals of this region made them a valuable metal product.

Wells at the Campo alle Buche sometimes have a depth of 40 or 50 feet, someone I think is deeper, there are traces of lead and copper, they were obviously abandoned as unprofitable ...

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