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RESEARCH

New data and insights on the secondary glass workshop of Comacchio (Italy): MgO contents, steatite crucibles and alternatives to recycling

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Abstract

This study introduces a collection of 33 glass samples, encompassing production indicators (blocks, fluidity tests, drops, cuts and wastes) and finished products (mainly goblets and probably a lamp) dating to the second half of the 7th century, except for a single more recent specimen (12th-14th). Additionally, a fragment was taken from a crucible bearing a thin layer of glass inside it. This new collection complements the investigation of glass materials from the Comacchio workshop previously analysed by Bertini et al. (2020).

Measurements were performed using scanning electron microscopy, electron microprobe, laser ablation inductively coupled plasma mass spectroscopy on all samples and Sr–Nd isotopic analyses on 5 blocks.

The results showed how the entire collection can be classified as natron-based silica-soda-lime glass and that the high MgO contents frequently observed are due to contamination with the steatite crucible. Contextually, the hypothesis of using plant ash-based glass mixed with natron-based glass formulated in the previous literature seems to have run out, along with the use of plant ash-based glass itself, further weakened by the very low representativeness of this latter type of glass on the site. The technological investigation further elucidated that recycling may not singularly account for the Comacchio glass technology. Discernible correlations may suggest the introduction of different types of metals, indicating a specialised control over the production process. Notably, the preference for green–blue glass emerges as a distinctive hallmark, underscoring the deliberate pursuit of a specific aesthetic taste.

Lastly, the provenance analysis showed that over three-quarters of production was based on semi-finished products from Egypt, while only the remaining quarter came from the Levantine coast.

Keywords Glass technology · Secondary production · Steatite crucibles · Metals and glass colouring

Introduction

Before the early 2000s, there were very few written sources on Comacchio and limited archaeological data. The archaeological area of Comacchio was thoroughly investigated from 2006 to 2009 under the direction of Prof. Sauro Gelichi. In 2021, the comprehensive volume summarising this archaeological research was published (Gelichi et al. 2021), including Ferri's works on glass (2021a) and the glass workshop (2021b).

Comacchio is situated on the Adriatic coast, north of Ravenna, at the mouth of the Po It is from this area (44°41′45.3"N 12°10′52.5"E). The town of Comacchio has several distinctive features, mainly ecological. Before its establishment, the area was characterised by scattered settlements whose main economic activities included fish farming, salt production and brick manufacturing. Some of

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these settlements evolved into religious centres in the sixth century. The historic centre's current boundaries align with its original layout, comprising a series of small islands in brackish lagoons. In the eastern part of the settlement, which is less explored archaeologically, there was likely a monastery. To the west, a port area with docks and wharves has been identified in the Villaggio San Francesco area. In the central part of the settlement, corresponding to the present Piazza XX Settembre, excavations have uncovered evidence of the bishop's residence, preceded by an artisan workshop.

In the artisanal area, dating to the second half of the 7th century, various productive activities occurred (Fig. 1). The best-preserved remains belong to a glass kiln, a third of which has been excavated, and a forge of the metal workshop. Bone working probably took place in an adjacent, unexcavated room since the remains of carved bones have also been found in the area (Garavello 2021 on animal bones).

The glass kiln had a semicircular shape, ca. 2.4 m (south side) by ca. 1.2 m, and the workshop was in use long enough to have undergone some renovations. It was built in an area previously occupied by residential buildings. Based on the traces left on the ground surface, two different working places can be described quite clearly to the northeast, while the access to the combustion chamber and the fuel loading area were located in the area to the northwest (not excavated).

To the east of the kiln, there must have been a passageway connecting the various workplaces to each other and with the other workshops in the immediate vicinity of the kiln itself, as no further structures or holes have been found. In this earlier phase, the room to the east was

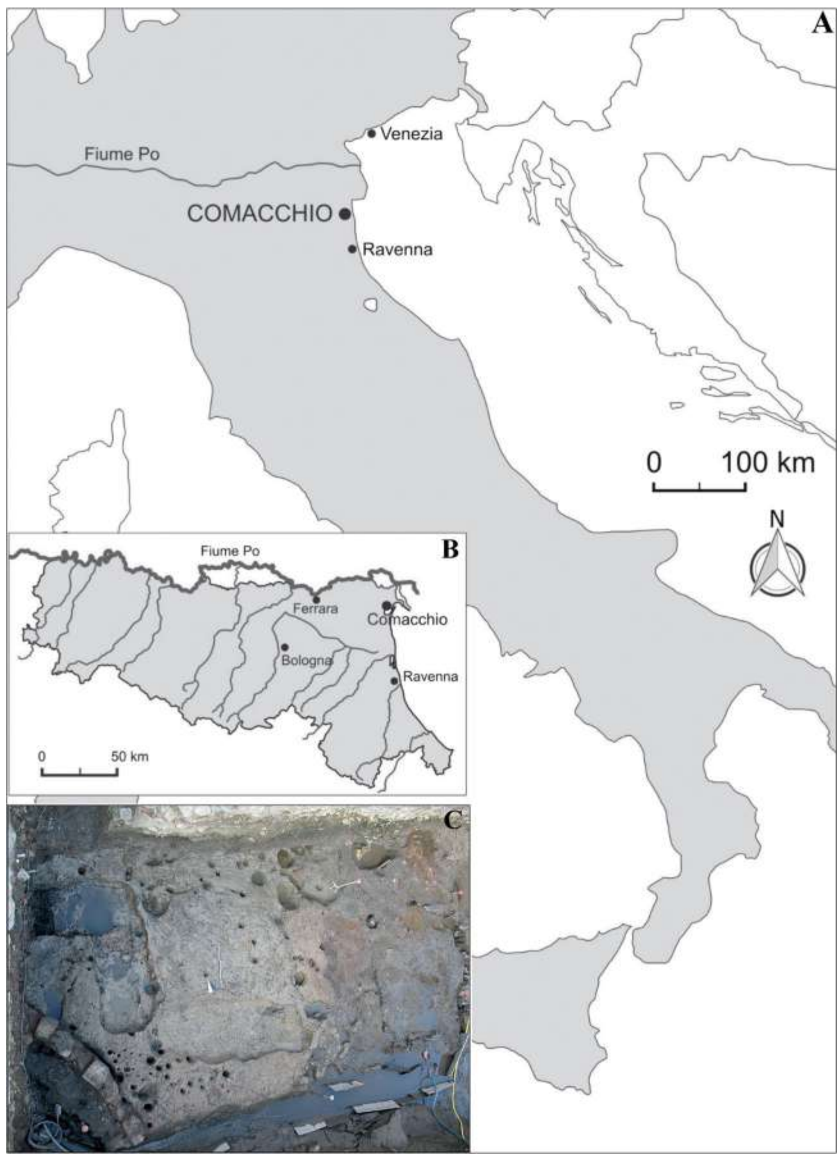

Fig. 1 **A**-**B**) Location of the archaeological site of Comacchio. **C**) The glass kiln during the excavation (credits: Laboratorio di Archeologia Medievale Ca' Foscari)

divided by a wooden partition, behind which was a quadrangular structure that did not appear to be related to the kiln or the glassmaking process.

In a short space of time, the work area was reorganised. The wooden partition was demolished and the eastern part of the workshop was converted into a metalworking area. In this new building reconfiguration, the metal and glass workshops were thus arranged in the same large room. The passageway to the east of the kiln was maintained and a free space of about 1 m in width remained between the glassworking area and the forge's service structures.

The production indicators testify that, later in time, the blowing of glass, the production of iron tools (especially nails but also tools for ironworking) and lead objects (weights for fishing nets) took place at the same time and in the same area (Rapone 2021). Some finds also indicate that copper (bronze) alloys were worked in the same area. The evidence that testifies to the polyvalence of the Comacchio workshop is numerous and all converge to reconstruct an activity aimed at the production of both everyday objects (goblets, nails, net weights) and sophisticated, technically complex objects such as double-layered cameos or bronze letters for epitaphs. For example, it is possible to cite the discovery of a Cu-Sn–Pb mould for cameos (Gagetti 2021; Galli and Bonizzoni 2021), a stone mould for casting the letter N (found in a phase dating from the 10th century but stylistically compatible with early mediaeval production; Mitchell 2021), and a small crucible, made of refractory ceramic, deemed for precious metals works but bearing remains of coloured glass (Ferri 2021a, p. 408).

Before the end of the 7th century, the entire room was redesigned. The glass kiln must have already been decommissioned since no waste was found during this phase. Some of the structures remained, probably for a short period of only a few years. The presence of a blacksmith strongly marked this phase. The main forge was moved to the east, closer to the kiln, thus occupying part of the space that was previously reserved for the movement of the glassmakers.

At the end of the 7th century and the beginning of the 8th century, the entire area was affected by extensive demolition and levelling work, which marked the end of all the artisanal activities that had previously been established in the area. The remains of the working structures were flattened to make way for a burial ground.

In the late 7th and early 8th centuries, Comacchio functioned primarily as a specialised trade nexus rather than a primarily land-based economy. It played a vital role in facilitating the flow of Mediterranean goods to inland regions. The significance of Comacchio in the history of the early medieval Mediterranean underscores the importance of characterising the glass artifacts found here and understanding the production technology employed.

A comprehensive examination of 89 samples found in the 7th to 11th c. phases of the Comacchio workshop was provided by Bertini et al. (2020). They divided their glass collection into plant ash glass (n = 3) and natron-based glass (n = 86), further grouped as Levantine A *Apollonia*-type glass (n = 12), Levantine B Jalame-type glass (n = 5), HIMT glass (n = 2), Foy 2 (n = 4 samples) and a mixed composition named "intermediate", "*similar to that of the Foy-2 compositional group*" (n = 63). Further groups, such as the Foy 2 high-Fe variant, were intentionally omitted by the authors. Focused on recycling, the authors recognised crucible contamination by higher Al_2O_3 and Fe contents, contaminants from the fuel ash based on the increase of K_2O or MgO levels and limited natron-plant ash mixing based on MgO, K_2O and P_2O_5 amounts. The overall reconstruction proposed by the authors is summarised in the following sentence: "*all major natron glass compositions were involved in heavy recycling practices (…), minus the intermediate group, for which we suggest is the result of mixing reserves of heavily recycled glass with unrecycled glass (…)*". The authors also extensively discussed plant ash-based glass as one of the components used for local production, mixed with natron-based glass.

This study intends to expand the collection of previously analysed materials by adding 34 samples of production indicators, vessels and a crucible. The research objectives fit into the frame of the Food & S.T.O.N.E.S. project aimed at studying the circulation of different types of early medieval goods, especially glass, in the Adriatic Sea (Gliozzo et al. 2023a-c). The archaeometric investigation seeks to obtain additional data on the provenance of the semi-finished products and the production technique of Comacchio glassworkers. In particular, it seems necessary to re-discuss the presence and use of plant ash-based glass already from the 7th century (Bertini et al. 2020) and to frame Comacchio's production in the wider context of early mediaeval Adriatic trade. An expansion of the database and new considerations on the use of steatite crucibles may indeed provide new food for thought both in terms of glass production technology and the type of Adriatic imports during the late antiquity and early mediaeval ages.

Materials

The samples were selected based on typological and stratigraphic criteria to obtain a representative collection of raw materials, objects -which are both products (*i.e.* goblets: Ferri 2021a) and objects intended for recycling- and glass-working wastes (Table 1). As for the latter, some of them were found in the stratigraphic phase subsequent to the period of activity of the kiln. However, these findings were contemporary with the production of glass but were subsequently disturbed and brought to the surface due to

Table 1 Basic information on investigated samples: the inventory no. (inv.); the context and the period of discovery; the shape and colour abbreviated as aB (aqua blue), laB (light aqua blue), dB (dark blue), C (colourless), lG (light green), Y (yellow). Reference to the shape as in Stiaffini (1985). All finds, except for CO530, were attributed to the glass workshop, which dates from the second half of the seventh century, even if they were found in later stratigraphic units

Inv	Context	Period	Shape	Colour	Typology
Finished objects					
CO92	1842	7.1	Goblet	lG	A2
CO93	1842	7.1	Goblet (marvered)	lG	A2
CO94	1842	7.1	Goblet	lG	A2
CO95	1842	7.1	Goblet	lG	A2
CO96	1842	7.1	Goblet	lG	A2
CO325	1956	8.1	Goblet	lG	A2
CO366	2172	8.3	Goblet	laB	A2
CO368	2172	8.3	Goblet	laB	A2
CO530	2418	4.3	Lamp?	G (with red strips)	A2
CO88	1842	7.1	Wall (marvered)	C	A2
CO99	1842	7.1	Pad-base	Y	-
CO233 A	2019	8.3	Window	G	-
CO233 B	2019	8.3	Window	G	-
CO233 C	2019	8.3	Window	dB	-
CO25	1851 t. 60	7.1	*Tessera*	C	-
Production indicators					
CO24	1851 t. 60	7.1	Block	dB	-
CO58 A	1701 t 43	6	Block	aB	-
CO100 B	1842	7.1	Block	G	-
CO121 E	1185	6	Block	lG	-
CO122	1185	6	Block	B	-
CO184 B	1826 t. 56	7.1	Block	G	-
CO100 A	1842	7.1	Moil	lG (with red strips)	-
CO121 C	1185	6	Moil	G	-
CO121 D	1185	6	Moil	lG (greyish)	-
CO230	2019	8.3	Moil	G	-
CO184 A	1826 t. 56	7.1	Cutting	G (greyish)	-
CO58 B	1701 t 43	6	Dripping	lG	-
CO121 A	1185	6	Dripping	lG	-
CO121 B	1185	6	Dripping	lG	-
CO23(a)	1851 t. 60	7.1	Fluidity test or test droplet?	G	-
CO23(b)	1851 t. 60	7.1	=	aB	-
CO58 C	1701 t 43	6	Glass on crucible	G	-
CO365	2172	8.3	Waste	laB	-
CO184 C	1826 t. 56	7.1	Waste (deformed wall)	lG	-

the excavation of burial pits (9th-11th centuries) and the construction of the episcopal buildings (12th-14th centuries). The production indicators were undoubtedly part of the glassworks of the mid-7th century, thus earlier than the context in which they were found.

The total number of glass fragments found at Comacchio was about 2000 and the finished glass objects found were numerous (531 fragments attributable to 269 individual objects). The 34 samples selected for this study correspond to 33 objects that can be divided into working wastes (19), tableware (9 goblets and 1 beaker/cup resting on a pad-base), lighting vessel (1 lamp) and glass for architectural use including 1 mosaic *tessera* and 3 fragments of window glass (Table 1; Figs. 2–3).

Among the most attested vessels are stemmed goblets, which correspond to the late antique type Isings no. 111 (Isings 1957, p. 139; on the Italian early mediaeval evolution of type, see Stiaffini 1985, type A2, pp. 669–670). In these goblets, the foot and the bowl are obtained by working a single blown *paraison*, which is folded back on itself to form the foot, characterised by a tubular rim, with a bell-shaped profile or, as more common in Comacchio, with a flattened profile (CO94; CO95; CO96). The stem is short and hollow (CO366). The cup has a fire-polished rim (CO92;

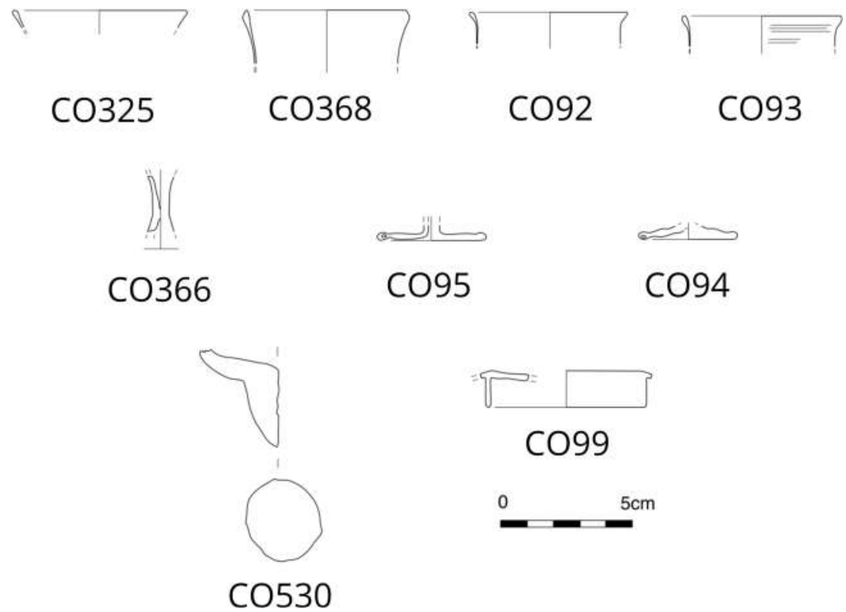

Fig. 2 Glass typology. Representative shapes (credits: Laboratorio di Archeologia Medievale Ca' Foscari)

CO93; CO325; CO368). The body may have a deep bowl with an inverted conical or bell-shaped profile (with a flared upper rim and a wall that descends in a more or less/slightly S-shaped curve). Some vessels have a white marvered in trail positioned 1–2 cm below the rim (CO88; CO93; Fig. 3). Small goblets with a flattened disc base between 3.6 and 4 cm in diameter were the main output of the late seventh-century workshop, as they were the only failed vessels found. This type of goblet was produced throughout the Mediterranean from the 5th century onward, possibly until the 8th-10th centuries, and was widely used among glassware. It is a multipurpose object that could also be used for lighting domestic spaces.

Some lamps have been found in Comacchio, but far from the workshop and close to the site where the cathedral would be built a few decades later. Moreover, the absence of wastes that can be typologically assigned to lamps with certainty suggests that these vessels were not produced in the Comacchio workshop. The sampled handle presumably belonging to this type was found in contexts dating from the 12th to the 14th centuries and was chosen for its double colour (CO530).

A few bottles and the base CO99, probably belonging to a late antique cup, have peculiar formal characteristics, unparalleled in the Comacchio repertoire. The hypothesis is that they are broken fragments collected for recycling. Part of the sample set is further represented by windowpanes (CO233a; CO233b; CO233c) and mosaic *tesserae* (CO25).

Working wastes include drops, drips and filaments (CO23a; CO23b; CO58b; CO121a; CO121b; CO365), small blocks (CO24; CO58a; CO100b; CO121e; CO122; CO184b), moils (remains of the detachment of the vessel from the blowpipe: CO100a; CO121c; CO121d; CO230), and cut-outs produced during the finishing of the objects (CO184a; CO184c); none are attributable to a specific form.

Finally, a fragment of a crucible bearing an internal thin layer of glass was also retrieved and archaeometrically investigated (CO58c).

Experimental

The chemical composition of all samples was obtained through electron microprobe analysis (EMPA) and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). A small set of 5 blocks, was processed for Sr and Nd isotopic analysis. Lastly, the crucible and the glass attached to it was further investigated through optical microscopy (OM), scanning electron microscopy (SEM–EDS) and EMPA.

EMPA The quantitative determination of major and selected minor elements (Cu, Sb and Pb), as well as volatiles (Cl and S) was performed at the joined laboratory of the DST-UNIFI and CNR-IGG of Florence, using a JEOL Superprobe JXA-8230, equipped with five wavelength-dispersive spectrometers (WDS), under the following operating conditions: 15 kV, beam current at 10nA and beam diameter 10 µm. The peak counting time was of 10 s for Na, 15 s for MgO, Al_2O_3, SiO_2, K_2O, CaO, FeO, TiO_2, 30 s for P_2O_5, Cl, S and 40 s for MnO, Sb_2O_5, SnO_2, PbO and CuO. Matrix effects were corrected by ZAF algorithm. A selection of natural phases is used as primary standard for the elemental calibration (Astimex albite for Si and Na, plagioclase for Al, olivine for Mg, diopside for Ca, sanidine for K, apatite for P, celestine for S, tugtupite for Cl, barite for Ba and Smithsonian

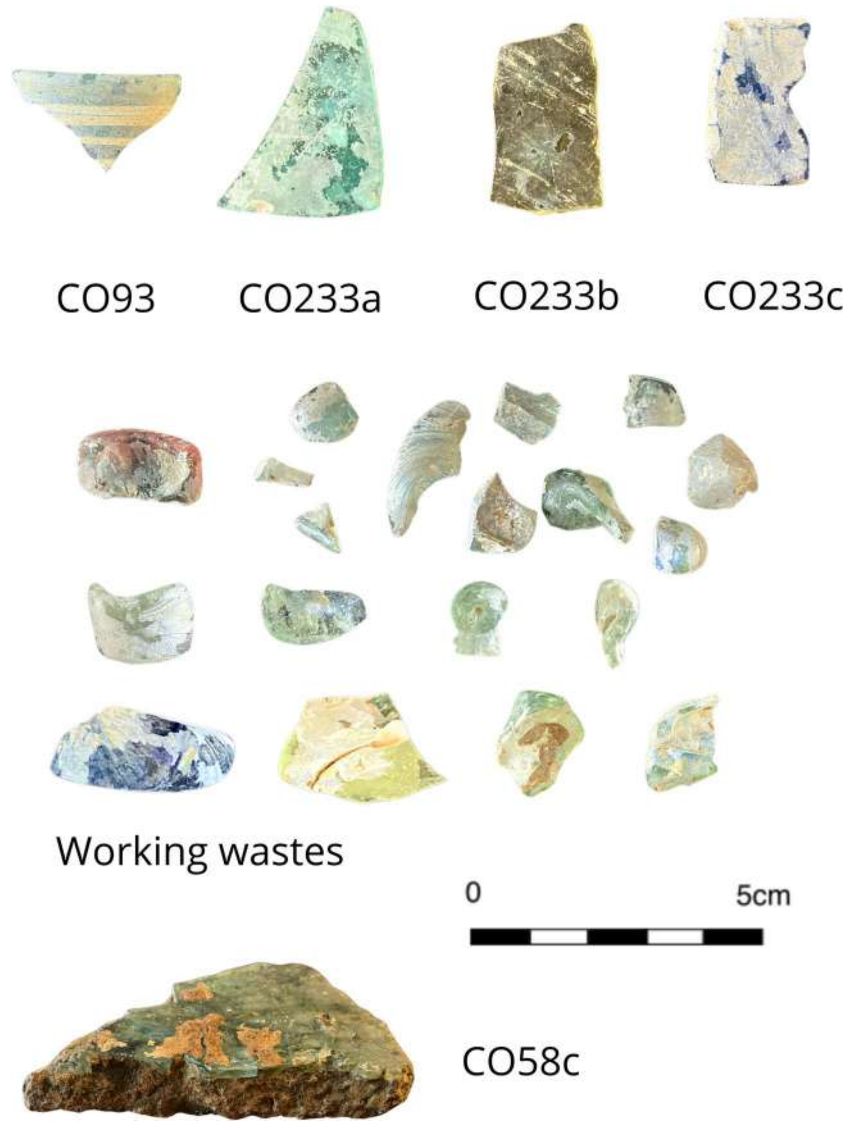

Fig. 3 Representative images of the glass collection. At the top: rim of a goblet with white marvered trails and windowpanes. In the centre: drops, filaments, moils and small blocks. At the bottom: crucible with an inner layer of glass (credits: Laboratorio di Archeologia Medievale Ca' Foscari)

ilmenite for Ti and Fe). Synthetic reference material glass NIST-SRM1832 and three different Smithsonian Corning glasses (Corning-A NMNH 117218–4, Corning-B NMNH 117218–1 and Corning-D NMNH 117218–3; Vicenzi et al. 2002) are used as specific secondary standards for the analytical quality control. Replicate measurements (10 to 25) on the above-mentioned international reference standards show a good precision with a variation coefficient lower than 1% for silica, up to 2% for the other major elements and up to 5% for minor elements. Accuracy is lower than 0.5% for silica, up to 0.5% for the other major elements, between 0.8–1% for most minor elements while up to 2% for Sb_2O_5 and PbO. The total R^2 is considerably lower than 1 for all the analysed standards.

LA-ICP-MS The trace element content was determined by laser ablation-inductively coupled plasma-mass spectrometry (at IGG-CNR, Pavia, Italy). The instrument combined an ablation microbeam, based on a Nd:YAG laser source (Brilliant, Quantel) operating at 266 nm (for details see Tiepolo et al. 2003), and a quadrupole ICP-MS (Drc-e, Perkin Elmer). Forty masses were acquired; the laser was operated at 10 Hz of repetition rate, the power on the sample was 1.5 mW and the spot size was set at 40 µm. Accuracy was assessed on the USGS BCR-2 reference glass (analysed as an unknown in each analytical run) and was better than 20% at the sub ppm level. Data reduction was carried out with the software package GLITTER (Van Achterbergh et al. 2001) and using NIST SRM 610 and ^{29}Si as external and internal standards, respectively.

Sr and Nd isotopes Samples preparation and isotopic analysis were performed at the DST-UNIFI Laboratory of Geochemistry of Radiogenic Isotopes. The selected samples were preliminary crushed in small shards and weighted to an amount of some 150–200 mg, to get enough material for Sr and Nd isotopic measurements. The shards were then placed in an ultrasonic bath with ethanol for few minutes to remove any external impurities.

Sample dissolution was carried out through acid digestion using concentrated HF and multiple additions of HNO_3 in the first step, followed by diluted 6N HCl (Avanzinelli et al. 2005 for details). The separation and purification of Sr and Nd were performed using cation-exchange AG W5x mesh and Ln-spec reusable resins respectively by sequential additions of properly diluted HCl Suprapure acid. A representative international standard reference material (USGS granite standard G-2) was also processed together with samples for data validation (Table S3). The G-2 standard is well defined in terms of Sr and Nd isotope values, as demonstrated by Weiss et al. (2006), showing good homogeneity in isotopic composition. Moreover, being a granite, which represents one of the more common protoliths for sands and is compositionally representative of crustal-derived material, it is the most suitable choice for a sand-dominated matrix, such as artificial glass. The total procedural blank for Sr was 300 pg, resulting in a negligible effect on isotope results, considering the amount of the processed material. Isotope ratios were measured via Thermo Finnigan Triton-Ti® thermal ionization mass spectrometer (TIMS) equipped with nine movable collectors. Sr isotopic compositions were measured in dynamic mode and corrected for mass fractionation, normalising to the natural value of $^{88}Sr/^{86}Sr = 8.375209$. Possible ^{87}Rb interference has been corrected using the natural $^{87}Rb/^{85}Rb$ ratio of 0.386, resulting in minor or negligible variations in the measured isotope value. International standard NIST-SRM 987 and USGS G-2, used to check for data quality, yielded results of 0.710264 ± 0.000004 (2sd, average of two measurements) and 0.709777 ± 0.000006 (2se), respectively. These results overlap within the error margins (2sd) of the known values from literature references by Thirlwall (1991) and Weis et al. (2006) (Table S3). Nd isotopic ratios were measured in static mode, using the natural $^{146}Nd/^{144}Nd$ value of 0.7219 for correction of mass fractionation. Internal NdFi and international USGS G-2 standard were used as quality control, providing values of 0.511463 ± 0.000005 (2sd, average of two measurements) and 0.512219 ± 0.000007 (2se), respectively well within the error (2sd) of the literature reference values provided by Avanzinelli et al. (2005) and Weis et al. (2006) (Table S3).

SEM–EDS For the crucible, a small slice was cut perpendicular to the sample surface to prepare the polished thin section. Morphological and semi-quantitative micro-chemical analyses were obtained by means of a SEM–EDS electronic microscope (ZEISS EVO MA 15; M.E.M.A. University of Florence) equipped with an analytical system in dispersion of energy EDS/SDD, Oxford Ultimax 40 (40mm^2 with resolution 127 eV @5.9 keV). The operative conditions were: acceleration potential of 15 kV, 500 pA beam current, working distance of 9–8.5 mm; 20 s live time as acquisition rate useful to archive at least 600.000 cts, on Co standard, process time 4 for point analyses. The microanalysis software (Aztec 5.0 SP1) applies the XPP matrix correction scheme developed by Pouchou & Pichoir (1991). This is a Phi-Rho-Z approach which uses exponentials to describe the shape of the φ (ρz) curve. XPP matrix correction was chosen because of its favourable performance in situations of severe absorption, such as the analysis of light elements in a heavy matrix. The quantitative analysis is "standard-less", *i.e.* using pre-acquired standard materials for calculations, and the achievement of constant analytical conditions (*i.e.* filament emission) is obtained through repeated analyses of a Co metallic standard. Detection limits and precision were of 0.1 wt% and ~ 2%, respectively. Observations were mainly performed in backscattered electrons on carbon-coated polished surfaces and compositional maps were further acquired.

Results

The results of the analyses conducted by EMPA, LA-ICP-MS and isotopic analyses are shown in Supplementary Tables S1, S2 and S3, respectively. EMPA and LA-ICP-MS full data set is also provided in Supplementary Tables S4 and S5. A further file containing measurements has been provided as supporting documentation in Supplementary Materials (Excel Table).

Textural features

The collection mainly includes homogeneous glass but also numerous banded samples (CO23A, 92, 100A, 121A, 121B, 230, 325, 365, 530; Supplementary Fig. S1). Among banded samples, the compositional differences vary from sample to sample and are related to changes in the levels of Cu and/or Sb and/or Pb. The lighter bands show higher Cu, Sb and Pb levels than dark bands in CO92 (light green), higher Pb in CO325 (green), higher Pb and, to a lesser extent Sb, in CO121A-B (light green), CO230 (green) and CO365 (green). In samples CO100A and CO530, dark and light bands macroscopically correspond to green and red glass, respectively. Green glass is characterised by lower Fe, Cu and Pb contents than red glass. Sb levels do not show consistent variation between the two glass colours. The fluidity test no. CO23 comprises a homogeneous, likely fresh, aqua blue portion (CO23B) and a finely banded, intentionally coloured, green portion (CO23A). The latter was obtained due to the addition of Cu, Sb and Pb and does not show colour variations on a macroscopic scale. Moreover, a heterogeneous aggregate (Supplementary Fig. S2) has been found close to the surface. It contains wollastonite -incorporating other elements such as Na, Al, Fe, Mn, Mg and Sb (Supplementary Table S6)—and clinopyroxene. The latter shows a Na-rich composition, ranging from a Mg- and Ca-poor diopside to a Fe-poor salitic augite and an aegirine-augite (Supplementary Table S7).

In Supplementary Table S1 (EMPA results), the bands are indicated as db (dark grey bands), mb (grey bands), lb (light grey bands) and wb (white bands) and the composition of each band is provided together with their average (av.) values.

Glass components

Based on MgO-K_2O ratio, the glass collection is all made of natron-based glass, although samples CO58B and CO58C are characterised by high K_2O (2.73 wt%) and MgO (4.33 wt%) levels, respectively (Lilyquist and Brill 1993). As will be explained later, while the increase in K_2O levels can be mainly due to environmental contamination, those of MgO can be explained by the use of steatite crucibles. Al_2O_3 contents ranging between 1.95 and 3.42 wt% point to the use of impure sands as the vitrifying agent (Henderson et al. 2004). Nevertheless, other values such as FeO, TiO_2 and Zr, clearly indicate the use of different types of sands. The stabilising agent is CaO in all samples (3.9–9.5 wt%). Sr contents show a wide range of values (from 176 to 612 ppm) and those above 350 may further suggest the presence of shells, either deliberately added to the glass batch or naturally present in the sand (Freestone et al. 2003; Degryse 2014), as it further discussed below commenting on isotopic analyses.

Regarding colouring agents, one aqua blue fluidity test (CO23B) and two goblets (aqua blue CO368 and light green CO94) show MnO contents below 0.025 wt% and negligible levels of decolouring/colouring agents (each < 10 ppm Cu, Sn, Sb and Pb each). Therefore, they are considered naturally coloured by the iron present in the sand. Similarly, the green sample CO233Ais deemed naturally coloured glass, assuming the use of a MnO-richer sand (MnO 0.179 wt%).

All other samples can be classified as either recycled or intentionally de/coloured by using the conventional thresholds of 100 ppm and 1000 ppm, respectively, for the contents of Cu, Sn and Sb (Jackson 1996; Gliozzo 2017). Based on this criterion, a small group of 8 samples, including the crucible glass, exhibit concentrations of at least one of these elements between 100 and 1000 ppm (CO23A, CO25, CO58A, CO58C, CO230, CO233B, CO365 and CO366).

Among the remaining 22 intentionally coloured samples, the green olive pad-base CO99 had only FeO and MnO added, while the light green block CO121E had only Sb added to a MnO-rich glass (2019 ppm Sb; 0.385 wt% MnO). All the other 20 samples show Cu and/or Sb or even Sn concentrations above 1000 ppm, with none of the indicative elements below 100 ppm. Within this subgroup, the green–red samples (CO100A and CO530) and the blue glass samples (CO24, CO122 and CO233C) warrant further attention. Concerning the former, despite iron levels not being particularly high (0.97 and 1.33 wt% FeO, respectively), as might be expected to favour reducing conditions for red glass (Cable and Smedley 1987), it is noteworthy that Pb and Sn amounts are double or even triple in the red areas compared to the green ones, while copper and antimony show similar levels in all bands. Overall, the low iron levels and, particularly, the green–red banded texture suggest the mixing of green and red glass. Regarding the blue blocks and the blue window, glass colour was obtained by the addition of cobalt, and the Co/Ni ratio—varying between 6.9 to 10.2—fits well within the 2–23 range indicated by Gratuze et al. (2018) for Byzantine glass.

Additionally, most of the green and blue-green glass exhibit strong linear correlations between several de/colouring agents, providing compelling evidence that warranted the in-depth analysis presented in the Discussion section.

Isotopic composition

The isotopic systematics of strontium (Sr) and neodymium (Nd) in ancient glasses offer valuable insights into the sources of the different components utilised in the glass-making process. In the case of natron-based glass, the isotopic ratios of Sr are significantly influenced by the carbonates that act as stabilizing agents. In contrast, the isotopic ratios of Nd are primarily linked to the sand used as a vitrifying agent.

Five blocks were selected for Sr and Nd isotopic analyses (Supplementary Table S3). These specimens were chosen because they are more likely to represent the original composition of the imported materials.

In these samples, the elevated Sr concentrations (above 400 ppm) may suggest the presence of shells. These shells could either have occurred naturally in the sand or been intentionally added to the glass batch (Freestone et al. 2003; Degryse 2014). The measured $^{87}Sr/^{86}Sr$ isotopic ratios vary from 0.70882 ± 0.000005 (CO121E) to 0.70894 ± 0.000005 (CO58A), indicating values slightly lower than the modern seawater standard of 0.709165 (Stille & Shields 1997; Banner 2004), but higher than the typical signature of the ancient Mesozoic carbonate platform (0.707–0.7075) extensively exposed in the Mediterranean region (Fig. 4A). While these initial findings seem to rule out the addition of limestones, they align with the utilisation of coastal sand, potentially containing abundant carbonate shells.

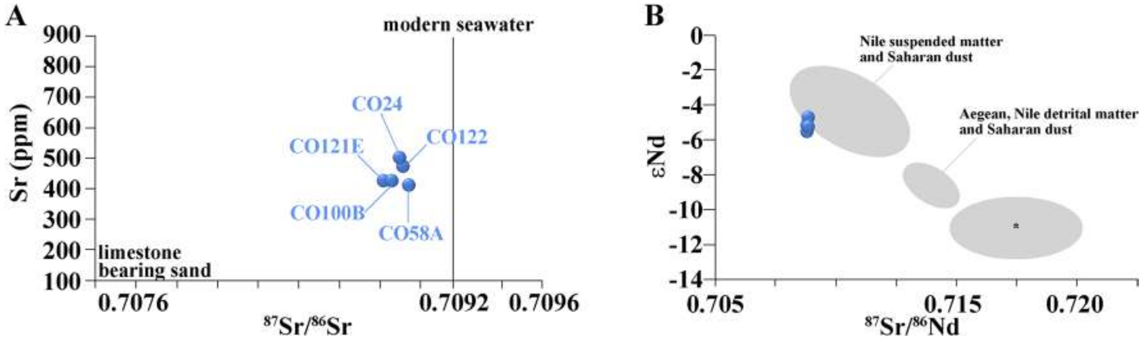

Fig. 4 The Sr, Nd isotopic values in Comacchio blocks. Measurements errors are encompassed within the symbol size

In terms of neodymium, the absolute concentrations among the five samples are notably consistent (5.6/7.0 ppm). However, there is relative heterogeneity in the $^{143}Nd/^{144}Nd$ isotopic ratios, ranging from 0.512357 (CO121E) to 0.512399 (CO58A), corresponding to -5.48 and -4.66 εNd, respectively. Notably, samples CO121E and CO58A exhibit the lowest and highest isotopic ratios for both $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$, respectively, indicating variations in the materials used compared to the other three samples. In a broader context, the integration of Sr and Nd isotopic signatures with additional geochemical parameters linked to sand composition (such as Ti_2O, Al_2O_3 and Zr) offers insights into the provenance of the sands employed. While it is conceivable that CO24 and CO122 may have utilised similar sands, the remaining three samples exhibit a discernible heterogeneity. This observation suggests the potential utilisation of different sands or variability in composition within the sourcing locale.

Lastly, it should be noted that all the samples fall within the range of variability of the surface sediments of the Nile River's riverine suspended matter and Saharan dust as characterised by Weldeab et al. (2002), among the various comparisons that can be proposed (Fig. 4B). This suggests a possible provenance of the sands used as a vitrifying agent from the easternmost regions of the Mediterranean basin.

The crucible – CO58c

This small fragment, measuring 5 cm in width and 2.5 cm in thickness, exhibits three distinct layers, as depicted in Fig. 5. The bottom layer comprises quartz, K-feldspar, albitic plagioclase, orthoamphibole, calcite and rare Mg-Fe chlorite (typically below 150 μ), embedded in a poorly sintered clayey matrix. The presence of calcite and the poor sintering of the matrix suggests that this layer did not undergo high temperatures. However, it remains uncertain whether this layer represents a fragment of earth inadvertently adhered to the crucible or a deliberately laid layer. While the former hypothesis would explain the low temperatures observed, the latter hypothesis appears less plausible, albeit ceramic linings of crucibles have been known to effectively mitigate heat loss and prevent cracking of the overlying layers, a technique frequently observed in other crucibles (Bayley and Rehren 2007; Thornton and Rehren 2009).

The middle layer is a carbonate talc schist, commonly referred to as steatite or soapstone, subjected to high temperatures. It is worth noting that the process

Fig. 5 The crucible layering

of transforming talc ($Mg_3Si_4O_{10}(OH)_2$) into enstatite ($Mg_2Si_2O_6$) begins at a temperature of 900 °C. This transformation is then followed by two more between 1000 °C and 1200 °C (from enstatite to protoenstatite), and between 1300 °C and 1400 °C (from protoenstatite to clinoenstatite). The process ends with complete melting, which occurs between 1405 °C and 1545 °C. This information has been supported by research from Antonelli et al. (2006), Silva Torres et al. (2015), and Baehre et al. (2019). Due to these transformations, it is possible to hypothesise a mixture of these phases from the internal to the external section of the crucible, although not inferable by SEM–EDS.

Chlorite breakdown products with acicular habitus are ubiquitous and show a Mg-rich and Cr-rich composition. Forsterite is sporadic and areas rich in calcite and magnesium probably testify to the original presence of dolomite and magnesite (both decomposed at 700 °C; see, *e.g.*, Tian et al. 2014, Olszak-Humienik and Jablonski 2015). Iron compounds (hematite and/or magnetite?) and Mn-rich apatite are the prevalent accessory phases.

Lastly, the outermost layer is made up of glass corresponding to sample CO58C. In this layer, newly formed diopside is present at the interface with the steatite. Five transects were carried out by SEM–EDS to investigate the potential diffusion of elements between the crucible and the glass (Supplementary materials Figs. S3-S7). Both materials were crossed by these transects. The full documentation is available in the Supplementary materials, where the total transect and two partial transects—one on the glass and one on the crucible—are shown, leaving out the altered surface and the interface where newly formed crystals are sometimes present.

Regarding the glassy portion, it is worth noting that in all transects, a few elements consistently display the same trend. MgO continually increases as the analysis proceeds toward the crucible once the surface alteration has been overcome. On the other hand, CaO shows the opposite trend, with a constant decrease from the glass to the crucible.

Despite modest quantities and a more heterogeneous distribution do not allow the variation to be equally clear, also K_2O and FeO show a similar trend to MgO (especially in transect no. 1). Na_2O's behaviour is more similar to that of CaO but not as consistent. Al_2O_3, SiO_2, TiO_2, and MnO do not show significant changes.

The crucible portion has a composition so diverse from that of the glass and so heterogeneous that it does not allow continuous diffusion to be observed, except for CaO. Therefore, the relevant data primarily concerns (a) MgO and, to a lesser extent, K_2O and FeO, whose contents are enriched proportionally to the proximity to the crucible, and (b) CaO with the opposite behaviour, perhaps partly followed by Na_2O.

Discussion

Glass provenance

In a secondary production context like Comacchio, determining provenance can be challenging. Production and recycling cycles may have mixed, diluted or increased the amounts of indicative geo-markers (*e.g.*, TiO_2, Al_2O_3, Zr and Hf). In this section, an attempt has been made to answer the provenance question and specify its reliability level. Table 2 summarises the results concisely, reporting key values. The compositional reference groups used for comparison are provided in Supplementary Tables S8a-b (Brill 1988; Freestone 1994; Freestone et al. 2000; Foy et al. 2003; Foster and Jackson 2009; Rosenow and Rehren 2014; Ceglia et al. 2015; Cholakova and Rehren 2018; Schibille et al. 2019; De Juan Ares et al. 2019; Schibille 2022). Compatibility with reference groups was tested based on all major elements and a selection of minor and trace elements, including Co, Cu, Sn, Sb, Sr, Zr, Hf, Pb, and REEs. Individual values that fell outside the compositional range of the reference group were noted in the text. Moreover, a reassessment of the provenance of the samples analysed in Bertini et al. (2020) has been performed and the results (which are quite similar) are compared in Supplementary Table S9. It may help the reader to consider that all samples from Bertini et al. (2020) are indicated with “Com” while those investigated in this study are indicated with “CO”. The sum of the samples analysed here with those previously investigated by Bertini et al. (2020) is equal to 123 vitreous findings. Among these, complete analyses (EMPA and LA-ICP-MS) are available for 94 samples.

Levantine glass The naturally coloured fluidity tests CO23B and the goblet CO368 present the typical composition of Levantine glass, characterised by low TiO_2/Al_2O_3 and high Al_2O_3/SiO_2 ratio, along with low amounts of FeO, MgO, K_2O and Zr. In particular, the very low levels of MnO (0.22 and 0.010 wt%) and the Na_2O/SiO_2 and CaO/Al_2O_3 ratios closely resemble the composition of the *Apollonia* products (Freestone et al. 2000, 2008; Tal et al. 2004; Phelps et al. 2016; Brems et al. 2018). Similarly, the moil CO230 and the waste CO365 can be associated with *Apollonia* products despite showing evident traces of recycling and lower Al_2O_3 amounts in CO230. The goblets CO94 and CO366 bears the same general characteristics of the previous samples but differs in relatively lower Al_2O_3 contents and, regarding CO94, higher CaO levels. These characteristics find comparison with Jalame products (4th c.; see Brill 1988 and Freestone et al. 2023); therefore, these two samples have been indicated as *Apollonia*/Jalame, meaning that both comparisons

Table 2 Main features of Comacchio glass, ordered by provenance assignment. Full EMPA and LA-ICP-MS data are provided in Supplementary Tables S1–S2 and S4–S5

Provenance	Publ.no.	Type	Colour		SiO_2	TiO_2	Al_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	Cl	Co	Cu	Sn	Sb	Pb	Sr	Zr
Apollonia	CO23B	Fluidity test	aB	Nat. col.	71.98	0.06	3.20	0.43	0.02	6.24	0.43	15.77	0.55	0.04	0.21	0.98	1	5	2	1	6	324	39
Apollonia	CO368	Goblet	laB	Nat. col.	72.21	0.06	3.13	0.37	0.01	6.96	0.48	15.18	0.51	0.04	0.12	0.86	1	3	1	0	5	369	32
Apollonia/Jalame	CO366	Goblet	laB	Rec.	69.24	0.08	2.79	0.64	0.33	7.98	0.95	15.77	0.78	0.15	0.19	0.78	9	348	196	273	893	443	52
Apollonia-like	CO230	Moil	G	Rec.	71.00	0.08	2.71	0.64	0.15	6.66	0.71	15.64	0.63	0.09	0.17	0.91	8	607	874	209	3504	405	50
Apollonia-like	CO365	Waste	laB	Rec.	72.83	0.07	2.99	0.47	0.06	6.80	0.63	14.33	0.53	0.07	0.15	0.79	2	205	137	73	650	380	43
Jalame/*Apollonia*	CO94	Goblet	lG	Nat. col.	71.64	0.06	2.82	0.39	0.02	9.51	0.62	13.28	0.97	0.06	0.22	0.38	1	12	2	0	13	353	38
Levantine area	CO58C	Crucible g.	G	Rec.	72.63	0.08	2.75	0.75	0.05	3.94	4.33	13.55	0.83	0.07	0.12	0.79	15	105	183	42	295	268	50
G2.1/G2.2	CO23A	Fluidity test	G	Rec.	67.26	0.13	2.64	0.96	0.75	7.33	1.13	16.84	0.89	0.16	0.26	0.80	23	885	521	924	4076	536	88
G2.1/G2.2	CO24	Block	dB	Int. col.	67.55	0.09	2.39	0.77	0.58	6.61	0.88	17.67	0.57	0.12	0.36	0.85	277	2133	178	6991	3381	501	61
G2.1/G2.2	CO58B	Dripping	lG	Int. col.	66.80	0.13	2.52	1.05	0.68	6.63	0.98	15.98	2.72	0.15	0.23	0.82	37	1124	668	2645	6528	517	76
G2.1/G2.2	CO92	Goblet	lG	Int. col.	64.95	0.16	2.56	1.01	0.87	7.25	0.99	17.07	0.73	0.20	0.30	0.85	71	3180	2875	3402	17683	605	100
G2.1/G2.2	CO93	Goblet	lG	Int. col.	67.97	0.11	2.55	0.93	0.63	6.50	0.97	17.16	0.73	0.12	0.26	0.93	33	1742	706	1788	4578	498	69
G2.1/G2.2	CO95	Goblet	lG	Int. col.	66.49	0.14	2.58	1.07	0.88	6.78	0.90	17.79	0.73	0.14	0.28	1.07	29	1805	381	1745	4603	500	93
G2.1/G2.2	CO96	Goblet	lG	Int. col.	66.04	0.13	2.46	1.29	0.93	6.78	1.04	17.65	0.79	0.15	0.28	1.02	43	2579	896	1263	5929	528	83
G2.1/G2.2	CO100A	Moil	lG(R)	Int. col.	68.72	0.13	2.81	0.93	0.34	5.94	0.90	16.63	0.83	0.13	0.21	0.91	29	2290	1801	1100	7719	435	72
G2.1/G2.2	CO121A	Dripping	lG	Int. col.	67.80	0.13	2.49	1.06	0.86	6.55	1.14	17.07	0.76	0.08	0.26	0.93	26	1233	575	1189	3344	462	80
G2.1/G2.2	CO121B	Dripping	lG	Int. col.	68.06	0.11	2.82	1.00	0.45	6.47	0.96	16.89	0.91	0.16	0.23	0.91	24	1882	444	1389	4083	443	66
G2.1/G2.2	CO121D	Moil	lG	Int. col.	66.81	0.12	2.49	1.01	0.82	6.79	0.93	17.33	0.71	0.17	0.32	1.05	40	2550	417	2819	4635	482	74
G2.1/G2.2	CO122	Block	B	Int. col.	67.58	0.09	2.32	0.90	0.61	6.78	0.90	17.42	0.70	0.11	0.34	0.69	275	2482	182	6345	2435	473	79
G2.1/G2.2	CO184A	Cutting	G	Int. col.	67.25	0.13	2.62	1.02	0.68	6.80	1.07	17.29	0.82	0.14	0.26	0.69	41	1908	670	1906	5311	459	75
G2.1/G2.2	CO184B	Block	G	Int. col.	67.29	0.10	2.45	0.89	0.73	6.60	0.89	17.82	0.57	0.11	0.31	1.11	24	2098	261	2196	4389	455	64
G2.1/G2.2	CO184C	Wall	lG	Int. col.	66.90	0.12	2.44	0.98	0.75	6.52	1.04	17.93	0.69	0.14	0.29	1.01	47	2057	421	2343	4725	458	72
G2.1/G2.2	CO233C	Window	dB	Int. col.	66.33	0.11	2.43	1.11	0.78	7.31	1.00	17.30	0.78	0.22	0.32	0.88	442	2099	523	3349	4264	543	72
G2.1/G2.2	CO325	Goblet	lG	Int. col.	66.93	0.12	2.67	1.02	0.57	7.21	1.19	16.50	0.85	0.19	0.24	0.78	27	1986	1203	718	9245	513	72
G2.1/G2.2	CO530	Lamp?	G(R)	Int. col.	65.67	0.12	2.78	1.33	0.59	7.56	1.00	14.82	0.85	0.18	0.19	0.73	72	7270	5277	301	23672	533	62
G2.1HFe	CO233B	Window	G	Rec.	68.50	0.12	2.56	1.75	1.15	6.74	1.01	16.19	0.61	0.13	0.28	0.83	8	48	5	101	80	612	82
G3.2	CO25	*Tessera*	C	Rec.	70.38	0.07	1.95	0.42	0.60	5.98	0.62	17.95	0.42	0.02	0.24	1.29	5	24	2	228	16	423	42
G3.2-like (/G2.1)	CO88	Wall	C	Int. col.	67.12	0.08	2.28	0.54	0.37	6.47	0.72	17.99	0.49	0.06	0.34	1.15	16	1561	2201	1608	14546	429	51
G3.2-like (/G2.1)	CO100B	Block	G	Int. col.	67.46	0.09	2.35	0.91	0.80	6.46	0.81	18.24	0.61	0.10	0.27	1.06	19	1548	192	1404	2700	428	56
G3.2-like (/G2.1)	CO121E	Block	lG	+Mn+Sb	67.48	0.09	2.28	0.65	0.38	6.16	0.99	19.45	0.43	0.04	0.34	1.34	4	15	2	2019	22	424	54
HIMTa	CO99	Unknown	oG	+Fe+MnO	64.34	0.51	3.42	2.15	2.31	4.68	1.39	19.23	0.38	0.07	0.25	1.20	16	84	1	0	8	417	298
Egypt 2 low Na_2O	CO233A	Window	G	Nat. col.	69.95	0.23	2.52	0.90	0.18	9.34	0.69	14.51	0.42	0.10	0.08	1.05	6	25	4	14	44	176	177
Intemediate	CO58A	Block	aB	Rec.	69.97	0.10	2.93	0.82	0.28	6.44	0.75	16.23	0.70	0.11	0.21	0.88	17	797	343	797	1866	411	59
Intemediate	CO121C	Moil	G	Int. col.	68.28	0.10	2.61	0.80	0.60	6.63	0.79	17.24	0.65	0.15	0.27	1.09	14	1491	305	1516	3395	436	58

G2.1/G2.2 Foy series 2.1 and 2.2; *a* aqua; *l* light, *d* dark, *o*, olive; *B* blue; *G* green; (*R*) red stripes; *Rec*. recycled; *Int. col*. intentionally coloured; *Nat. col*. naturally coloured

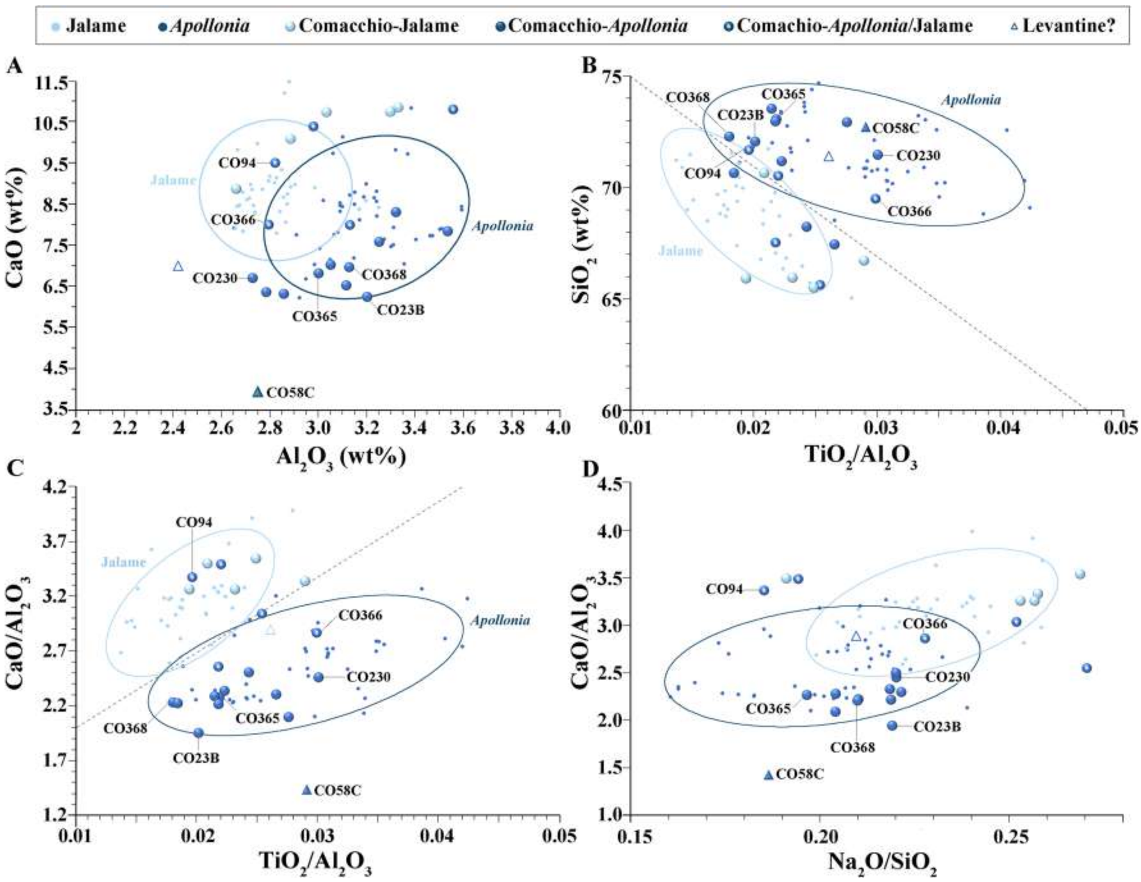

Fig. 6 Levantine glass. Both the reference samples from *Apollonia* and Jalame and the samples from Comacchio studied in and by Bertini et al. (2020) are represented. The confidence ellipses (90%) are drawn for the two reference groups. The dotted grey lines that separate the distribution fields of *Apollonia* and Jalame are indicative only and correspond to the following functions: B) y = -405x + 79.05; C) y = 68.75x + 1.3125; D) y = -22.143x + 7.6

are reliable. This refers to the Jalame-type glass, not to the glass produced at Jalame many centuries earlier. It should also be noted that CO94 shows K_2O amounts relatively high compared to both *Apollonia* and Jalame products and could thus provide an indication of environmental contamination. Lastly, a Levantine provenance can be indicated for the glass from the crucible CO58C while explaining the anomalous CaO and Sr low levels due to the interaction with the crucible. Minor and trace elements are averagely low, as is typical of Levantine products.

Hence, 7 samples from this study are added to the 16 Levantine samples measured in Bertini et al. (2020) and all 23 are plotted in Fig. 6. In this figure, several diagrams are used for the same samples. Notably, the Na_2O/SiO_2-CaO/Al_2O_3 diagram introduced by Phelps et al. (2016) is no longer particularly effective for discriminating *Apollonia*'s products from those recently characterised from Jalame (Freestone et al. 2023). On the contrary, the Al_2O_3-CaO diagram and the Ti_2O/Al_2O_3-SiO_2 and Ti_2O/Al_2O_3-CaO/Al_2O_3 diagrams present smaller overlaps of the confidence ellipses (90%). Similarly, Fig. 7A shows the compositional of Levantine glass alongside with that of the crucible glass CO58C (highlighted in red), showing a clear match with Levantine products.

Egyptian glass The poorly represented groups are the HIMT, the Egypt series and the séries 3.2:

- HIMTa glass is testified by the olive-green fragment CO99 thus bringing the total number of attested specimens to 3 (Com74 and Com75 in Bertini et al. 2020);
- the green window CO233A represents the first and only sample comparable to the poorly distributed group named "Egypt 2 (low Na_2O)" by Schibille et al. (2019);
- the colourless *tessera* CO25 fits well within the compositional range of the série 3.2 (henceforth G3.2), except for a slightly low Zr content (42 ppm) and an antimony level (228 ppm) higher than expected (< 30 ppm) in a practically uncontaminated com-

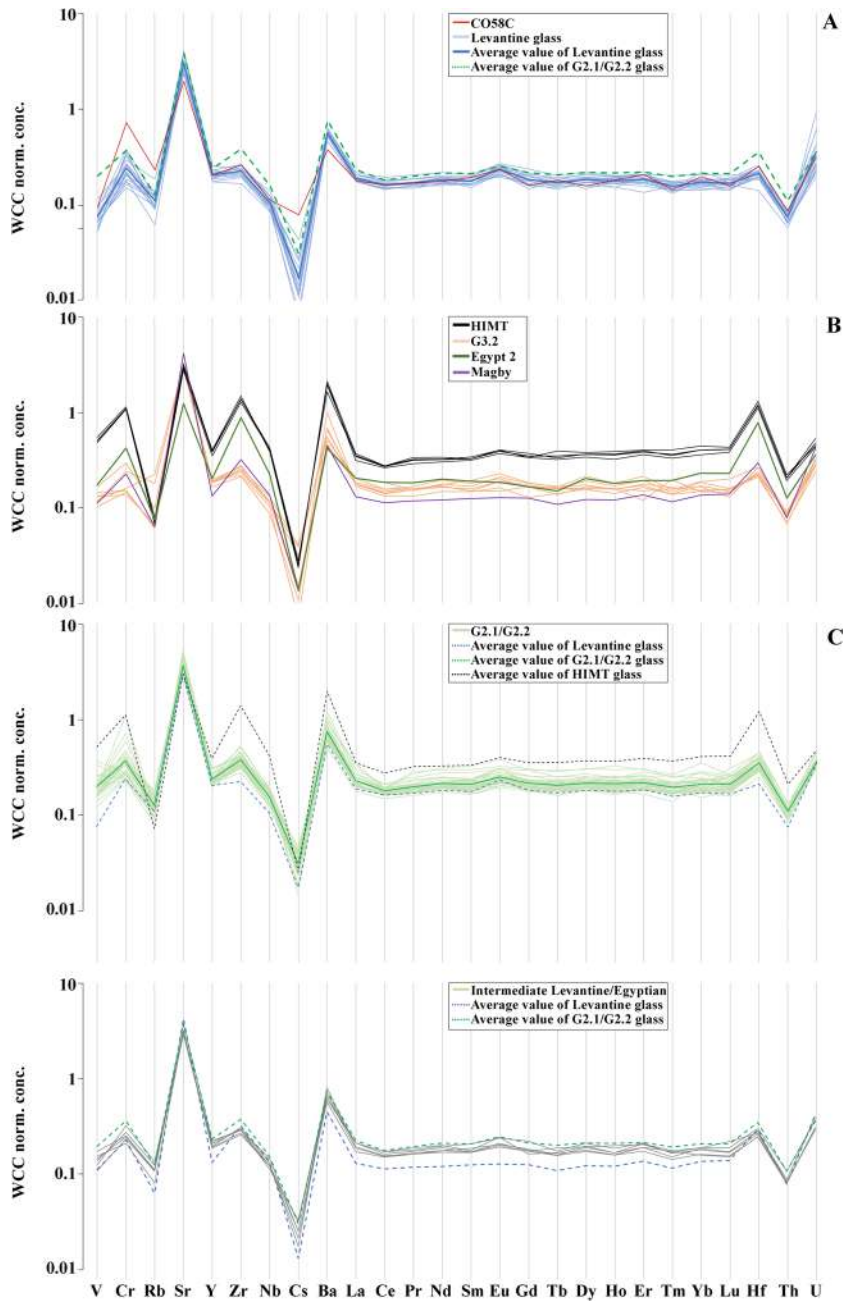

Fig. 7 The pattern of minor and trace elements contents in Levantine (**A**) and Egyptian glass (**B**-**C**). Values were normalised to the weathered continental crust, based on Kamber et al. (2005)

positional group such as the G3.2 (Schibille 2022). With less reliability, the wall CO88 and the blocks COO100B and CO121E could be assimilated to the G3.2 while taking into account lower MnO contents (CO88 and 121E) and admitting the later introduction of colourants (CO88, CO100B) or decolourant (CO121E). Among the materials previously investigated, only 4 other samples could be compared with this group (Com71, Com86, Com87 and Com91); however, only CO25 and Com87 show a trustable fit, while the others present features comparable also with the séries 2.1 and 2.2.

– The green window CO233B and the yellow fragment Com85 represent the Fe-rich variant of the séries 2.1 (henceforth G2.1HFe) and other two samples can be added (Com38 and Com94) despite a weaker compatibility.
– To these scarcely attested groups, the sample Com14 in Bertini et al. (2020) may be added based on its attribution to the Magby-type glass defined by De Juan Ares et al. (2019).

In each case listed above, both the major and minor elements and traces are consistent with the proposed attributions. Among the overall collection, at least 60 samples are assigned to the série 2.1 and 2.2 (henceforth G2.1 and G2.2; Fig. 7C): 20 from this study and 47 from Bertini et al. (2020). These two groups -identified by Foy et al. (2003)- are distinguished essentially based on the contents of Mn (high in G2.1, low in G2.2) and colouring agents (variable in G2.1, constantly high in G2.2), although other distinctions may also be inconsistently observed (*e.g.*, Na_2O, CaO and Sr amounts). Since many of the samples considered in this study show greater affinity with G2.2 than with G2.1, both groups are recalled even if treated together. Among these samples, the provenance assignment is sometimes straightforward, other times less feasible due to the lack of measurement of key elements such as Zr and other minor and trace elements in reference data. It may be interesting to note that only a few samples present a composition perfectly comparable with G2.1 (*e.g.*, Com6, Com18 and Com29) and correspond to materials with slight traces of recycling. In contrast, all the others are more similar to G2.2 because they are heavily added. To provide some numbers, 53 samples contain Cu > 1000 ppm, 15 samples Sn > 1000 ppm, 43 samples Sb > 1000 ppm and 59 samples Pb > 1000 ppm. In the final section ("colouring coloured glass"), some food for thought is provided on these values.

Uncertain The list concludes with a small series of 4 samples (Com25, Com54, Com67, Com80) for which it is unrealistic to indicate a provenance. Additionally, there are 9 samples that show characteristics compatible with an Egyptian provenance but cannot be assigned to any known group (Com40, Com50, Com55, Com58, Com62, Com69, Com70, Com89, Com93). There are also 10 samples displaying intermediate values between Levantine and Egyptian products, possibly representing mixtures of both (CO58A, CO121C, Com1, Com4, Com27, Com48, Com63, Com92, Com96a). In Fig. 7, the trace and rare earth element pattern indicates that while the zirconium content is more compatible with Levantine glass, the REE profile aligns more closely with Egyptian glass. The isotopic analyses, primarily conducted to clarify the provenance of block CO58A, show that this sample also falls in the intermediate range between the Levantine materials from *Apollonia* and the Egyptian ones corresponding to G2.1 (Fig. 8). Given the similarly "intermediate" composition of G3.2, the hypothesis of an Egyptian origin seems more realistic but cannot be proven with certainty.

It should also be noted that the isotopic analyses conducted on samples from the mentioned groups are limited, and for Egyptian products in particular, they show wide distribution. However, while the attribution of samples CO24 and CO122 to G2.1/G2.2 appears to be confirmed, the non-unique classification of samples CO100B and CO121E as G3.2-like (/G2.1) remains unresolved.

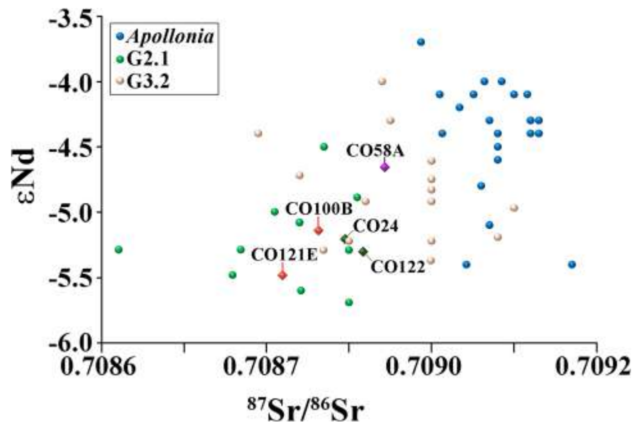

Fig. 8 $^{87}Sr/^{86}Sr$ ratio and εNd values for Comacchio blocks compared to literature data available for the *Apollonia*, G2.1 and G3.2 glass groups. Selected data from Degryse et al. (2005), Degryse and Schneider (2008), Degryse et al. (2009), Ganio et al. (2012), Gallo et al. (2014), Maltoni et al. (2016), Brems et al. (2018), Gliozzo et al. (2019) and Barfod et al. (2022a)

To conclude this section and visualise the provenance assignments indicated above, Fig. 9 shows the Al_2O_3/SiO_2-TiO_2/Al_2O_3 diagram proposed by Schibille et al. (2017) and the diagram TiO_2/Al_2O_3-Zr in which the different Levantine and Egyptian products are discriminated based on elements representative of the sands used. Overall, Levantine glass was imported and worked at Comacchio but, following a trend that now seems consolidated for the Adriatic area (Gliozzo et al. 2023c), it does not represent a consistent supply, much less a priority one. Out of 116 for which provenance can be proposed, the materials investigated allowed only 20 samples to be identified as Levantine products. In contrast, Egyptian glass was particularly abundant based on at least 74 occurrences. The most attested type of glass is decidedly G2.1/G2.2, almost always heavily added, while Egypt 2 and HIMT glass represent only 4% of total imports and are practically fresh. Glass type G3.2 is poorly represented and, like Jalame-type glass for Levantine products, can testify to the recovery of older materials as well as the presence of productions that inherited their characteristics.

Working glass at comacchio

The Comacchio excavations returned consistent evidence of the various processing phases and, among these, the crucible, the crucible-glass and the blocks deserve further discussion.

The crucible added valuable information on the production cycle. Unfortunately, the tiny dimensions of the fragment do not allow its shape to be reconstructed; however,

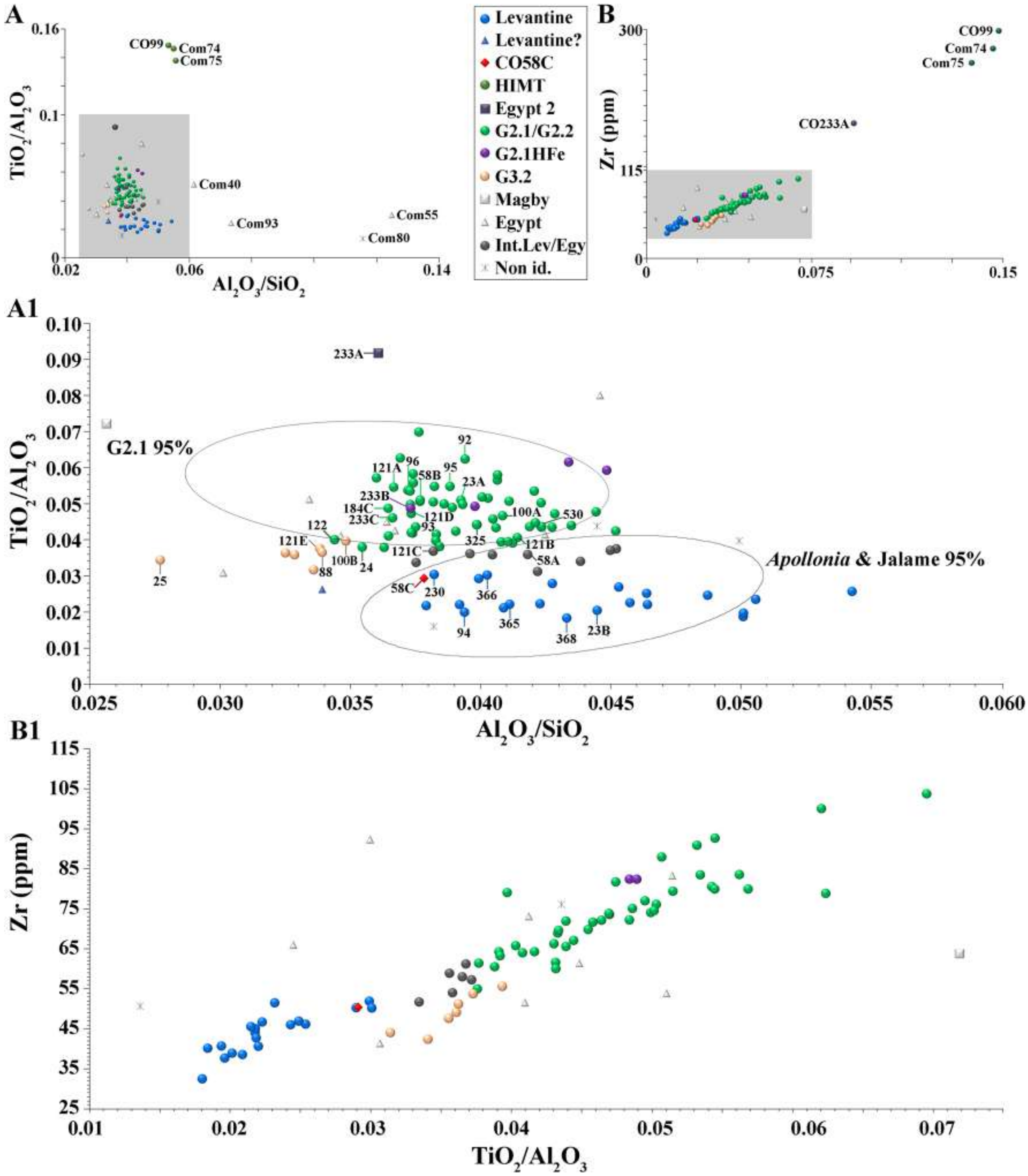

Fig. 9 Provenance assignment of Comacchio's glass. The diagrams A1 and B1 are inset of the smaller diagrams **A** and **B** on top

its flat profile may suggest a flat-bottomed crucible, thus perfectly comparable with the truncated cone shape of other crucibles found on the site (Alberti 2021). The effects of the pyrotechnological process hinder further insights into the provenance of steatite; however, it must be noted that in the western and central Alps, this type of rock is common and was exploited in ancient times (see, *e.g.*, Mannoni et al. 1987, Santi et al. 2005, Santi et al. 2009). For example, north of Comacchio, several occurrences of western and central "pietra ollare" were found at Nogara (Monaco et al. 2023) and Aquileia (Antonelli and Lazzarini 2012); however, in both cases, their use was mainly related to food preparation, benefiting from the low porosity and very low hardness of this rock. Undoubtedly, these sites and Comacchio could take advantage of an easy communication route such as the Po River, which must have facilitated their transport.

Notably, the excavations at Comacchio brought to light numerous steatite artefacts. Indeed, they had various destinations and uses and were imported to Comacchio to be distributed along the southern Adriatic Sea (they were found as

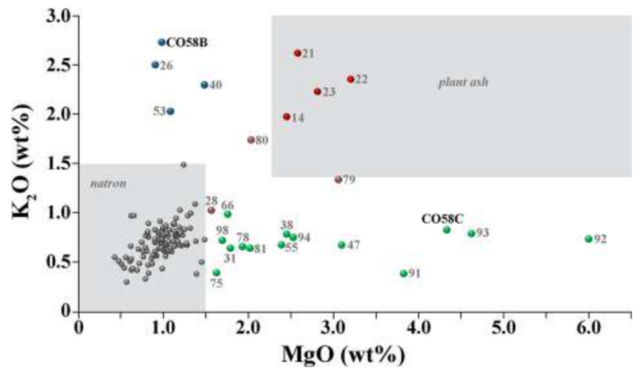

Fig. 10 MgO-K_2O binary diagram showing the use of different fluxes and the effects of different environmental or crucible contaminations. All numbers without label refer to Bertini et al. (2020). Coloured dots indicate natron-based glass (small grey), plant ash-based glass (red), environmental contamination (blue), crucible contamination (green), uncertain cases (pink)

far as Otranto; Alberti 2021). Some crucibles were analysed by Mini et al. (2016), who determined the provenance of most of those artefacts from Valchiavenna and Valmalenco (Central Alps). Further, they investigated four fired fragments (COM4, COM6, COM8 and COM10), which are perfectly comparable with the crucible investigated in this study. The fragments analysed by Mini et al. (2016) were not used in the glass workshop and bore no useful traces to understand what type of artisanal activity they had served.

A further consideration arising from the study of the crucible concerns the MgO contamination of the glass associated with it. The sample CO58C and the six crucible glasses from Bertini et al. (2020) show MgO contents between 2.0 to 4.6 wt% (Fig. 10). The common characteristic of this group of samples is the high levels of MgO and the contamination with the steatite crucible can now help explaining this evidence. This result is of particular interest even outside the context investigated here because it can clarify why some natron-based glass has high magnesium contents, especially if contents variations are observed along the thickness of the glass. Within the Comacchio materials, for example, other ten samples show this characteristic despite not being visibly associated with a crucible: 2 undiagnostic fragments (Com28 and Com75), 4 wasters (Com38, Com66, Com31 and Com55), 2 *tesserae* (Com91 and Com92) and 2 goblets (Com78 and Com 98).

It follows, however, that the level of contamination can vary based on different factors such as the greater/lesser proximity of the steatite surface to the analysed glass, the thickness of the glass, the firing time and the temperature reached. Therefore, the canonical limit of 1.5 wt% MgO for natron-based glass can be decreased or increased depending on the amount of MgO present in the initial glass – which is, however, difficult to establish.

As a side effect, the increase in MgO, the decrease of CaO and the other possible contaminations less consistently observed (K_2O, FeO and Na_2O) can make the provenance study even more challenging and/or less reliable.

As a final note on this topic, it is important to consider that sample Com91, a white *tessera*, exhibits the highest Sb content in the entire collection. High MgO contents in opaque white glass have been attributed to the use of ankerite, based on comparisons with Roman enamels (Fiorentino et al. 2020, following Henderson 1991, on enamels). Alternatively, it has been proposed that an MgO-rich source for antimony (Fiorentino et al. 2020, following Wypyski & Becker 2004) or the introduction of dolomite (Wypyski & Becker 2004) into the mixture might be responsible. In the context of Comacchio, the introduction of magnesium via antimony can be excluded. Among the 17 samples with MgO content exceeding 1.6 wt%, five have Sb levels below 100 ppm, including those with the highest MgO values. Moreover, there are no correlations suggesting a link between these two elements. However, this hypothesis should remain open for the opaque white *tessera* Com91. Moving on to the blocks, they are all representative of Egyptian glass imports, except for CO58A. The intermediate composition of CO58A does not allow for a definitive determination of its provenance, although isotopic analyses suggest an Egyptian origin as well. The only block in which the decolouring purpose can be understood is CO121E. In this sample, the MnO level is higher than 0.025 wt% (0.39 wt%) and the antimony appears intentionally added (2019 ppm) but the final colour is light green. Since it is difficult to imagine that they were not capable of producing colourless glass, it will perhaps be more likely that the taste or market destination of this workshop favoured blue-green glass, as testified by production indicators (e.g. collars, cuts, drops and fluidity tests) and the entire collection of glass vessels found on the site (Ferri 2021a).

Colouring coloured glass

This section delves deeper into glass colouring techniques after observing interesting linear correlations between Sn and Pb, Cu and Sb and Sb and Pb contents in blue and green glass ($n = 82$; Fig. 11).

The 76 samples for which both Sn and Pb values were provided show a strong Sn-Pb linear correlation with $R^2 = 0.751$ (Fig. 9A). The Pb/Sn ratio cover a wide range from 1.61 to 110.79, corresponding to hypothetical alloys ranging from Sn_1Pb_{99} to $Sn_{38}Pb_{62}$ (Supplementary Table S10) and the subset of 32 samples running along the correlation line has the strong R^2 value of 0.969 (Pb/Sn ratio from 4.55 to 8.82); however, most samples ($n = 73$) would show $Pb > 75\%$ in a hypothetical SnPb alloy. Despite the correlation, the use of lead stannates is possible but not directly demonstrable since crystals of lead

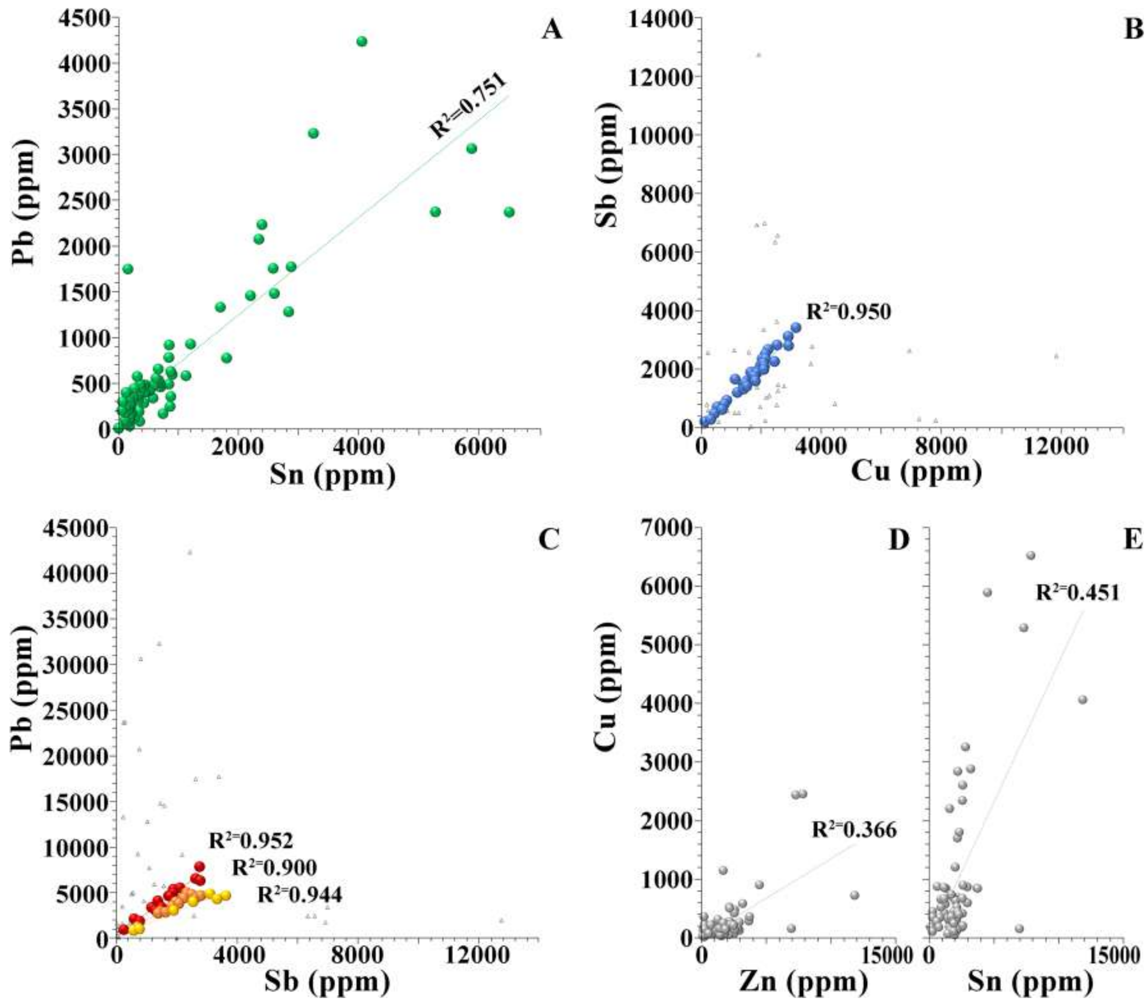

Fig. 11 The linear correlations between Sn and Pb, Cu and Sb, Sb and Pb, Cu and Zn/Sn

stannates -usually showing “30–35% tin oxide and 60–65% lead oxide” (Peake and Freestone 2014) – were not found. Hence, to further test this hypothesis, the PbO/SnO_2 ratio has been calculated and compared with the data reported by Tite et al. (2008, Table 1) for “lead stannate opacified glass and enamels”. In the latter, the PbO/SnO_2 ratio ranges from 2.8 to 12.2; within the Comacchio dataset, 58 samples fall within this range. It should be noted, however, that while in the (non-opaque) glass from Comacchio, the absolute values are mostly (PbO) or constantly (SnO_2) lower than 1 wt%, the beads, the *tesserae* and the enamels considered in the reference literature contain from 8.4 to 53.3 wt% PbO and from 1.2 to 9.2 wt% SnO_2. Matin (2019) highlighted the importance of a Pb/Sn ratio equal to or above 3.5 for the formation of Pb_2SnO_4 and showed that in 80 green glasses collected from the literature, the average Pb/Sn ratio was 9.1 (s.d. 4.4), with minimum and maximum values ranging between 0.2 and 25.6, *i.e.* compatible with 73 of the 76 Comacchio samples.

Another possibility for explaining the Sn:Pb correlation is the use of soldering alloys. In this case, however, the alloys resulting from the recalculation (Supplementary Table S10) are Pb-richer than those we know from ancient sources such as Pliny (*e.g.*, *tertiarium* with Pb:Sn = 2:1 and *argentarium* with Pb:Sn = 1:2) and *Theophilus* (with Sn/Pb = 2/1) (see also Miśta-Jakubowska et al. 2022). Archaeometric investigation on SnPb solders is not frequent and the few examples available regard soft soldering for applying silver and gold foil. For example, the solders analysed in a 3rd-c. CE belt-fitting from Linowo in Poland (Kowalski et al. 2017) were made of a SnPb alloy with a ratio of 1:4, which is close to that of a small group of Comacchio samples.

The second correlation that deserves an additional note is the one observed between Cu and Sb (Supplementary Table S11; Fig. 9B). In the 78 samples where Cu > 100 ppm and/or Sb > 25 the correlation is very weak ($R^2 = 0.011$); conversely, a subgroup of 35 samples (*i.e.* just under half of the total) reaches an R^2 value of 0.959. These samples are of great interest because the Cu/Sb ratio ranges between 0.75 and 1.27 and consequently implies that Cu:Sb ratio is approximately of 1:1. Indeed, the consistency of the group may suggest a voluntary action rather than randomness.

The third correlation between Sb and Pb (Supplementary Table S12) does not regards all 75 samples ($R^2 = 0.005$). Nevertheless, at least three different correlations can be identified within a subset of 37 samples. The first one includes 15 samples showing Pb/Sb ratio ranging from 3.42 to 2.24 (red dots with $R^2 = 0.952$ in Fig. 9C); the second one includes 14 samples showing Pb/Sb ratio between 2.12 and 1.64 (orange dots with $R^2 = 0.900$ in Fig. 9C) and the third one includes 8 samples with a Pb/Sb ratio (1.58/1.24; yellow dots with $R^2 = 0.944$ in Fig. 9C) which corresponds to the composition of the lead antimonate pigment with 58 wt% lead oxide and 42 wt% antimony oxide (Molina et al. 2014). As for lead stannates, however, also lead antimonates were sought but not found by SEM–EDS and it must be kept in mind that the production of pigments and 'animes' could vary on the Pb:Sb ratio to obtain different shades of yellow.

Finally, various recalculations on green and blue-green samples were carried out to verify the possibility of significant trends. Several combinations have been tested, assuming, for example, that copper had been introduced unalloyed or as bronze, brass or a ternary alloy such as gunmetal (Supplementary Table S13 and Appendix). Then, other constraints have been added, such as fixing the Sb and Pb contents to an $Sb_{42}Pb_{58}$ ratio (constraint 1), fixing the copper alloy to a $Cu_{90}Sn_{10}$ ratio (constraint 2) or fixing the gunmetal alloy to Sn = Zn (constraint 3 to lower the contents of Sn and be able to redistribute it). The results of these tests are provided in the Supplementary Appendix.

Calculations show that in samples with Cu:Sb ~ 1:1, the most frequent combinations are:

1. 1 part Cu (unalloyed copper) + 1 part Sb;
2. 1 part Cu (unalloyed copper) + 2 − 3 parts $Sb_{42}Pb_{58}$;
3. 1 part $Cu_{90}Sn_{10}$(bronze) + 1 part Sb;
4. 1 part $Cu_{90}Sn_{10}$(bronze) + 2 − 3 parts $Sb_{42}Pb_{58}$;
5. 1 part $Cu_{75}Zn_{25}/Cu_{96}Zn_4$(brass) + 1 part $Sb_{42}Pb_{58}$;
6. 1 part $Cu_{75}Zn_{25}/Cu_{96}Zn_4$(brass) + 2 − 3 parts $Sb_{42}Pb_{58}$;
7. 1 part $Cu_{73}Sn_{14}$/ $Cu_{92}Sn_4Zn_4$(ternary alloys) + 2 parts $Sb_{42}Pb_{58}$.

Of all the possible combinations, those that would have allowed better control of the colour are those with "pure" components. On the contrary, with the use of alloys, the procedure to obtain the 1:1 ratio seems more complicated except for the combinations no. 3 (bronze + Sb) and no. 5 (Zn-poor brass + Sb) in a 1:1 ratio and the combination no. 7 (ternary alloy + $Sb_{42}Pb_{58}$) in ratio 1: 2. In all combinations, the resulting SnPb compound is rarely Sn-rich, while in most cases, Pb represents over 75% (on average ~ $Sn_{16}Pb_{84}$). Furthermore, there is no constant SnPb ratio in any of the hypothetical combinations.

In samples where the Cu/Sb correlation is not apparent, the most frequently observed combinations are:

1. Brass + SnPb + Sb;
2. Brass + $Sb_{42}Pb_{58}$ + SnPb;
3. Ternary alloy (constraint no.3) + $Sb_{42}Pb_{58}$ + SnPb.

The ratios between the various components are quite variable. Still, in the combination no. 2, it is interesting to note that while the Cu/Sb ratio varies from 1.27 to 4.83, the brass:$Sb_{42}Pb_{58}$ ratio ranges from 0.6 to 1.3, therefore returning to that 1:1 ratio observed in the samples of the previous group.

In both subgroups, the metal that has most frequently provided plausible combinations was brass and its (possible) use may have been varied depending on the Zn content of the alloy, *i.e.* a feature that could have been roughly determined by glassworkers since the higher the zinc, the more golden the colour, while the lower the zinc, the more silvery the colour. Hence, the process may have been practically simple, using Zn-poor brass alloys and two parts of $Sb_{42}Pb_{58}$ or Zn-richer brass alloys (or Zn and Sn in the case of gunmetals) and only one part of $Sb_{42}Pb_{58}$.

It is worth highlighting that these calculations are not intended to completely discard the recycling hypotheses -which in part will certainly have happened- but introduce the possibility that deliberate colouring procedures can be reconstructed based on the same values, when a series of correlations may suggest intentionality (intentional colouring) rather than controlled randomness (recycling).

Upon comparing our findings with other published research, such as the study conducted on the San Vincenzo al Volturno workshop by Schibille and Freestone (2013), notable differences and similarities emerge. Unlike the study in Comacchio, their investigation reveals the absence or very weak presence of Sn–Pb and Sb–Pb correlations. Additionally, they report a Cu-Sb correlation in clear and colourless glasses, with copper values averaging 3198 ppm (ranging from 719 to 9586 ppm), which they attribute to recycling.

While attributing strong correlations solely to recycling may pose challenges due to the possible mixing of materials from different epochs and provenances, the introduction of "pure" components or those with a predictable composition, such as metals, might offer greater control over the final product. For instance, the introduction of antimony (Sb) might have aided in maintaining copper in its oxidised state, thus reducing the risk of alloy formation. Conversely, the presence of copper could have facilitated the reduction of antimony from (V) to (III) oxidation states, necessary for Sb to decolourise glass ($2Cu^+ + Sb^{5+} \rightleftharpoons 2Cu^{2+} + Sb^{3+}$). This mechanism could potentially explain the high copper content in colourless glass. Nevertheless, at Comacchio, a consistent correlation where Cu and Sb are present in approximately equal ratios is challenging to attribute solely to the reuse of older *tesserae*. Moreover, the coexistence of the glass workshop and the metallurgical workshop encourages exploring alternative explanations alongside recycling, within the frame of cross-crafts interactions.

These considerations suggest the possibility of a technology less reliant on recycling, akin to that reconstructed for San Vincenzo al Volturno. Consequently, each case should be evaluated individually.

Additionally, it is noteworthy that high lead (Pb) contents have often been interpreted as indicative of continuous recycling when comparing different contexts from various periods (Rehren and Freestone 2015, Fig. 6). While recycling certainly contributed to increased average Pb levels, could we exclude the possibility that lead's properties, such as lowering the melting temperature and viscosity of glass and improving workability, have been increasingly exploited over the centuries by intentionally increasing its content?

The Comacchio samples, all from a single, restricted chronological period, exhibit Pb values ranging from 5 ppm to 23672 ppm. Is it plausible that lead was intentionally added for technological reasons when levels exceed 1000 ppm, rather than solely relying on recycling?

We do not claim to have definitive answers to propose. Presumably, there may not be a rigid model in the context of pre-industrial production, but all various options should be considered in the current state of research; however keeping in mind that the intentional colouration does not exclude previous recycling cycles.

Conclusions

The study of representative 34 samples, combined with the data already available, made it possible to frame Comacchio's glass production within the trade routes of Levantine and Egyptian products and obtain original production technology data.

Comacchio's imports fit perfectly into an increasingly consistent and significant picture, showing the priority of imports from Egypt over those from the primary glassmaking kilns on the Levantine coast. In this framework, Comacchio data are even more important because they offer a glimpse of the glass trade in the second half of the seventh century, corresponding to or immediately following the activity of the *Apollonia* furnaces. However, despite the revitalization of Levantine production testified by the *Apollonia* products, the relationship between Levantine and Egyptian imports is 22% to 78%. Undoubtedly, the greater manufacturing difficulty imposed by Levantine glass and an increasing trend of imports from Egypt may have both played an important role.

Regarding production technology, the most interesting result certainly concerns the use of steatite crucibles and the relative increase in MgO in the glass. This result, supported by archaeological and archaeometric evidence, can be used as a valid argument to explain high MgO contents in the absence of a corresponding increase in K_2O and can therefore be applied to the study of many other finds beyond this case study. On the other hand, this aspect seems to invalidate the reconstruction of mixing between natron-based and plant ash-based glass proposed in the previous literature. Furthermore, the discovery of only three samples of plant ash glass among the 123 investigated suggests a randomness that tends to exclude the import and processing of plant ash-based glass at Comacchio.

Finally, the presence of evident correlations (*e.g.*, Sn–Pb and Cu-Sb) led to a series of calculations to understand which compounds could have been used as an alternative to the hypothesis of a random introduction due to recycling. The calculations highlighted that the colour could be obtained by introducing appropriate compounds including metals and, among these, brass returned the greatest compatibility. Furthermore, the SnPb correlation may indicate the use of lead stannates or soldering alloys, although they have not been directly observed.

Ultimately, the purpose of the calculations was not to discard the recycling hypothesis but rather to not give in to a hypothesis invoked perhaps too often, even when not necessarily the only one. In this regard, it is worth remembering that glassworking was closely connected with metalworking at the production site of Comacchio. While recycling can account for part of the evidence, the rest could be attributed to the expertise of Comacchio artisans. They aimed to produce green–blue glass and knew how to control both the glass and metal production processes to achieve it.

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Authors contribution Introduction: MF, EG; Materials: MF; Experimental: EG, EB; Results: EG, EB (isotopic investigations); Discussion: EG; Conclusions: EG, MF, EB.

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Data availability The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

Declarations

Competing interest The authors declare no competing interests.

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List of Supplementary materials

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- Appendix

- Excel Table (uploaded separately)

Table S1. Results obtained by EMPA Dark grey bands (db), medium grey bands (mb), light grey bands (lb) and white bands (wb) are indicated. Average data of "n=" measurements are expressed as wt% [sd=standard deviation].

		SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO23A db	n=4	67.61	0.14	2.69	0.93	0.75	1.14	7.39	16.60	0.88	0.16	0.26	0.81	0.11	0.41	0.13	bdl	100.02
	sd	0.1	-	-	-	-	-	0.1	0.1	-	-	-	-	-	-	-	-	
CO23A mb	n=9	67.47	0.13	2.62	0.96	0.73	1.10	7.24	16.74	0.89	0.16	0.26	0.81	0.14	0.47	0.17	0.07	99.98
	sd	0.1	-	-	-	-	0.1	0.2	0.2	-	-	-	-	-	-	0.1	-	
CO23A lb	n=5	66.60	0.12	2.63	0.99	0.79	1.17	7.43	17.21	0.89	0.17	0.25	0.77	0.13	0.59	0.15	0.11	99.99
	sd	0.2	-	-	-	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	
**CO23A (av.)*	*n=18*	*67.26*	*0.13*	*2.64*	*0.96*	*0.75*	*1.13*	*7.33*	*16.84*	*0.89*	*0.16*	*0.26*	*0.80*	*0.13*	*0.49*	*0.15*	*0.06*	*99.99*
	sd	0.40	-	-	-	-	-	0.20	0.30	-	-	-	-	-	-	-	-	
CO23B	n=6	71.98	0.08	3.20	0.43	0.02	0.43	6.24	15.77	0.55	0.04	0.21	0.98	bdl	bdl	bdl	bdl	99.93
	sd	0.2	-	-	-	-	-	0.1	0.1	-	-	-	-	-	-	-	-	
CO24	n=5	67.55	0.08	2.39	0.77	0.58	0.88	6.61	17.67	0.57	0.12	0.36	0.85	0.28	0.34	0.92	0.02	99.99
	sd	0.2	-	-	-	-	0.1	0.1	0.1	-	-	-	0.1	-	-	-	-	
CO25	n=6	70.38	0.09	1.95	0.42	0.60	0.62	5.98	17.95	0.42	0.02	0.24	1.29	bdl	bdl	0.02	bdl	99.97
	sd	0.2	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	
CO58A	n=10	69.97	0.13	2.93	0.82	0.28	0.75	6.44	16.23	0.70	0.11	0.21	0.88	0.11	0.21	0.15	0.04	99.98
	sd	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	
CO58B	n=10	66.80	0.14	2.52	1.05	0.68	0.98	6.63	15.98	2.72	0.15	0.23	0.82	0.13	0.68	0.37	0.09	99.99
	sd	0.1	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	
CO58C	n=7	72.63	0.07	2.75	0.75	0.05	4.33	3.94	13.55	0.83	0.07	0.12	0.79	0.02	0.04	0.01	0.02	99.96
	sd	0.4	-	-	0.3	-	1.1	0.8	0.1	-	-	-	-	-	-	-	-	
CO88	n=6	67.12	0.10	2.28	0.54	0.37	0.72	6.47	17.99	0.49	0.06	0.34	1.15	0.22	1.63	0.22	0.29	99.99
	sd	0.1	-	-	-	-	-	0.1	0.2	-	-	-	-	-	-	-	-	
CO92 db	n=3	65.39	0.17	2.78	1.03	0.84	1.01	7.40	16.97	0.76	0.18	0.26	0.82	0.34	1.39	0.31	0.28	99.94
	sd	0.1	-	-	-	-	-	0.1	0.3	-	-	-	-	-	-	-	-	
CO92 mb	n=11	64.98	0.17	2.54	1.00	0.86	0.99	7.22	17.12	0.73	0.21	0.31	0.86	0.39	1.76	0.45	0.34	99.93
	sd	0.3	-	-	-	-	-	-	0.1	-	-	-	-	-	0.1	0.1	-	
CO92 lb	n=4	64.56	0.14	2.44	1.02	0.91	0.97	7.24	17.02	0.73	0.18	0.33	0.82	0.46	2.24	0.51	0.44	100.00
	sd	0.1	-	-	-	-	-	0.1	0.1	-	-	-	-	-	0.1	-	-	
**CO92 (av.)*	*n=18*	*64.95*	*0.16*	*2.56*	*1.01*	*0.87*	*0.99*	*7.25*	*17.07*	*0.73*	*0.20*	*0.30*	*0.85*	*0.40*	*1.81*	*0.44*	*0.35*	*99.94*
	sd	0.3	-	0.1	-	-	-	0.1	0.1	-	-	-	-	-	0.2	0.1	-	
CO93	n=9	67.97	0.12	2.55	0.93	0.63	0.97	6.50	17.16	0.73	0.12	0.26	0.93	0.23	0.51	0.25	0.10	99.96
	sd	0.1	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	
CO94	n=6	71.64	0.08	2.82	0.39	0.02	0.62	9.51	13.28	0.97	0.06	0.22	0.38	bdl	bdl	bdl	bdl	99.98
	sd	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO95	n=5	66.49	0.15	2.58	1.07	0.88	0.90	6.78	17.79	0.73	0.14	0.28	1.07	0.25	0.52	0.24	0.04	99.93
	sd	0.1	-	-	0.1	-	-	-	0.1	-	-	-	-	-	0.1	-	-	
CO96	n=8	66.04	0.14	2.46	1.29	0.93	1.04	6.78	17.65	0.79	0.15	0.28	1.02	0.35	0.70	0.21	0.13	99.96
	sd	0.2	-	-	0.1	-	0.1	0.1	0.3	-	-	-	-	-	0.1	-	-	
CO99	n=7	64.34	0.55	3.42	2.15	2.31	1.39	4.68	19.23	0.38	0.07	0.25	1.20	0.01	bdl	bdl	bdl	99.98
	sd	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	

		SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO100A db	n=9	68.96	0.13	2.84	0.90	0.34	0.92	6.09	16.73	0.85	0.14	0.20	0.88	0.25	0.52	0.14	0.09	99.97
	sd	0.3	-	-	-	-	-	0.2	0.2	-	-	-	-	-	0.1	-	-	
CO100A lb	n=9	68.49	0.14	2.77	0.97	0.35	0.88	5.80	16.53	0.81	0.13	0.21	0.93	0.32	1.14	0.15	0.37	99.99
	sd	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	0.1	-	-	
_*CO100A (av.)_	_n=18_	_68.72_	_0.13_	_2.81_	_0.93_	_0.34_	_0.90_	_5.94_	_16.63_	_0.83_	_0.13_	_0.21_	_0.91_	_0.29_	_0.83_	_0.15_	_0.23_	_99.98_
	_sd_	_0.3_	-	-	-	-	-	_0.2_	_0.2_	-	-	-	-	-	_0.3_	-	_0.1_	
CO100B	n=7	67.46	0.11	2.35	0.91	0.80	0.81	6.46	18.24	0.61	0.10	0.27	1.06	0.20	0.32	0.20	0.03	99.94
	sd	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	
CO121A db	n=5	68.06	0.15	2.57	1.02	0.83	1.01	6.67	17.00	0.79	0.13	0.27	0.86	0.15	0.21	0.19	0.04	99.96
	sd	0.2	-	-	0.1	-	0.1	0.1	0.3	-	-	-	0.1	-	-	-	-	
CO121A lb	n=6	67.58	0.16	2.54	1.04	0.87	1.10	6.62	17.13	0.77	0.10	0.28	0.94	0.17	0.51	0.13	0.06	99.99
	sd	0.5	-	0.1	0.1	-	0.3	0.2	0.1	-	-	-	0.1	-	-	-	-	
_*CO121A (av.)_	_n=11_	_67.80_	_0.16_	_2.49_	_1.06_	_0.86_	_1.14_	_6.55_	_17.07_	_0.76_	_0.08_	_0.26_	_0.93_	_0.17_	_0.48_	_0.13_	_0.05_	_99.99_
	_sd_	_0.40_	-	_0.10_	_0.10_	-	_0.30_	_0.20_	-	-	-	-	_0.10_	-	-	-	-	
CO121B db	n=3	69.37	0.23	3.32	0.90	0.25	0.88	5.13	17.21	0.99	0.11	0.17	0.77	0.22	0.25	0.09	0.05	99.94
	sd	0.2	-	0.1	-	-	-	0.3	0.3	0.1	-	-	0.2	-	-	-	-	
CO121B mb	n=6	68.06	0.13	2.67	0.85	0.49	0.94	6.85	16.82	0.89	0.17	0.24	0.95	0.24	0.46	0.19	0.03	99.96
	sd	-	-	-	-	-	-	0.1	0.1	-	-	-	-	-	-	-	-	
CO121B lb	n=4	67.08	0.12	2.67	1.31	0.56	1.06	6.92	16.77	0.90	0.18	0.26	0.95	0.26	0.62	0.28	0.03	99.96
	sd	0.6	-	0.1	0.7	-	0.1	0.1	-	-	-	-	-	-	-	-	-	
_*CO121B_	_n=13_	_68.06_	_0.15_	_2.82_	_1.00_	_0.45_	_0.96_	_6.47_	_16.89_	_0.91_	_0.16_	_0.23_	_0.91_	_0.24_	_0.46_	_0.19_	_0.04_	_99.95_
	_sd_	_0.9_	-	_0.3_	_0.4_	_0.1_	_0.1_	_0.7_	_0.2_	-	-	-	_0.1_	-	_0.1_	-	-	
CO121C	n=8	68.28	0.10	2.61	0.80	0.60	0.79	6.63	17.24	0.65	0.15	0.27	1.09	0.19	0.36	0.21	0.05	99.99
	sd	0.2	-	-	-	-	-	0.1	0.2	-	-	-	-	-	-	-	-	
CO121D	n=7	66.81	0.13	2.49	1.01	0.82	0.93	6.79	17.33	0.71	0.17	0.32	1.05	0.35	0.58	0.42	0.04	99.96
	sd	0.1	-	-	-	-	-	0.1	0.2	-	-	-	-	-	-	-	-	
CO121E	n=5	67.48	0.11	2.28	0.65	0.38	0.99	6.16	19.45	0.43	0.04	0.34	1.34	bdl	bdl	0.29	bdl	99.95
	sd	0.2	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	
CO122	n=5	67.58	0.08	2.32	0.90	0.61	0.90	6.78	17.42	0.70	0.11	0.34	0.69	0.33	0.28	0.88	0.01	99.93
	sd	0.1	-	-	-	-	0.1	0.2	-	-	-	-	0.1	-	-	-	-	
CO184A	n=5	67.25	0.13	2.62	1.02	0.68	1.07	6.80	17.29	0.82	0.14	0.26	0.69	0.25	0.60	0.28	0.08	99.98
	sd	0.2	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	
CO184B	n=7	67.29	0.11	2.45	0.89	0.73	0.89	6.60	17.82	0.57	0.11	0.31	1.11	0.28	0.49	0.31	0.02	99.97
	sd	0.1	-	-	-	-	-	0.1	0.1	-	-	-	-	-	-	-	-	
CO184C	n=6	66.90	0.13	2.44	0.98	0.75	1.04	6.52	17.93	0.69	0.14	0.29	1.01	0.28	0.53	0.33	0.04	100.00
	sd	0.3	-	-	0.1	-	0.1	0.2	0.1	-	-	-	-	-	0.1	-	-	
CO230 db	n=10	71.49	0.09	2.75	0.65	0.11	0.74	6.67	15.41	0.62	0.09	0.15	0.90	0.05	0.13	0.08	0.03	99.95
	sd	0.2	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	
CO230 lb	n=10	70.51	0.09	2.67	0.62	0.18	0.68	6.66	15.86	0.64	0.10	0.19	0.93	0.09	0.52	0.09	0.14	99.97
	sd	0.5	-	-	-	-	-	0.2	0.2	-	-	-	-	-	0.1	-	-	
_*CO230 (av.)_	_n=20_	_71.00_	_0.09_	_2.71_	_0.64_	_0.15_	_0.71_	_6.66_	_15.64_	_0.63_	_0.09_	_0.17_	_0.91_	_0.07_	_0.33_	_0.08_	_0.09_	_99.96_
	_sd_	_0.6_	-	-	-	-	-	_0.1_	_0.3_	-	-	-	-	-	_0.2_	-	-	

		SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO233A	n=7	69.95	0.27	2.52	0.90	0.18	0.69	9.34	14.51	0.42	0.10	0.08	1.05	bdl	bdl	bdl	bdl	100.01
	sd	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO233B	n=17	68.50	0.15	2.56	1.75	1.15	1.01	6.74	16.19	0.61	0.13	0.28	0.83	0.01	0.02	0.02	bdl	99.95
	sd	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	
CO233C	n=16	66.33	0.12	2.43	1.11	0.78	1.00	7.31	17.30	0.78	0.22	0.32	0.88	0.30	0.52	0.47	0.08	99.94
	sd	0.2	-	-	-	-	-	0.1	0.1	-	-	-	-	-	-	-	-	
CO325 db	n=4	67.10	0.16	2.80	1.10	0.57	1.26	7.09	16.48	0.88	0.17	0.22	0.70	0.28	0.92	0.16	0.09	99.97
	sd	0.1	-	0.3	0.1	-	0.2	0.2	0.2	-	-	-	0.1	-	-	-	-	
CO325 lb	n=11	66.87	0.14	2.62	0.99	0.56	1.16	7.25	16.51	0.84	0.19	0.25	0.81	0.27	1.14	0.15	0.20	99.97
	sd	0.3	-	-	0.1	-	0.2	0.2	0.1	-	-	-	-	-	0.1	-	0.1	
**CO325 (av.)*	*n=15*	*66.93*	*0.15*	*2.67*	*1.02*	*0.57*	*1.19*	*7.21*	*16.50*	*0.85*	*0.19*	*0.24*	*0.78*	*0.27*	*1.08*	*0.15*	*0.17*	*99.97*
	sd	*0.3*	-	*0.1*	*0.1*	-	*0.2*	*0.2*	*0.1*	-	-	-	-	-	*0.1*	-	*0.1*	
CO365 db	n=7	73.26	0.07	2.98	0.41	0.03	0.56	6.79	14.22	0.54	0.06	0.14	0.78	0.04	0.05	0.02	0.01	99.98
	sd	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	
CO365 lb	n=6	72.33	0.09	3.02	0.54	0.09	0.70	6.80	14.46	0.52	0.07	0.15	0.80	0.05	0.27	0.05	0.08	100.00
	sd	0.4	-	0.1	0.1	-	-	0.1	0.1	-	-	-	-	-	-	-	-	
**CO365 (av.)*	*n=13*	*72.83*	*0.08*	*2.99*	*0.47*	*0.06*	*0.63*	*6.80*	*14.33*	*0.53*	*0.07*	*0.15*	*0.79*	*0.04*	*0.15*	*0.03*	*0.04*	*99.99*
	sd	*0.5*	-	*0.1*	*0.1*	-	-	-	*0.1*	-	-	-	-	-	*0.1*	-	-	
CO366	n=8	69.24	0.11	2.79	0.64	0.33	0.95	7.98	15.77	0.78	0.15	0.19	0.78	0.06	0.12	0.05	0.02	99.96
	sd	0.4	-	-	-	-	-	0.4	0.2	-	-	-	-	-	-	-	-	
CO368	n=7	72.21	0.07	3.13	0.37	0.01	0.48	6.96	15.18	0.51	0.04	0.12	0.86	bdl	bdl	bdl	bdl	99.94
	sd	0.2	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	
CO530 db	n=3	68.20	0.09	2.99	0.80	0.31	0.80	7.63	14.79	0.89	0.11	0.12	0.76	0.83	1.37	0.06	0.19	99.93
	sd	0.9	-	-	0.1	0.1	-	0.3	-	-	-	-	-	-	0.4	-	-	
→CO530 mb	n=7	65.83	0.12	2.77	1.33	0.59	1.00	7.56	14.75	0.85	0.16	0.19	0.73	0.88	2.46	0.05	0.69	99.96
	sd	0.2	-	-	-	-	-	-	0.2	-	-	-	-	-	0.1	-	0.2	
→ CO530 lb	n=11	65.50	0.12	2.78	1.34	0.60	0.99	7.55	14.90	0.84	0.19	0.19	0.73	0.94	2.64	0.04	0.65	100.02
	sd	0.4	-	-	-	-	-	0.1	0.2	-	-	-	-	-	-	-	0.2	
CO530 wb	n=5	62.42	0.14	2.70	1.93	0.60	1.00	7.37	14.84	0.80	0.26	0.22	0.72	1.19	4.31	0.03	1.40	99.93
	sd	0.1	-	-	0.4	-	-	0.2	0.2	-	-	-	-	0.2	0.5	-	0.3	
**CO530 (av.)*	*n=26*	*65.67*	*0.12*	*2.78*	*1.33*	*0.59*	*1.00*	*7.56*	*14.82*	*0.85*	*0.18*	*0.19*	*0.73*	*0.91*	*2.55*	*0.04*	*0.67*	*99.99*
	sd	*0.2*	-	-	-	-	-	-	*0.1*	-	-	-	-	-	*0.1*	-	-	

* Average values must be taken with caution since the volume of each kind of band is not known. For sample CO530 only the bands indicated with the arrows have been used to calculate the average composition since the other types of bands are infrequent.

Table S2. The results achieved by LA-ICP-MS on the glass collection from Comacchio. All values are provided as ppm. Abbreviations: db=dark grey bands; mb=medium grey bands; lb=light grey bands; n=number of measurements.

	CO23A		CO23B		CO24		CO25		CO58A		CO58B		CO58C		CO88	
	n=4		n=4		n=4		n=5		n=4		n=4		n=6		n=4	
	av.	s.d.	av.	s.d.	av.	s.d.	av.	av.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.
Li	7.8	1.4	5.3	1.3	6.1	1.7	4.3	1.1	6.1	1.1	5.9	1.8	4.9	0.8	6.1	1.8
Be	4.4	1.1	4.4	1.7	3.6	0.9	3.4	-	1.7	-	-	-	4.2	1.9	1.7	-
B	120	8	55	5	135	14	168	22	104	10	144	10	59	10	104	15
Sc	4.2	0.3	2.6	0.3	3.2	0.1	2.5	0.1	2.5	0.4	3.7	0.3	3.7	0.4	2.5	0.3
Ti	891	21.1	430	28.3	601	48.9	442	21.3	550	44.8	843	74.0	532	32	550	26.3
V	23	1	8	1	18	1	17	1	14	1	24	2	11	1	14	2
Cr	38	4	11	2	24	6	10	1	16	3	22	5	45	7	16	3
Co	23	1	1	-	277	39	5	1	16	2	37	-	15	2	16	1
Ni	30	3	3	1	29	4	6	1	11	-	18	1	123	18	11	1
Cu	885	21	5	1	2133	324	24	6	1561	13	1124	26	105	12	1561	147
Zn	102	3	5	1	59	2	9	1	186	41	142	12	37	5	186	23
Ga	3.4	0.4	3.0	0.2	3.4	0.2	1.9	0.1	2.4	0.3	2.9	0.1	3.2	0.3	2.4	0.4
Ge	1.0	-	0.7	0.2	1.5	0.3	1.1	0.5	0.8	0.2	1.3	0.3	1.4	0.8	0.8	0.1
As	11.9	0.6	1.0	0.4	31.0	6.2	6.5	0.3	19.3	2.0	25.6	3.7	2.3	0.5	19.3	3.0
Rb	10.7	0.4	9.2	0.3	8.7	0.9	4.8	0.3	14.3	0.3	12.5	0.2	17.9	1.1	14.3	4.5
Sr	536	9	324	12	501	14	423	6	429	12	517	7	268	26	429	16
Y	8.3	0.5	5.8	0.3	7.7	0.4	5.3	0.3	6.1	0.5	7.5	0.3	6.4	0.3	6.1	0.4
Zr	87.9	3.7	38.8	1.8	61.4	3.9	42.3	1.2	51.2	3.9	76.1	6.8	50.4	2.5	51.2	2.9
Nb	2.48	0.30	1.51	0.18	1.93	0.22	1.34	0.08	2.02	0.19	2.60	0.55	1.69	0.20	2.02	0.84
Mo	1.80	0.41	0.35	0.06	2.00	0.43	0.45	0.24	0.84	0.26	1.91	0.24	0.32	0.05	0.84	0.18
Ag	1.46	0.27	1.91	2.65	1.69	0.19	0.15	0.10	4.48	0.07	0.05	0.03	0.45	0.12	4.48	0.79
Cd	-	-	-	-	0.48	0.1	0.39	0.1	0.36	-	0.65	0.1	0.22	0.08	0.36	-
In	2.00	0.09	0.04	-	0.90	0.22	0.02	-	8.69	0.22	2.55	0.23	0.69	0.09	8.69	0.70
Sn	521	46	2	-	178	51	2	-	2201	42	668	33	183	27	2201	168
Sb	924	69	1	-	6991	354	228	2	1608	121	2645	553	42	7	1608	220
Cs	0.165	0.045	0.092	0.014	0.168	0.032	0.057	0.01	0.219	0.023	0.209	0.016	0.417	0.066	0.219	0.032
Ba	313	5	206	7	259	14	400	5	204	3	294	6	145	11	204	10
La	8.043	0.260	5.702	0.234	7.357	0.261	5.448	0.13	6.622	0.242	7.998	0.391	5.670	0.309	6.622	0.506
Ce	13.669	0.433	11.112	0.392	12.861	0.189	9.462	0.436	13.171	0.190	13.551	0.325	11.212	0.652	13.171	5.129
Pr	1.778	0.075	1.341	0.022	1.542	0.098	1.126	0.011	1.291	0.126	1.697	0.096	1.391	0.117	1.291	0.100
Nd	8.119	0.950	5.887	0.350	7.035	0.413	4.886	0.095	5.806	0.294	7.063	0.225	5.663	0.427	5.806	0.545
Sm	1.617	0.337	1.164	0.155	1.551	0.537	1.019	0.160	1.334	0.260	1.582	0.277	1.310	0.325	1.334	0.242
Eu	0.484	0.080	0.398	0.061	0.351	0.071	0.254	0.085	0.357	0.102	0.484	0.063	0.360	0.061	0.357	0.043
Gd	1.310	0.294	0.992	0.065	1.390	0.155	0.818	0.132	1.173	0.353	1.329	0.177	0.990	0.177	1.173	0.139
Tb	0.232	0.027	0.169	0.026	0.209	0.021	0.140	0.028	0.163	0.043	0.210	0.023	0.176	0.035	0.163	0.030
Dy	1.300	0.368	0.906	0.149	1.375	0.236	0.927	0.107	1.265	0.308	1.301	0.132	0.906	0.083	1.265	0.168
Ho	0.305	0.032	0.183	0.023	0.276	0.025	0.193	0.041	0.221	0.025	0.268	0.044	0.217	0.042	0.221	0.030
Er	0.709	0.095	0.445	0.067	0.724	0.071	0.405	0.075	0.721	0.159	0.723	0.116	0.684	0.045	0.721	0.107
Tm	0.096	0.019	0.078	0.025	0.105	0.030	0.101	0.022	0.079	0.029	0.110	0.028	0.072	0.016	0.079	0.026
Yb	0.658	0.208	0.500	0.179	0.920	0.122	0.481	0.187	0.611	0.066	0.714	0.240	0.625	0.084	0.611	0.103
Lu	0.149	0.018	0.071	0.035	0.085	0.026	0.071	0.018	0.099	0.020	0.122	0.033	0.075	0.021	0.099	0.031
Hf	2.350	0.216	0.999	0.255	1.548	0.201	1.192	0.200	1.417	0.373	1.810	0.227	1.313	0.259	1.417	0.273
Ta	0.141	0.042	0.076	0.017	0.137	0.024	0.066	0.020	0.100	0.033	0.117	0.020	0.104	0.024	0.100	0.047
W	0.442	0.092	0.131	-	0.514	0.104	0.136	0.103	0.372	0.090	0.745	0.136	0.131	0.083	0.372	0.098
Au	0.425	0.097	0.029	0.016	0.987	0.482	0.039	0.001	6.675	0.088	0.680	0.166	0.313	0.183	6.675	0.752
Tl	0.064	0.022	0.024	-	0.089	0.054	0.020	0.014	0.196	0.004	0.081	0.035	-	-	0.196	0.034
Pb	4076	83	6	-	3381	1193	16	2	14546	117	6528	630	295	41	14546	1818
Bi	0.417	0.154	0.044	0.014	0.308	0.123	0.035	-	4.616	0.028	0.619	0.116	0.139	0.058	4.616	1.343
Th	1.446	0.093	0.737	0.082	1.220	0.145	0.760	0.132	1.008	0.107	1.311	0.028	0.948	0.094	1.008	0.074
U	1.100	0.060	0.671	0.131	1.062	0.052	0.780	0.047	0.907	0.171	1.118	0.037	0.868	0.105	0.907	0.076

(continued)

	CO92 n=5		CO93 n=4		CO94 n=3		CO95 n=4		CO96 n=4		CO99 n=4		CO100A db n=4		CO100A lb n=3	
	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.
Li	6.0	1.1	5.5	0.7	4.8	1.4	3.6	0.9	6.8	1.9	4.0	2.3	7.0	1.3	5.7	1.6
Be	3.5	1.2	3.0	-	-	-	1.7	0.1	-	-	2.5	1.4	1.9	1.3	-	-
B	148	13	138	19	79	8	155	12	144	11	225	7	92	13	98	7
Sc	4.2	0.4	4.4	0.5	2.3	0.3	3.5	0.4	3.1	0.2	7.1	0.3	4.6	0.3	4.9	0.4
Ti	1058	20	735	33.5	369	15	937	10.0	875	27.3	3383	59.8	828	58.0	884	16
V	29	-	20	-	7	1	25	1	24	-	59	1	19	1	19	-
Cr	24	3	24	1	14	2	22	1	23	3	70	2	24	4	26	5
Co	71	2	33	3	1	-	29	4	43	2	16	-	24	4	35	8
Ni	28	1	16	1	5	1	15	0	23	3	17	1	48	56	27	7
Cu	3180	46	1742	56	12	1	1805	33	2579	100	84	2	1950	413	2663	150
Zn	589	33	78	9	6	2	73	5	187	41	30	1	170	76	341	178
Ga	3.6	0.2	3.2	0.2	2.7	0.1	3.0	0.3	3.2	0.1	4.5	0.4	3.4	0.5	3.2	0.4
Ge	1.6	0.3	1.9	-	1.1	-	1.4	0.5	1.3	0.1	1.9	0.2	1.2	0.3	1.5	-
As	40.5	1.8	21.4	0.7	1.0	-	20.1	0.9	22.9	3.6	11.5	0.7	17.1	8.7	43.7	26.6
Rb	10.8	0.4	13.3	0.7	7.9	0.2	9.4	0.3	12.6	1.1	5.4	0.3	15.1	1.4	12.5	0.2
Sr	605	5	498	7	353	8	500	2	528	8	417	6	438	10	432	9
Y	8.5	0.4	6.6	0.5	5.4	0.2	8.0	0.2	7.8	0.3	12.9	0.5	7.7	0.2	7.5	-
Zr	100.0	8.8	68.9	3.4	37.6	1.4	92.6	1.5	83.4	2.4	297.7	1.2	70.3	3.4	74.0	2.2
Nb	2.85	0.06	2.15	0.08	1.32	0.1	2.30	0.11	2.45	0.08	5.99	0.25	2.29	0.25	2.36	0.1
Mo	2.25	0.28	1.62	0.26	0.23	0.03	1.96	0.29	2.44	0.37	3.70	0.63	1.15	0.26	1.17	0.04
Ag	9.24	0.37	2.01	0.20	-	-	1.95	0.18	2.87	0.16	0.06	-	1.71	0.51	2.37	0.26
Cd	-	-	-	-	0.92	-	0.54	0.3	0.10	-	0.36	-	0.12	-	0.96	0.26
In	9.13	0.38	2.72	0.14	0.03	0.01	1.45	0.10	3.49	0.57	0.04	0.02	3.37	1.97	10.85	7.19
Sn	2875	26	706	30	2	-	381	23	896	156	1	-	862	509	2855	1956
Sb	3402	127	1788	144	0.5	-	1745	27	1263	43	0.5	-	961	149.5	976	18.7
Cs	0.200	0.035	0.214	0.047	0.076	0.027	0.146	0.029	0.119	0.013	0.126	0.006	0.213	0.061	0.188	0.041
Ba	330	5	264	10	178	2.823	321	4	305	9	842	3	261	8	257	1.934
La	8.651	0.254	6.738	0.462	5.573	0.228	7.916	0.165	8.050	0.097	12.039	0.426	7.375	0.282	7.427	0.297
Ce	14.659	0.217	11.675	0.580	10.433	0.523	13.122	0.390	13.404	0.269	19.656	0.524	13.585	0.688	13.242	0.469
Pr	1.894	0.086	1.451	0.068	1.236	0.035	1.614	0.054	1.732	0.139	2.730	0.102	1.637	0.095	1.796	0.061
Nd	7.979	0.346	6.096	0.679	5.368	0.210	7.363	0.117	7.580	0.478	10.666	0.331	6.916	0.553	7.011	0.327
Sm	1.601	0.102	1.222	0.235	1.119	0.044	1.751	0.134	1.559	0.350	2.352	0.331	1.418	0.411	1.552	0.392
Eu	0.433	0.051	0.315	0.063	0.316	0.030	0.391	0.040	0.411	0.093	0.634	0.065	0.355	0.073	0.441	0.022
Gd	1.599	0.265	1.166	0.175	0.981	0.146	1.426	0.301	1.401	0.245	2.148	0.217	1.067	0.136	1.411	0.205
Tb	0.248	0.029	0.174	0.040	0.148	0.033	0.228	0.028	0.202	0.032	0.391	0.038	0.220	0.037	0.200	0.057
Dy	1.442	0.241	1.116	0.051	0.981	0.091	1.152	0.263	1.436	0.238	2.251	0.151	1.313	0.096	1.364	0.035
Ho	0.302	0.018	0.215	0.041	0.209	0.050	0.312	0.033	0.310	0.054	0.475	0.038	0.279	0.043	0.281	0.053
Er	0.844	0.156	0.551	0.116	0.542	0.098	0.749	0.138	0.777	0.060	1.360	0.209	0.584	0.094	0.739	0.063
Tm	0.130	0.020	0.069	0.023	0.077	0.012	0.104	0.032	0.109	0.013	0.206	0.023	0.102	0.021	0.102	0.017
Yb	0.764	0.159	0.798	0.234	0.482	0.305	0.771	0.157	0.698	0.168	1.450	0.090	0.681	0.140	0.594	0.217
Lu	0.101	0.021	0.094	0.010	0.088	0.023	0.103	0.018	0.132	0.023	0.213	0.014	0.091	0.018	0.091	0.011
Hf	2.425	0.254	1.763	0.359	0.957	0.076	2.202	0.447	2.336	0.108	7.013	0.357	1.725	0.073	2.061	0.086
Ta	0.177	0.027	0.153	0.035	0.082	0.018	0.184	0.018	0.137	0.027	0.389	0.038	0.101	0.030	0.145	0.012
W	0.441	0.106	0.586	0.188	0.087	0.055	0.864	0.136	0.765	0.259	1.102	0.062	0.347	0.107	0.324	0.105
Au	2.754	0.277	0.879	0.258	-	-	0.398	0.067	1.139	0.418	0.045	0.014	0.734	0.127	0.804	0.143
Tl	0.248	0.054	0.072	0.027	0.062	-	0.084	0.036	0.086	0.036	-	-	0.076	0.028	0.133	0.011
Pb	17683	383	4578	303	13	1	4603	58	5929	1217	8	1	4949	2031	10160	5040
Bi	3.413	0.320	0.441	0.109	-	-	0.338	0.027	0.625	0.039	0.074	0.047	0.509	0.101	0.707	0.313
Th	1.434	0.081	1.133	0.111	0.728	0.010	1.411	0.117	1.393	0.029	2.465	0.049	1.171	0.088	1.181	0.127
U	1.246	0.058	0.980	0.110	0.602	0.092	1.007	0.019	1.011	0.043	1.270	0.032	1.094	0.078	1.113	0.082

(continued)

	CO100B		CO121A		CO121B		CO121C		CO121D		CO121E		CO122		CO184A	
	n=4		n=4		n=3		n=4		n=4		n=4		n=3		n=3	
	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.
Li	3.6	1.4	8.1	1.2	7.1	3.2	5.1	2.1	6.2	2.3	4.1	0.2	4.9	2.4	5.2	1.1
Be	3.6	3.2	1.3	-	-	-	-	-	4.6	-	2.7	1.4	-	-	-	-
B	129	10	141	7	147	10	141	14	168	16	166	12	152	19	143	4
Sc	2.6	0.4	3.0	0.3	3.0	0.3	2.7	0.4	3.1	0.4	2.6	0.4	2.6	0.4	3.3	0.1
Ti	616	11.6	899	43	757	65	634	18	781	34	567	5	615	91	847	13
V	20	1	24	-	19	3	17	1	23	1	16	-	18	2	23	1
Cr	19	1	25	3	25	5	16	2	20	4	10	2	22	5	30	2
Co	19	1	26	2	24	4	14	1	40	1	4	-	275	11	41	1
Ni	20	2	19	2	16	3	11	1	16	2	8	1	27	4	23	2
Cu	1548	57	1233	27	1882	105	1491	34	2550	55	15	-	2482	167	1908	49
Zn	33	1	72	9	81	14	57	6	92	5	20	3	71	7	166	9
Ga	2.5	0.3	2.9	0.3	3.0	0.1	2.6	0.2	2.8	0.1	2.6	0.3	3.4	0.1	3.3	0.5
Ge	1.2	0.4	1.4	0.8	1.2	0.4	1.2	0.3	1.1	0.5	1.2	0.2	1.7	0.2	1.5	1.0
As	18.1	0.6	15.7	0.5	15.5	1.0	15.4	1.8	24.7	1.8	23.1	1.6	24.2	5.8	22.0	1.2
Rb	7.8	0.2	9.0	0.3	11.7	2.4	8.8	0.4	9.2	0.2	5.0	0.5	11.0	0.3	12.1	0.5
Sr	428	3	462	7	443	13	436	13	482	3	424	3	473	20	459	1
Y	6.0	0.1	7.2	0.4	7.3	0.6	6.6	0.6	7.2	0.4	6.3	-	6.9	0.3	7.3	0.4
Zr	55.6	2.1	80.5	5.8	65.7	3.5	57.9	1.5	73.5	2.0	53.7	1.0	79.0	41.5	75.0	1.0
Nb	1.76	0.10	2.22	0.12	2.14	0.25	1.74	0.08	2.14	0.16	1.79	0.08	1.76	0.17	2.29	0.17
Mo	1.63	0.30	2.11	0.38	1.31	0.30	1.45	0.13	2.00	0.31	0.46	0.06	2.02	0.16	1.51	0.18
Ag	2.05	0.32	1.27	0.10	1.77	0.44	1.18	0.23	6.62	0.29	0.06	-	1.26	0.18	1.82	0.20
Cd	-	-	-	-	0.46	-	0.34	0.09	0.26	-	-	-	0.14	-	-	-
In	0.75	0.05	2.28	0.63	1.71	0.15	1.16	0.34	1.64	0.17	0.04	-	0.92	0.19	2.67	0.01
Sn	192	17	575	180	444	35	305	83	417	34	2	-	182	46	670	39
Sb	1404	42.8	1189	84	1389	76	1516	108	2819	69	2019	28	6345	1382	1906	26
Cs	0.168	0.019	0.165	0.048	0.208	0.065	0.178	0.053	0.178	0.043	0.072	0.022	0.152	0.051	0.213	0.039
Ba	260	6	312	2	253	7	278	15	288	5	177	3	226	5	278	5
La	6.011	0.123	7.141	0.324	7.181	0.804	6.896	0.158	7.259	0.323	6.623	0.129	6.684	0.087	7.273	0.137
Ce	11.069	0.285	12.424	0.175	12.849	0.929	11.596	0.579	11.986	0.370	11.188	0.186	11.486	0.257	12.542	0.328
Pr	1.350	0.129	1.646	0.037	1.562	0.144	1.465	0.034	1.546	0.094	1.419	0.063	1.481	0.118	1.679	0.105
Nd	5.625	0.657	7.217	0.609	7.114	0.381	6.240	0.273	6.156	0.171	6.455	0.547	6.313	0.493	6.988	0.659
Sm	1.034	0.101	1.621	0.220	1.459	0.214	1.184	0.196	1.259	0.141	1.250	0.289	1.204	0.318	1.123	0.055
Eu	0.236	0.034	0.438	0.053	0.396	0.038	0.315	0.062	0.363	0.048	0.318	0.067	0.349	0.057	0.313	0.037
Gd	1.061	0.122	1.456	0.356	1.192	0.070	1.106	0.239	1.209	0.162	1.045	0.246	1.092	0.211	1.425	0.258
Tb	0.136	0.007	0.208	0.057	0.173	0.037	0.187	0.029	0.185	0.037	0.156	0.019	0.189	0.046	0.222	0.016
Dy	0.983	0.143	1.295	0.181	1.198	0.137	1.142	0.407	1.246	0.247	1.132	0.015	1.173	0.071	1.197	0.063
Ho	0.195	0.015	0.285	0.049	0.240	0.005	0.243	0.031	0.226	0.052	0.207	0.030	0.274	0.014	0.280	0.049
Er	0.510	0.110	0.699	0.154	0.818	0.146	0.689	0.081	0.657	0.063	0.657	0.055	0.613	0.203	0.726	0.003
Tm	0.081	0.024	0.110	0.025	0.110	0.020	0.086	0.023	0.095	0.008	0.074	0.022	0.089	0.019	0.109	0.024
Yb	0.543	0.121	0.736	0.147	0.568	0.285	0.617	0.107	0.574	0.221	0.601	0.297	0.640	0.174	0.753	0.279
Lu	0.063	0.015	0.110	0.017	0.083	0.056	0.093	0.016	0.098	0.009	0.078	0.033	0.124	0.006	0.109	0.050
Hf	1.413	0.162	1.878	0.086	1.629	0.525	1.596	0.055	1.710	0.280	1.170	0.441	2.139	1.170	2.092	0.156
Ta	0.116	0.020	0.117	0.004	0.150	0.036	0.124	0.051	0.127	0.032	0.087	0.011	0.094	0.005	0.121	0.024
W	0.605	0.111	0.568	0.105	0.758	0.098	0.802	0.262	0.929	0.265	0.152	0.054	0.394	0.032	0.737	0.010
Au	1.518	0.154	0.525	0.073	1.046	0.182	0.693	0.176	0.981	0.132	0.301	-	0.477	0.147	1.287	0.188
Tl	0.055	0.005	0.071	0.024	0.054	0.029	0.076	0.022	0.075	0.017	0.030	0.019	0.049	0.027	0.054	0.032
Pb	2700	262	3344	241	4083	530	3395	334	4635	176	22	1	2435	320	5311	106
Bi	0.231	0.015	0.193	0.029	0.278	0.089	1.254	1.508	0.338	0.069	0.080	0.014	0.317	0.052	0.556	0.025
Th	0.868	0.100	1.204	0.059	1.318	0.097	1.194	0.041	1.232	0.133	0.970	0.065	1.153	0.058	1.248	0.054
U	0.916	0.105	0.972	0.170	0.966	0.067	1.050	0.047	0.967	0.098	0.810	0.068	0.942	0.018	0.922	0.094

(continued)

	CO184B n=4		CO184C n=4		CO230 n=4		CO233A n=4		CO233B n=3		CO233C n=4		CO325 n=4		CO365 n=5	
	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.
Li	4.2	1.2	4.8	2.0	4.7	2.5	3.9	1.0	7.6	1.6	6.2	0.7	6.3	2.6	5.1	1.7
Be	-	-	3.1	-	4.8	-	3.5	-	-	-	4.7	4.3	-	-	-	-
B	156	8	158	17	96	16	99	11	172	16	179	9	129	13	195	330
Sc	2.7	0.4	2.9	0.3	2.7	0.2	3.7	0.4	3.3	0.2	3.2	0.2	3.0	0.3	3.0	0.3
Ti	667	82	786	19	544	19	1536	24	824	16	741	43	780	50	436	17
V	19	3	22	1	11	1	21	-	31	2	22	1	21	1	9	1
Cr	18	1	23	4	24	6	27	4	15	2	21	2	23	7	17	4
Co	24	4	47	4	8	1	6	-	8	-	442	15	27	9	2	1
Ni	12	1	18	3	14	4	7	-	18	3	64	1	25	7	5	1
Cu	2098	272	2057	41	607	39	25	1	48	3	2099	61	1986	104	205	91
Zn	58	9	114	19	194	121	29	4	25	2	87	4	267	84	19	2
Ga	2.7	0.3	3.0	0.3	2.7	0.4	3.1	0.1	3.0	0.2	4.0	0.2	2.9	0.4	2.9	0.3
Ge	1.5	0.6	0.8	0.1	1.6	0.5	1.9	0.3	0.9	0.4	2.7	0.9	1.2	0.5	1.1	0.2
As	21.9	2.7	26.7	3.0	10.7	6.0	1.0	0.2	14.8	0.8	25.0	3.4	15.6	5.1	2.3	0.6
Rb	11.5	5.4	8.3	0.3	9.2	0.5	5.9	0.6	7.4	0.3	9.0	0.5	10.1	1.4	9.2	0.2
Sr	455	16	458	2	405	10	176	5	612	0	543	18	513	18	380	10
Y	6.4	1.0	7.1	0.1	6.4	0.2	6.4	0.2	9.7	0.4	7.2	0.4	7.1	0.1	6.3	0.2
Zr	64.0	2.1	72.1	1.3	50.1	0.7	176.7	3.7	82.4	0.8	71.6	2.5	71.9	3.4	42.7	1.6
Nb	1.93	0.19	2.06	0.09	1.64	0.20	3.46	0.18	2.51	0.04	2.01	0.16	2.20	0.22	1.41	0.19
Mo	1.57	0.25	1.95	0.23	0.59	0.31	0.38	0.15	1.79	0.22	3.27	0.30	1.45	0.19	0.34	0.10
Ag	1.66	0.39	2.17	0.15	1.00	0.31	0.15	0.04	0.08	0.04	1.16	0.16	3.07	0.38	0.48	0.11
Cd	0.59	0.22	0.37	0.11	0.61	0.07	0.44	-	-	-	0.62	-	0.55	-	-	-
In	1.08	0.09	1.75	0.48	3.35	1.20	0.04	0.01	0.03	0.01	2.60	0.18	4.61	0.91	0.50	0.25
Sn	261	13	421	82	874	286	4	1	5	-	523	43	1203	250	137	75
Sb	2196	249	2343	293	209	78	14	4	101	1	3349	67	718	210	73	47
Cs	0.221	0.040	0.129	0.011	0.138	0.031	0.074	0.015	0.092	0.035	0.158	0.028	0.133	0.051	0.115	0.041
Ba	273	22	289	2	202	4	167	5	369	10	244	7	249	6	219	4
La	6.364	1.041	6.778	0.079	6.047	0.183	6.664	0.218	11.056	0.107	7.230	0.212	7.005	0.187	6.173	0.133
Ce	11.311	0.872	11.733	0.275	10.920	0.447	13.193	0.196	13.459	0.371	12.796	0.502	12.273	0.374	11.228	0.212
Pr	1.483	0.113	1.533	0.077	1.385	0.144	1.549	0.061	2.263	0.102	1.474	0.056	1.473	0.072	1.418	0.045
Nd	6.133	1.361	6.392	0.239	6.278	1.048	6.581	0.339	10.089	0.148	6.658	0.176	6.719	0.463	5.593	0.345
Sm	1.199	0.420	1.302	0.181	1.199	0.103	1.311	0.177	2.203	0.215	1.254	0.311	1.522	0.337	1.188	0.337
Eu	0.341	0.058	0.344	0.083	0.382	0.089	0.291	0.054	0.593	0.034	0.413	0.031	0.373	0.076	0.382	0.059
Gd	1.129	0.165	1.237	0.152	1.227	0.308	1.062	0.128	1.842	0.180	1.270	0.215	1.243	0.226	1.043	0.231
Tb	0.181	0.079	0.185	0.036	0.161	0.015	0.149	0.051	0.286	0.025	0.199	0.015	0.193	0.038	0.168	0.037
Dy	1.139	0.134	1.101	0.136	1.096	0.291	1.200	0.026	1.752	0.262	1.184	0.147	1.174	0.181	1.113	0.175
Ho	0.224	0.058	0.236	0.040	0.208	0.036	0.220	0.030	0.394	0.068	0.234	0.040	0.248	0.015	0.226	0.022
Er	0.708	0.195	0.655	0.233	0.587	0.148	0.652	0.090	0.993	0.154	0.604	0.148	0.787	0.181	0.728	0.174
Tm	0.094	0.022	0.082	0.033	0.082	0.015	0.099	0.026	0.134	0.011	0.090	0.011	0.099	0.022	0.073	0.002
Yb	0.489	0.235	0.704	0.103	0.580	0.220	0.750	0.255	1.123	0.044	0.589	0.270	0.653	0.232	0.694	0.070
Lu	0.085	0.019	0.124	0.025	0.090	0.014	0.112	0.017	0.127	0.030	0.099	0.041	0.113	0.030	0.086	0.031
Hf	1.895	0.301	1.661	0.186	1.139	0.261	4.169	0.542	1.815	0.020	1.714	0.127	1.675	0.188	1.113	0.107
Ta	0.152	0.062	0.142	0.030	0.112	0.011	0.230	0.034	0.125	0.021	0.136	0.031	0.126	0.021	0.086	0.025
W	0.674	0.100	0.675	0.084	0.192	0.115	0.139	0.058	0.381	0.058	0.216	0.095	0.292	0.050	0.140	0.016
Au	1.254	0.289	0.884	0.274	0.332	0.243	0.061	-	0.014	-	0.148	0.050	0.673	0.057	0.111	0.053
Tl	0.092	0.028	0.065	0.038	0.087	0.035	0.036	0.006	0.059	0.033	0.079	0.011	0.113	0.071	0.027	0.004
Pb	4389	415	4725	748	3504	493	44	6	80	1	4264	220	9245	580	650	177
Bi	0.289	0.082	0.416	0.024	0.820	0.250	0.038	0.005	0.058	0.018	0.512	0.057	1.682	0.318	0.175	0.173
Th	1.054	0.154	1.169	0.105	0.962	0.070	1.405	0.146	1.311	0.053	1.294	0.108	1.208	0.098	0.861	0.074
U	0.922	0.012	0.961	0.145	0.894	0.081	1.011	0.023	1.330	0.065	1.053	0.120	0.916	0.052	0.831	0.100

(continued)

	CO366 n=4		CO368 n=3		CO530 db n=3		CO530 lb n=3	
	av.	s.d.	av.	s.d.	av.	s.d.	av.	s.d.
Li	3.9	1.3	3.3	1.4	4.6	1.8	5.4	2.4
Be	3.2	-	1.9	0.8	4.0	-	-	-
B	99	8	44	13	109	20	100	5
Sc	2.6	0.3	2.8	0.1	3.0	0.2	3.2	0.2
Ti	555	24	376	17	721	15	717	53
V	14	1	8	1	21	-	21	1
Cr	17	3	10	4	17	1	18	-
Co	9	-	1	-	70	1	73	10
Ni	9	1	3	-	155	3	170	32
Cu	348	47	3	-	7185	60	8093	739
Zn	43	3	3	-	2319	2	2566	533
Ga	2.9	0.3	3.1	0.3	3.5	0.3	2.9	0.1
Ge	0.7	-	1.2	0.5	1.3	0.4	1.3	0.4
As	4.0	0.6	1.2	0.2	115.1	3.6	141.9	53.3
Rb	8.6	0.3	8.8	0.5	9.0	0.3	8.8	0.3
Sr	443	8	369	6	538	1	527	9
Y	5.9	0.1	5.4	0.5	7.4	0.2	7.6	0.3
Zr	51.8	1.2	32.4	0.8	61.0	1.3	62.1	3.0
Nb	1.66	0.15	1.27	0.08	2.18	0.13	2.14	0.13
Mo	0.86	0.15	0.42	0.18	1.84	0.46	1.80	0.15
Ag	0.70	0.14	0.03	-	2.45	0.15	3.97	2.62
Cd	0.28	-	0.41	-	0.70	0.31	0.39	0.20
In	0.70	0.07	0.02	0.01	22.60	0.17	24.34	4.91
Sn	196	9	1	-	5882	48	9527	1841
Sb	273	5	0.3	-	238	2	258	37
Cs	0.147	0.039	0.101	0.016	0.176	0.008	0.164	0.020
Ba	217	3	218	8	249	2	244	3
La	5.930	0.329	5.563	0.166	7.187	0.264	6.975	0.208
Ce	11.024	0.189	11.261	0.592	12.720	0.256	12.142	0.598
Pr	1.376	0.163	1.374	0.111	1.622	0.033	1.550	0.077
Nd	5.754	0.542	5.258	0.387	7.462	0.447	6.857	0.336
Sm	1.022	0.171	1.227	0.359	1.485	0.191	1.546	0.060
Eu	0.326	0.126	0.299	0.018	0.424	0.038	0.459	0.023
Gd	0.911	0.184	1.029	0.275	1.482	0.232	1.298	0.141
Tb	0.172	0.027	0.141	0.027	0.234	0.003	0.200	0.044
Dy	0.850	0.081	0.998	0.203	1.552	0.058	1.416	0.086
Ho	0.212	0.016	0.183	0.027	0.277	0.075	0.245	0.019
Er	0.591	0.161	0.640	0.104	0.653	0.043	0.833	0.135
Tm	0.066	0.033	0.069	0.024	0.109	0.030	0.087	0.024
Yb	0.564	0.130	0.571	0.132	0.698	0.020	0.652	0.045
Lu	0.091	0.027	0.078	0.033	0.115	0.018	0.098	0.013
Hf	1.346	0.117	0.734	0.119	1.626	0.236	1.537	0.497
Ta	0.109	0.014	0.088	0.024	0.122	0.022	0.149	0.014
W	0.133	0.043	0.132	0.075	0.408	0.123	1.184	1.091
Au	0.196	0.039	0.052	-	0.074	0.017	0.071	-
Tl	0.028	0.001	0.014	-	0.284	0.037	0.289	0.022
Pb	893	21	5	-	23916	109	39421	6628
Bi	0.180	0.012	0.025	-	1.888	0.064	2.167	0.423
Th	0.882	0.094	0.631	0.148	1.059	0.089	1.069	0.042
U	0.911	0.069	0.736	0.075	0.938	0.082	0.929	0.047

Table S3. Sr, Nd isotopic results on Comacchio blocks.

Sample		Rb	Sr	Nd	Sm	CaO/Sr	$^{87}Sr/^{86}Sr$	2se	$^{143}Nd/^{144}Nd$	2se	εNd	2se
		ppm	ppm	ppm	ppm							
CO24		8.7	501	7.04	1.55	132	0.708895	± 0.000005	0.512371	± 0.000005	-5.204	±0.09
CO121E		5.0	424	6.46	1.25	145	0.708819	± 0.000005	0.512357	± 0.000006	-5.482	±0.11
CO122		11	473	6.31	1.20	143	0.708917	± 0.000004	0.512366	± 0.000006	-5.301	±0.11
CO100B		7.8	428	5.63	1.03	151	0.708863	± 0.000005	0.512375	± 0.000006	-5.137	±0.11
CO58A		10.8	411	6.58	1.22	157	0.708943	± 0.000005	0.512399	± 0.000004	-4.655	±0.08
Standard							$^{87}Sr/^{86}Sr$	2se	$^{143}Nd/^{144}Nd$	2se		
G2	*Within-run standard*						0.709777	± 0.000006	0.512219	± 0.000007		
							$^{87}Sr/^{86}Sr$	2sd	$^{143}Nd/^{144}Nd$	2sd	n	
Weiss et al. 2008							**0.709770**	**± 0.000014**	**0.512222**	**± 0.000006**	**7**	
							$^{87}Sr/^{86}Sr$	2se				
SRM987	*Within-run international and internal standard*						0.710264	± 0.000006				
SRM987	*Within-run international and internal standard*						0.710261	± 0.000005				
							$^{87}Sr/^{86}Sr$	2sd			n	
average value							0.710263	± 0.000004			2	
Reference value	**Thilwall 1989**						**0.710248**	**± 0.000011**			**428**	
									$^{143}Nd/^{144}Nd$	2se		
NdFi	*Within-run international and internal standard*								0.511462	± 0.000006		
NdFi	*Within-run international and internal standard*								0.511465	± 0.000004		
									$^{143}Nd/^{144}Nd$	2sd	n	
average value									0.511463	± 0.000005	2	
Avanzinelli et al. 2004	*Long term reproducibility*								**0.511468**	**± 0.000009**	**58**	

Samples preparation and isotopic mesurements have been performed at the DST-UNIFI laboratory of Geochemistry of Radiogenic Isotopes . 2se= two standard error of the mean; 2sd= two standard deviation; n= number of analysis. eNd is calculated as $^{143}Nd/^{144}Nd$ of the sample/0.512638 -1 *10000, where the value 0.512638 is the CHUR ‘chondritic uniform reservoir’ of Jacobson and Wasserburg (1980).

Table S4. EMPA full dataset. All values in wt%.

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO23A-db1	67.75	0.15	2.68	0.91	0.85	1.17	7.40	16.45	0.84	0.16	0.26	0.83	0.12	0.40	0.13	0.00	100.09
CO23A-db2	67.62	0.13	2.69	0.98	0.73	1.10	7.19	16.81	0.91	0.13	0.24	0.82	0.10	0.40	0.13	0.00	99.98
CO23A-db3	67.49	0.14	2.69	0.98	0.70	1.20	7.48	16.49	0.88	0.19	0.27	0.81	0.12	0.41	0.15	0.00	100.00
CO23A-db4	67.57	0.15	2.71	0.87	0.72	1.10	7.48	16.67	0.87	0.18	0.25	0.80	0.11	0.43	0.10	0.00	100.01
CO23A-mb1	67.41	0.10	2.69	1.06	0.68	1.24	7.18	16.71	0.88	0.19	0.25	0.77	0.16	0.43	0.13	0.05	99.92
CO23A-mb2	67.43	0.11	2.55	0.99	0.76	1.21	7.46	16.57	0.90	0.15	0.28	0.75	0.12	0.50	0.13	0.09	100.01
CO23A-mb3	67.46	0.17	2.69	0.86	0.69	1.04	7.27	16.86	0.95	0.18	0.24	0.79	0.11	0.43	0.15	0.07	99.97
CO23A-mb4	67.47	0.08	2.58	0.87	0.70	1.11	7.26	16.98	0.96	0.18	0.27	0.75	0.12	0.44	0.14	0.00	99.91
CO23A-mb5	67.70	0.16	2.78	0.94	0.70	1.14	7.34	16.43	0.95	0.11	0.24	0.82	0.14	0.45	0.08	0.00	99.98
CO23A-mb6	67.60	0.15	2.58	1.00	0.69	1.03	7.15	16.88	0.91	0.14	0.25	0.83	0.10	0.45	0.16	0.04	99.96
CO23A-mb7	67.04	0.15	2.63	1.04	0.86	1.10	7.67	16.56	0.91	0.20	0.26	0.77	0.11	0.50	0.12	0.15	100.05
CO23A-mb8	67.52	0.15	2.66	0.99	0.71	1.20	7.28	16.58	0.89	0.14	0.26	0.78	0.09	0.51	0.12	0.12	99.98
CO23A-mb9	67.57	0.14	2.46	0.93	0.78	0.87	6.59	17.12	0.68	0.16	0.26	1.07	0.34	0.53	0.47	0.07	100.03
CO23A-lb1	66.29	0.12	2.60	0.96	0.91	1.13	7.57	17.35	0.84	0.23	0.29	0.81	0.14	0.59	0.16	0.00	99.98
CO23A-lb2	66.87	0.13	2.63	1.02	0.67	1.34	7.25	17.04	0.88	0.17	0.23	0.76	0.12	0.63	0.17	0.15	100.05
CO23A-lb3	66.36	0.10	2.59	0.95	0.79	1.15	7.63	17.29	0.93	0.16	0.30	0.76	0.13	0.53	0.15	0.14	99.96
CO23A-lb4	66.68	0.11	2.58	0.97	0.89	1.06	7.48	17.06	0.89	0.19	0.23	0.77	0.13	0.62	0.12	0.14	99.92
CO23A-lb5	66.80	0.14	2.73	1.02	0.70	1.16	7.21	17.31	0.93	0.12	0.22	0.76	0.12	0.59	0.15	0.10	100.04
CO23B	72.27	0.09	3.22	0.40	0.03	0.44	6.23	15.58	0.55	0.06	0.21	0.98	0.00	0.00	0.00	0.00	100.06
CO23B	71.96	0.06	3.26	0.42	0.01	0.45	6.20	15.84	0.55	0.04	0.20	0.98	0.00	0.00	0.00	0.00	99.97
CO23B	72.20	0.07	3.23	0.45	0.02	0.41	6.14	15.63	0.53	0.06	0.20	0.98	0.00	0.00	0.00	0.00	99.91
CO23B	71.91	0.09	3.21	0.47	0.02	0.44	6.27	15.73	0.55	0.03	0.19	0.97	0.00	0.00	0.00	0.00	99.88
CO23B	71.61	0.09	3.12	0.41	0.02	0.41	6.53	15.89	0.55	0.06	0.25	1.00	0.00	0.00	0.00	0.00	99.92
CO23B	71.93	0.06	3.17	0.42	0.04	0.43	6.06	15.98	0.55	0.02	0.20	0.98	0.00	0.00	0.00	0.00	99.83
CO24	67.34	0.08	2.44	0.85	0.60	0.98	6.37	17.80	0.57	0.12	0.34	0.86	0.29	0.35	0.83	0.02	99.83
CO24	67.79	0.05	2.41	0.79	0.59	0.96	6.56	17.47	0.56	0.12	0.37	0.78	0.26	0.37	0.92	0.01	99.99
CO24	67.29	0.06	2.36	0.76	0.57	0.81	6.82	17.85	0.58	0.11	0.36	0.99	0.25	0.29	0.97	0.01	100.07
CO24	67.61	0.09	2.35	0.73	0.60	0.74	6.55	17.61	0.59	0.12	0.38	1.00	0.31	0.34	0.94	0.02	99.98
CO24	67.74	0.11	2.42	0.74	0.57	0.91	6.74	17.60	0.56	0.12	0.35	0.64	0.28	0.35	0.92	0.02	100.07
CO25	70.51	0.11	1.96	0.37	0.58	0.62	5.86	17.84	0.43	0.05	0.22	1.28	0.00	0.00	0.03	0.00	99.86
CO25	69.99	0.09	1.94	0.45	0.61	0.64	6.11	18.26	0.41	0.00	0.24	1.29	0.02	0.00	0.03	0.00	100.08
CO25	70.43	0.10	1.87	0.43	0.56	0.64	5.96	17.92	0.40	0.00	0.25	1.30	0.00	0.01	0.02	0.00	99.88
CO25	70.38	0.09	1.99	0.41	0.60	0.59	6.00	17.97	0.41	0.03	0.24	1.29	0.00	0.00	0.03	0.00	100.03
CO25	70.63	0.05	1.95	0.40	0.63	0.61	5.97	17.79	0.44	0.03	0.23	1.26	0.00	0.00	0.02	0.00	100.01
CO25	70.33	0.09	2.00	0.43	0.66	0.64	5.98	17.90	0.42	0.00	0.26	1.30	0.00	0.01	0.01	0.00	100.03
CO58A	69.94	0.18	2.91	0.86	0.29	0.78	6.42	16.13	0.73	0.10	0.18	0.89	0.12	0.22	0.19	0.03	99.96
CO58A	69.87	0.14	2.93	0.84	0.29	0.79	6.37	16.29	0.64	0.13	0.23	0.92	0.11	0.24	0.14	0.04	99.97
CO58A	70.05	0.11	2.92	0.76	0.28	0.77	6.40	16.27	0.66	0.13	0.20	0.87	0.11	0.22	0.19	0.02	99.97
CO58A	69.94	0.15	2.87	0.78	0.29	0.77	6.52	16.14	0.71	0.16	0.20	0.87	0.12	0.21	0.17	0.02	99.93
CO58A	69.91	0.08	2.91	0.78	0.26	0.73	6.52	16.28	0.73	0.11	0.22	0.88	0.15	0.22	0.15	0.03	99.96
CO58A	69.97	0.14	2.92	0.87	0.30	0.76	6.36	16.15	0.67	0.10	0.24	0.88	0.14	0.20	0.19	0.05	99.95
CO58A	69.81	0.14	2.97	0.83	0.31	0.73	6.47	16.42	0.71	0.13	0.17	0.89	0.12	0.20	0.09	0.04	100.04
CO58A	70.27	0.12	2.96	0.89	0.20	0.73	6.27	16.35	0.71	0.08	0.15	0.85	0.10	0.16	0.07	0.03	99.92
CO58A	70.13	0.11	2.89	0.79	0.29	0.69	6.53	16.10	0.72	0.11	0.26	0.88	0.10	0.22	0.16	0.06	100.04
CO58A	69.84	0.18	2.98	0.84	0.26	0.75	6.57	16.18	0.70	0.08	0.22	0.90	0.07	0.23	0.17	0.11	100.05
CO58B	66.63	0.16	2.65	1.10	0.69	1.00	6.56	15.94	2.74	0.15	0.22	0.84	0.11	0.65	0.42	0.06	99.92
CO58B	66.84	0.13	2.45	1.07	0.67	1.03	6.79	15.93	2.67	0.13	0.21	0.79	0.11	0.69	0.37	0.07	99.96
CO58B	66.85	0.15	2.60	1.07	0.68	0.98	6.55	16.09	2.60	0.14	0.20	0.81	0.16	0.68	0.41	0.07	100.02
CO58B	66.41	0.16	2.47	1.05	0.72	1.00	6.71	16.06	2.69	0.18	0.24	0.82	0.17	0.79	0.39	0.08	99.95
CO58B	66.85	0.10	2.46	0.99	0.70	0.92	6.62	15.98	2.72	0.14	0.27	0.85	0.20	0.69	0.40	0.11	100.01
CO58B	66.86	0.14	2.52	0.97	0.66	0.99	6.60	15.97	2.79	0.17	0.25	0.85	0.12	0.70	0.31	0.07	99.97
CO58B	66.93	0.12	2.53	1.02	0.69	0.95	6.57	16.05	2.69	0.15	0.23	0.84	0.15	0.67	0.37	0.08	100.06
CO58B	67.03	0.17	2.42	1.03	0.68	0.98	6.79	15.79	2.60	0.19	0.23	0.78	0.12	0.71	0.36	0.12	99.98
CO58B	66.75	0.12	2.51	1.19	0.66	1.00	6.62	16.04	2.82	0.14	0.24	0.82	0.10	0.64	0.32	0.07	100.04
CO58B	66.81	0.15	2.54	1.02	0.68	0.96	6.51	15.99	2.93	0.15	0.23	0.85	0.10	0.56	0.34	0.12	99.95
CO58C	72.99	0.08	2.76	0.55	0.09	2.98	5.08	13.66	0.81	0.04	0.13	0.82	0.03	0.02	0.02	0.01	100.05
CO58C	72.93	0.09	2.69	0.59	0.06	3.33	4.62	13.64	0.78	0.08	0.13	0.79	0.02	0.05	0.03	0.02	99.86
CO58C	72.74	0.11	2.77	0.76	0.04	5.23	3.34	13.32	0.79	0.07	0.10	0.77	0.00	0.03	0.02	0.01	100.09
CO58C	71.84	0.05	2.69	1.43	0.02	5.34	3.17	13.65	0.85	0.09	0.11	0.70	0.02	0.02	0.01	0.02	100.01
CO58C	72.30	0.08	2.77	0.66	0.03	5.39	3.33	13.37	0.84	0.06	0.13	0.75	0.03	0.08	0.00	0.02	99.84
CO58C	72.87	0.05	2.76	0.60	0.06	3.13	4.73	13.73	0.81	0.02	0.12	0.89	0.02	0.06	0.00	0.03	99.87
CO58C	72.73	0.06	2.79	0.67	0.07	4.94	3.31	13.48	0.89	0.09	0.13	0.78	0.03	0.02	0.01	0.01	99.99
CO88	67.20	0.12	2.29	0.53	0.36	0.71	6.33	18.28	0.46	0.05	0.34	1.14	0.22	1.59	0.20	0.28	100.09
CO88	67.02	0.11	2.26	0.60	0.39	0.73	6.36	18.17	0.45	0.09	0.34	1.16	0.25	1.70	0.23	0.15	99.99
CO88	67.11	0.08	2.36	0.49	0.36	0.73	6.46	18.07	0.47	0.02	0.33	1.20	0.25	1.59	0.22	0.36	100.08
CO88	67.00	0.09	2.23	0.51	0.37	0.71	6.61	18.05	0.54	0.02	0.34	1.16	0.23	1.67	0.23	0.29	100.04
CO88	67.10	0.10	2.27	0.54	0.36	0.75	6.60	17.70	0.51	0.07	0.37	1.17	0.17	1.68	0.20	0.33	99.92
CO88	67.32	0.10	2.26	0.59	0.36	0.69	6.45	17.65	0.49	0.10	0.34	1.11	0.23	1.55	0.27	0.35	99.85
CO92 db1	65.39	0.12	2.83	1.05	0.91	0.98	7.53	16.58	0.78	0.18	0.28	0.84	0.31	1.40	0.40	0.31	99.87
CO92 db2	65.20	0.21	2.83	1.06	0.77	1.02	7.46	17.08	0.78	0.18	0.26	0.82	0.36	1.43	0.28	0.28	100.00
CO92 db3	65.59	0.18	2.68	0.98	0.84	1.03	7.20	17.27	0.73	0.18	0.25	0.82	0.35	1.35	0.27	0.25	99.94
CO92 mb1	64.47	0.16	2.57	1.10	0.90	1.06	7.34	17.14	0.78	0.14	0.31	0.89	0.37	1.90	0.45	0.45	100.03
CO92 mb2	65.17	0.19	2.48	0.87	0.84	0.97	7.10	17.08	0.68	0.25	0.35	0.92	0.40	1.75	0.45	0.43	99.92
CO92 mb3	65.24	0.20	2.55	0.97	0.88	1.01	7.13	17.07	0.72	0.19	0.27	0.84	0.43	1.62	0.58	0.33	100.02
CO92 mb4	65.28	0.17	2.55	0.99	0.89	0.95	7.27	17.16	0.71	0.22	0.28	0.85	0.30	1.64	0.52	0.29	100.05
CO92 mb5	64.75	0.15	2.60	1.04	0.84	0.99	7.31	17.26	0.77	0.27	0.34	0.89	0.40	1.82	0.26	0.29	99.97
CO92 mb6	65.14	0.19	2.57	1.01	0.87	0.99	7.29	17.11	0.65	0.22	0.27	0.87	0.40	1.68	0.44	0.27	99.96
CO92 mb7	65.21	0.17	2.54	1.02	0.86	1.04	7.25	17.06	0.76	0.17	0.36	0.84	0.31	1.74	0.36	0.28	99.98
CO92 mb8	64.38	0.15	2.49	1.05	0.91	1.01	7.12	16.91	0.70	0.20	0.27	0.82	0.43	1.95	0.63	0.43	99.45
CO92 mb9	65.06	0.18	2.48	0.97	0.90	0.93	7.19	17.36	0.68	0.25	0.27	0.86	0.47	1.78	0.41	0.27	100.04
CO92 mb10	65.23	0.10	2.59	0.99	0.81	0.95	7.12	16.91	0.78	0.16	0.31	0.86	0.43	1.84	0.40	0.35	99.83
CO92 mb11	64.84	0.18	2.57	0.97	0.81	0.96	7.30	17.27	0.78	0.20	0.34	0.87	0.36	1.67	0.48	0.39	99.96

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO92 lb1	64.48	0.14	2.49	1.10	0.91	0.95	7.48	17.01	0.69	0.17	0.29	0.84	0.47	2.06	0.59	0.39	100.05
CO92 lb2	64.36	0.15	2.38	0.94	0.96	0.98	7.12	17.29	0.77	0.16	0.36	0.78	0.46	2.27	0.49	0.50	99.96
CO92 lb3	64.68	0.13	2.44	1.02	0.90	0.96	7.17	16.95	0.75	0.21	0.35	0.87	0.44	2.28	0.43	0.44	100.00
CO92 lb4	64.71	0.14	2.44	1.02	0.86	0.98	7.20	16.82	0.72	0.20	0.33	0.79	0.45	2.36	0.52	0.44	99.98
CO93	68.18	0.13	2.58	0.87	0.55	0.92	6.52	17.18	0.68	0.13	0.24	0.94	0.24	0.46	0.30	0.10	100.03
CO93	68.23	0.07	2.53	0.92	0.64	0.96	6.40	17.08	0.73	0.11	0.27	0.90	0.21	0.57	0.27	0.09	99.98
CO93	67.82	0.14	2.54	0.84	0.67	0.97	6.56	17.33	0.77	0.09	0.25	0.93	0.23	0.47	0.26	0.10	99.96
CO93	68.08	0.14	2.55	0.99	0.60	0.90	6.45	17.16	0.71	0.15	0.28	0.94	0.20	0.51	0.24	0.10	100.00
CO93	67.78	0.10	2.60	1.00	0.66	0.93	6.67	17.08	0.68	0.18	0.26	0.92	0.25	0.51	0.25	0.11	99.99
CO93	68.10	0.13	2.57	0.91	0.60	0.93	6.54	17.12	0.68	0.12	0.26	0.92	0.20	0.51	0.23	0.08	99.89
CO93	67.85	0.15	2.52	0.94	0.65	1.05	6.40	17.23	0.79	0.12	0.29	0.89	0.25	0.55	0.22	0.11	100.01
CO93	67.90	0.12	2.50	0.98	0.68	0.87	6.66	17.02	0.74	0.09	0.28	0.97	0.21	0.46	0.24	0.11	99.84
CO93	67.75	0.12	2.55	0.97	0.63	1.18	6.31	17.22	0.78	0.14	0.26	0.93	0.29	0.53	0.24	0.10	99.98
CO94	71.46	0.11	2.84	0.36	0.02	0.60	9.64	13.31	0.92	0.06	0.23	0.38	0.00	0.00	0.00	0.00	99.92
CO94	71.58	0.09	2.86	0.40	0.03	0.64	9.51	13.27	1.00	0.05	0.22	0.38	0.00	0.00	0.00	0.00	100.03
CO94	71.74	0.09	2.83	0.41	0.01	0.63	9.53	13.23	0.92	0.04	0.21	0.38	0.00	0.00	0.00	0.00	100.01
CO94	71.58	0.09	2.83	0.39	0.03	0.64	9.45	13.40	1.00	0.06	0.20	0.38	0.00	0.00	0.00	0.00	100.04
CO94	71.63	0.05	2.78	0.38	0.02	0.61	9.50	13.19	1.00	0.09	0.23	0.39	0.00	0.00	0.00	0.00	99.87
CO94	71.84	0.05	2.78	0.39	0.02	0.63	9.43	13.28	0.96	0.05	0.21	0.38	0.00	0.00	0.00	0.00	100.03
CO95	66.32	0.13	2.58	0.93	0.84	0.91	6.82	17.96	0.73	0.16	0.29	1.05	0.24	0.61	0.28	0.03	99.87
CO95	66.67	0.15	2.53	1.00	0.87	0.93	6.75	17.66	0.75	0.13	0.28	1.09	0.25	0.55	0.28	0.04	99.92
CO95	66.50	0.17	2.61	1.34	0.90	0.89	6.67	17.85	0.72	0.12	0.29	1.07	0.23	0.36	0.23	0.07	100.01
CO95	66.34	0.18	2.63	1.14	0.92	0.89	6.77	17.73	0.74	0.16	0.28	1.08	0.26	0.49	0.19	0.03	99.82
CO95	66.65	0.14	2.57	0.92	0.89	0.90	6.88	17.76	0.70	0.14	0.24	1.06	0.29	0.61	0.23	0.05	100.04
CO96	66.03	0.13	2.45	1.17	0.97	0.97	6.84	18.02	0.79	0.16	0.29	1.04	0.34	0.59	0.21	0.09	100.06
CO96	66.17	0.15	2.48	1.23	0.92	0.89	6.97	17.71	0.78	0.12	0.28	1.03	0.32	0.70	0.20	0.11	100.05
CO96	65.65	0.16	2.47	1.48	0.96	1.24	6.66	17.72	0.80	0.15	0.27	0.99	0.36	0.66	0.18	0.15	99.88
CO96	66.27	0.17	2.50	1.13	0.93	0.94	6.88	17.97	0.82	0.13	0.32	1.05	0.32	0.44	0.15	0.13	100.13
CO96	65.58	0.10	2.40	1.43	0.90	1.23	6.82	17.74	0.76	0.18	0.28	1.00	0.37	0.96	0.24	0.17	100.14
CO96	66.18	0.14	2.46	1.15	0.91	0.98	6.78	17.82	0.78	0.15	0.30	1.02	0.38	0.68	0.26	0.14	100.11
CO96	66.19	0.16	2.48	1.36	0.87	1.10	6.49	17.50	0.81	0.18	0.28	1.01	0.35	0.74	0.17	0.08	99.79
CO96	66.25	0.13	2.43	1.35	1.02	0.97	6.77	16.76	0.79	0.12	0.26	1.03	0.38	0.86	0.26	0.16	99.53
CO99	64.07	0.56	3.48	2.24	2.33	1.39	4.76	19.22	0.39	0.07	0.25	1.19	0.01	0.00	0.00	0.00	99.96
CO99	64.41	0.51	3.40	2.08	2.32	1.34	4.79	19.24	0.36	0.08	0.26	1.20	0.02	0.00	0.00	0.00	100.02
CO99	64.37	0.55	3.48	2.20	2.33	1.41	4.68	19.10	0.38	0.06	0.24	1.18	0.00	0.00	0.00	0.00	99.97
CO99	64.44	0.54	3.44	2.09	2.32	1.40	4.66	19.26	0.38	0.03	0.25	1.20	0.01	0.00	0.00	0.00	100.01
CO99	64.49	0.54	3.37	2.16	2.30	1.39	4.60	19.20	0.36	0.05	0.26	1.22	0.01	0.00	0.00	0.00	99.94
CO99	64.10	0.57	3.42	2.13	2.34	1.40	4.66	19.45	0.37	0.10	0.26	1.20	0.00	0.00	0.00	0.00	99.99
CO99	64.47	0.56	3.37	2.17	2.26	1.44	4.59	19.18	0.40	0.06	0.24	1.19	0.02	0.00	0.00	0.00	99.95
CO100A db1	68.63	0.14	2.74	0.95	0.34	0.95	5.69	17.30	0.89	0.14	0.24	0.92	0.22	0.55	0.20	0.10	100.00
CO100A db2	68.84	0.13	2.84	0.85	0.39	0.93	6.36	16.65	0.83	0.16	0.20	0.89	0.23	0.52	0.18	0.08	100.05
CO100A db3	69.21	0.14	2.79	0.88	0.34	0.87	5.98	16.74	0.86	0.10	0.22	0.97	0.21	0.41	0.12	0.12	99.97
CO100A db4	69.44	0.13	2.94	0.80	0.27	0.83	6.21	16.54	0.87	0.12	0.18	0.84	0.22	0.42	0.13	0.06	99.98
CO100A db5	68.70	0.11	2.83	0.89	0.35	0.86	6.15	16.70	0.80	0.13	0.19	0.90	0.33	0.74	0.14	0.05	99.85
CO100A db6	68.35	0.11	2.90	1.04	0.39	1.01	6.33	16.77	0.88	0.13	0.18	0.85	0.30	0.56	0.18	0.09	100.06
CO100A db7	68.80	0.15	2.77	0.86	0.38	0.89	6.17	16.72	0.79	0.14	0.20	0.91	0.29	0.58	0.11	0.11	99.88
CO100A db8	69.21	0.09	2.93	0.93	0.30	0.85	6.09	16.46	0.81	0.16	0.18	0.84	0.22	0.54	0.13	0.11	99.87
CO100A db9	69.44	0.13	2.85	0.87	0.30	1.12	5.78	16.65	0.88	0.16	0.23	0.85	0.23	0.38	0.11	0.09	100.07
CO100A lb1	68.39	0.16	2.78	1.10	0.35	0.93	5.85	16.49	0.86	0.17	0.21	0.94	0.30	1.00	0.12	0.37	100.01
CO100A lb2	68.28	0.12	2.74	0.92	0.35	0.86	5.90	16.94	0.80	0.10	0.20	0.95	0.27	1.04	0.18	0.32	99.96
CO100A lb3	68.20	0.14	2.77	0.97	0.33	0.93	5.72	16.57	0.79	0.13	0.23	0.93	0.37	1.48	0.16	0.36	100.07
CO100A lb4	68.38	0.14	2.78	0.97	0.38	0.86	5.79	16.52	0.81	0.12	0.21	0.93	0.43	1.16	0.14	0.44	100.04
CO100A lb5	68.49	0.15	2.76	1.00	0.37	0.88	5.85	16.49	0.78	0.15	0.19	0.94	0.41	1.14	0.18	0.33	100.09
CO100A lb6	68.71	0.12	2.78	0.90	0.31	0.89	5.73	16.34	0.78	0.14	0.20	0.96	0.31	1.09	0.17	0.38	99.81
CO100A lb7	68.52	0.14	2.79	0.94	0.37	0.87	5.85	16.58	0.83	0.15	0.25	0.92	0.24	1.09	0.10	0.36	99.98
CO100A lb8	68.78	0.15	2.74	0.98	0.33	0.88	5.80	16.30	0.83	0.11	0.20	0.91	0.36	1.10	0.14	0.37	99.96
CO100A lb9	68.63	0.11	2.79	0.98	0.33	0.86	5.77	16.60	0.79	0.10	0.22	0.88	0.23	1.17	0.14	0.38	99.99
CO100B	67.36	0.15	2.34	0.91	0.79	0.79	6.55	18.18	0.56	0.11	0.29	1.05	0.24	0.33	0.28	0.02	99.93
CO100B	67.46	0.13	2.39	0.78	0.84	0.79	6.33	18.50	0.58	0.10	0.25	1.05	0.20	0.30	0.20	0.01	99.91
CO100B	67.51	0.07	2.35	0.93	0.78	0.82	6.51	18.23	0.60	0.07	0.23	1.07	0.24	0.33	0.19	0.04	99.97
CO100B	67.61	0.12	2.35	0.92	0.81	0.86	6.44	18.21	0.55	0.09	0.28	1.05	0.20	0.33	0.18	0.03	100.04
CO100B	67.32	0.11	2.33	1.05	0.80	0.81	6.54	18.01	0.71	0.11	0.32	1.06	0.18	0.38	0.24	0.03	99.99
CO100B	67.53	0.09	2.33	0.84	0.76	0.79	6.52	18.14	0.66	0.14	0.27	1.06	0.17	0.30	0.20	0.03	99.83
CO100B	67.41	0.08	2.34	0.98	0.82	0.80	6.36	18.42	0.61	0.11	0.26	1.09	0.15	0.24	0.14	0.08	99.89
CO121A db1	67.99	0.11	2.51	0.85	0.85	1.01	6.96	16.62	0.81	0.14	0.32	1.01	0.20	0.26	0.26	0.04	99.92
CO121A db2	68.15	0.17	2.52	0.87	0.80	0.88	6.79	16.86	0.85	0.16	0.28	0.89	0.22	0.26	0.24	0.03	99.95
CO121A db3	67.80	0.16	2.65	1.05	0.78	1.18	6.60	17.13	0.69	0.16	0.27	0.99	0.09	0.25	0.12	0.06	99.97
CO121A db4	68.40	0.16	2.51	1.12	0.93	0.91	6.53	16.99	0.77	0.11	0.26	0.83	0.11	0.15	0.18	0.05	100.01
CO121A db5	67.98	0.13	2.67	1.22	0.80	1.07	6.48	17.43	0.82	0.09	0.22	0.59	0.12	0.14	0.16	0.04	99.96
CO121A lb1	67.38	0.15	2.53	0.85	0.77	0.95	6.60	17.35	0.81	0.14	0.33	1.03	0.15	0.66	0.17	0.07	99.92
CO121A lb2	66.80	0.18	2.75	1.15	0.99	1.07	6.90	17.15	0.78	0.14	0.28	0.93	0.18	0.49	0.10	0.08	99.96
CO121A lb3	68.17	0.15	2.67	1.23	0.79	0.91	6.31	17.00	0.71	0.06	0.27	0.97	0.14	0.43	0.08	0.06	99.94
CO121A lb4	68.09	0.16	2.37	0.87	0.92	0.83	6.83	17.19	0.69	0.08	0.21	1.15	0.16	0.41	0.01	0.05	100.01
CO121A lb5	67.80	0.15	2.46	0.99	0.84	1.15	6.52	17.05	0.87	0.12	0.26	0.88	0.18	0.52	0.20	0.04	100.02
CO121A lb6	67.23	0.17	2.45	1.15	0.89	1.68	6.56	17.06	0.79	0.08	0.29	0.71	0.19	0.57	0.21	0.05	100.09
CO121B db1	69.41	0.27	3.47	0.95	0.20	0.90	4.69	17.54	1.13	0.07	0.14	0.51	0.26	0.22	0.07	0.07	99.89
CO121B db2	69.14	0.19	3.18	0.92	0.31	0.88	5.46	17.16	0.90	0.17	0.18	0.87	0.20	0.25	0.12	0.00	99.95
CO121B db3	69.56	0.22	3.32	0.84	0.23	0.85	5.23	16.92	0.93	0.11	0.19	0.92	0.20	0.28	0.08	0.09	99.97
CO121B mb1	68.00	0.14	2.63	0.83	0.54	0.90	7.01	16.85	0.83	0.18	0.26	0.97	0.20	0.40	0.16	0.06	99.94
CO121B mb2	68.05	0.16	2.69	0.95	0.50	1.03	6.74	16.82	0.90	0.17	0.26	0.90	0.23	0.46	0.25	0.00	100.09
CO121B mb3	68.06	0.13	2.67	0.92	0.47	1.00	6.73	16.81	0.93	0.16	0.25	0.93	0.21	0.48	0.19	0.00	99.94
CO121B mb4	68.03	0.12	2.81	0.81	0.47	0.83	6.62	16.93	0.93	0.16	0.23	0.96	0.27	0.47	0.16	0.06	99.87
CO121B mb5	68.14	0.10	2.57	0.68	0.48	0.86	7.13	16.97	0.81	0.15	0.23	0.99	0.24	0.47	0.19	0.00	99.99
CO121B mb6	68.05	0.14	2.63	0.90	0.47	1.05	6.85	16.51	0.92	0.19	0.23	0.95	0.28	0.48	0.19	0.07	99.91

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO121B lb1	66.48	0.12	2.55	2.41	0.51	1.01	6.69	16.67	0.90	0.23	0.26	0.92	0.27	0.60	0.26	0.06	99.92
CO121B lb2	67.92	0.13	2.63	0.77	0.55	0.90	7.10	16.71	0.84	0.18	0.23	1.01	0.22	0.55	0.23	0.00	99.97
CO121B lb3	66.94	0.10	2.77	1.02	0.59	1.17	7.02	16.84	0.89	0.18	0.26	0.93	0.28	0.66	0.29	0.06	99.98
CO121B lb4	66.99	0.15	2.73	1.05	0.60	1.16	6.86	16.86	0.96	0.13	0.29	0.93	0.29	0.65	0.34	0.00	99.97
CO121C	68.55	0.12	2.56	0.84	0.65	0.83	6.64	16.80	0.66	0.12	0.28	1.16	0.21	0.30	0.21	0.03	99.95
CO121C	68.38	0.08	2.62	0.82	0.59	0.80	6.77	16.87	0.64	0.18	0.26	1.13	0.22	0.40	0.25	0.04	100.04
CO121C	68.26	0.12	2.69	0.78	0.51	0.78	6.62	17.32	0.59	0.13	0.28	1.09	0.15	0.41	0.22	0.06	99.99
CO121C	68.19	0.10	2.67	0.73	0.54	0.81	6.80	17.26	0.65	0.17	0.27	1.08	0.18	0.33	0.25	0.03	100.07
CO121C	67.90	0.08	2.56	0.85	0.59	0.81	6.71	17.40	0.72	0.17	0.27	1.06	0.20	0.42	0.21	0.05	99.99
CO121C	68.62	0.10	2.53	0.75	0.67	0.77	6.38	17.44	0.62	0.13	0.26	1.04	0.19	0.32	0.17	0.01	99.99
CO121C	68.14	0.09	2.63	0.87	0.68	0.79	6.43	17.42	0.63	0.13	0.24	1.10	0.20	0.34	0.19	0.10	99.97
CO121C	68.17	0.11	2.60	0.79	0.58	0.75	6.68	17.46	0.65	0.15	0.27	1.05	0.15	0.35	0.18	0.05	99.96
CO121D	66.57	0.13	2.40	0.92	0.81	0.94	6.70	17.76	0.72	0.18	0.33	1.06	0.34	0.62	0.39	0.07	99.93
CO121D	67.02	0.12	2.48	1.02	0.79	0.90	6.64	17.39	0.72	0.14	0.33	1.02	0.34	0.56	0.39	0.04	99.89
CO121D	66.83	0.13	2.49	1.00	0.76	0.93	6.73	17.37	0.67	0.16	0.35	1.06	0.31	0.66	0.48	0.02	99.95
CO121D	66.77	0.14	2.53	1.08	0.85	0.95	6.71	17.33	0.69	0.18	0.31	1.04	0.40	0.52	0.40	0.03	99.93
CO121D	66.99	0.14	2.43	0.96	0.85	0.90	6.86	17.24	0.76	0.19	0.28	1.05	0.32	0.48	0.42	0.03	99.91
CO121D	66.91	0.14	2.52	1.03	0.82	0.95	6.86	17.16	0.72	0.15	0.33	1.05	0.36	0.57	0.43	0.06	100.06
CO121D	66.58	0.14	2.62	1.09	0.84	0.97	7.03	17.06	0.66	0.17	0.29	1.10	0.37	0.64	0.44	0.05	100.04
CO121E	67.20	0.10	2.25	0.67	0.39	0.94	6.13	19.72	0.45	0.00	0.35	1.39	0.00	0.01	0.28	0.00	99.87
CO121E	67.26	0.08	2.27	0.71	0.38	1.02	6.13	19.64	0.43	0.03	0.32	1.33	0.01	0.00	0.33	0.00	99.95
CO121E	67.69	0.13	2.37	0.61	0.39	0.99	6.21	19.16	0.43	0.05	0.35	1.32	0.00	0.00	0.28	0.00	99.98
CO121E	67.49	0.12	2.26	0.68	0.38	1.01	6.13	19.53	0.41	0.07	0.35	1.33	0.00	0.01	0.27	0.00	100.05
CO121E	67.76	0.11	2.26	0.60	0.37	0.98	6.23	19.22	0.43	0.03	0.34	1.34	0.00	0.00	0.27	0.00	99.95
CO122	67.57	0.09	2.29	0.92	0.63	0.87	6.98	17.28	0.68	0.11	0.35	0.65	0.31	0.29	0.90	0.00	99.92
CO122	67.63	0.08	2.32	0.90	0.62	0.77	6.88	17.39	0.66	0.13	0.33	0.59	0.34	0.28	0.95	0.03	99.89
CO122	67.56	0.06	2.42	0.98	0.57	1.15	6.38	17.41	0.73	0.12	0.32	0.86	0.34	0.29	0.82	0.01	100.03
CO122	67.79	0.06	2.32	0.80	0.61	0.83	6.90	17.53	0.68	0.10	0.33	0.57	0.32	0.28	0.87	0.00	99.98
CO122	67.36	0.10	2.26	0.90	0.65	0.90	6.77	17.47	0.74	0.11	0.36	0.77	0.32	0.26	0.84	0.02	99.83
CO184A	67.46	0.12	2.57	1.00	0.66	1.03	6.84	17.35	0.83	0.13	0.26	0.39	0.35	0.61	0.33	0.10	100.01
CO184A	66.94	0.10	2.64	1.05	0.72	1.04	6.79	17.31	0.84	0.18	0.26	0.92	0.17	0.64	0.27	0.07	99.93
CO184A	67.22	0.12	2.62	0.98	0.69	1.12	6.78	17.30	0.80	0.15	0.27	0.71	0.29	0.57	0.30	0.08	99.99
CO184A	67.54	0.12	2.63	1.02	0.65	1.06	6.85	17.20	0.79	0.14	0.22	0.78	0.20	0.61	0.24	0.05	100.09
CO184A	67.08	0.17	2.62	1.05	0.69	1.11	6.77	17.28	0.86	0.13	0.29	0.64	0.26	0.56	0.27	0.09	99.87
CO184B	67.29	0.09	2.39	0.87	0.76	0.91	6.89	17.63	0.56	0.14	0.29	1.10	0.29	0.57	0.29	0.00	100.05
CO184B	67.19	0.06	2.43	0.80	0.74	0.95	6.72	17.96	0.56	0.08	0.33	1.08	0.31	0.47	0.28	0.04	99.98
CO184B	67.09	0.14	2.46	0.92	0.70	0.95	6.68	17.89	0.60	0.12	0.31	1.02	0.28	0.52	0.33	0.03	100.01
CO184B	67.49	0.12	2.48	0.96	0.72	0.86	6.47	17.89	0.56	0.07	0.30	1.11	0.27	0.48	0.28	0.00	100.05
CO184B	67.24	0.12	2.48	0.94	0.71	0.82	6.43	18.01	0.55	0.15	0.32	1.19	0.23	0.44	0.33	0.00	99.95
CO184B	67.37	0.09	2.44	0.82	0.74	0.86	6.39	17.89	0.63	0.09	0.29	1.19	0.30	0.44	0.32	0.02	99.89
CO184B	67.36	0.13	2.49	0.90	0.72	0.92	6.67	17.46	0.54	0.10	0.33	1.10	0.28	0.49	0.35	0.02	99.85
CO184C	66.46	0.16	2.52	1.11	0.76	1.25	6.25	17.90	0.69	0.18	0.27	1.00	0.30	0.65	0.35	0.06	99.88
CO184C	66.73	0.12	2.46	1.10	0.80	1.16	6.41	17.83	0.67	0.12	0.27	1.00	0.27	0.67	0.41	0.03	100.03
CO184C	66.87	0.12	2.49	1.05	0.79	1.09	6.57	17.69	0.65	0.17	0.28	1.01	0.25	0.54	0.32	0.04	99.93
CO184C	67.51	0.12	2.37	0.81	0.71	0.83	6.36	18.25	0.68	0.08	0.32	1.14	0.25	0.37	0.22	0.05	100.06
CO184C	67.14	0.11	2.28	0.89	0.67	0.93	6.92	18.00	0.74	0.17	0.29	0.89	0.31	0.39	0.34	0.03	100.10
CO184C	66.67	0.16	2.51	0.91	0.78	0.99	6.59	17.91	0.69	0.14	0.31	1.02	0.30	0.59	0.35	0.04	99.96
CO230 db1	71.64	0.08	2.80	0.68	0.04	0.72	6.69	15.20	0.65	0.08	0.16	0.96	0.06	0.00	0.08	0.05	99.88
CO230 db2	71.77	0.09	2.80	0.53	0.15	0.86	6.67	15.31	0.59	0.10	0.14	0.84	0.03	0.10	0.08	0.03	100.08
CO230 db3	71.09	0.08	2.72	0.62	0.14	0.66	6.86	15.73	0.59	0.10	0.15	0.90	0.10	0.12	0.10	0.01	99.96
CO230 db4	71.46	0.08	2.72	0.60	0.13	0.81	6.66	15.36	0.66	0.08	0.14	0.88	0.05	0.18	0.04	0.05	99.88
CO230 db5	71.32	0.10	2.67	0.70	0.17	0.77	6.68	15.54	0.60	0.09	0.17	0.88	0.01	0.16	0.08	0.01	99.98
CO230 db6	71.35	0.10	2.85	0.84	0.06	0.65	6.50	15.45	0.66	0.09	0.14	0.90	0.04	0.17	0.10	0.03	99.91
CO230 db7	71.54	0.10	2.70	0.65	0.14	0.76	6.61	15.43	0.61	0.11	0.15	0.89	0.02	0.18	0.10	0.04	100.01
CO230 db8	71.79	0.08	2.80	0.56	0.08	0.73	6.69	15.36	0.65	0.07	0.14	0.90	0.03	0.09	0.08	0.01	100.06
CO230 db9	71.38	0.10	2.74	0.75	0.13	0.78	6.63	15.34	0.61	0.06	0.19	0.87	0.08	0.21	0.05	0.06	99.96
CO230 db10	71.56	0.11	2.75	0.60	0.08	0.64	6.69	15.42	0.58	0.08	0.11	0.94	0.07	0.14	0.06	0.02	99.83
CO230 lb1	71.34	0.07	2.67	0.51	0.17	0.65	6.47	15.52	0.69	0.11	0.17	0.94	0.15	0.34	0.05	0.09	99.95
CO230 lb2	70.99	0.05	2.69	0.58	0.12	0.63	6.58	15.88	0.63	0.09	0.15	0.92	0.09	0.34	0.05	0.10	99.90
CO230 lb3	70.93	0.11	2.63	0.60	0.15	0.65	6.70	15.70	0.62	0.11	0.19	0.86	0.08	0.47	0.05	0.09	99.95
CO230 lb4	70.97	0.09	2.69	0.61	0.17	0.67	6.46	15.57	0.68	0.07	0.17	0.98	0.13	0.52	0.12	0.12	100.01
CO230 lb5	70.52	0.09	2.63	0.60	0.26	0.73	6.81	15.53	0.63	0.07	0.20	0.93	0.09	0.54	0.15	0.17	99.95
CO230 lb6	69.69	0.13	2.60	0.60	0.21	0.77	7.03	16.18	0.61	0.10	0.21	0.93	0.07	0.56	0.10	0.15	99.92
CO230 lb7	69.77	0.14	2.62	0.68	0.25	0.72	6.83	16.04	0.65	0.16	0.23	0.96	0.07	0.58	0.11	0.17	99.98
CO230 lb8	70.51	0.03	2.70	0.63	0.17	0.66	6.68	15.99	0.62	0.08	0.20	0.91	0.07	0.59	0.07	0.14	100.05
CO230 lb9	70.59	0.09	2.87	0.64	0.13	0.63	6.27	16.09	0.66	0.05	0.14	0.89	0.05	0.60	0.07	0.19	99.97
CO230 lb10	69.80	0.08	2.62	0.72	0.20	0.68	6.73	16.13	0.62	0.14	0.22	0.97	0.09	0.67	0.14	0.18	99.99
CO233A	69.90	0.28	2.58	0.90	0.18	0.67	9.46	14.52	0.42	0.08	0.07	1.03	0.00	0.01	0.00	0.00	100.07
CO233A	70.06	0.30	2.49	0.92	0.17	0.68	9.40	14.41	0.41	0.11	0.05	1.04	0.00	0.00	0.00	0.00	100.04
CO233A	69.64	0.29	2.57	0.89	0.20	0.71	9.33	14.68	0.39	0.16	0.06	1.04	0.01	0.01	0.00	0.00	99.98
CO233A	69.90	0.28	2.49	0.88	0.20	0.69	9.30	14.58	0.44	0.11	0.08	1.09	0.00	0.00	0.00	0.00	100.03
CO233A	69.89	0.23	2.57	0.96	0.19	0.73	9.30	14.45	0.41	0.09	0.08	1.06	0.00	0.00	0.00	0.00	99.95
CO233A	70.08	0.27	2.48	0.91	0.19	0.72	9.30	14.45	0.39	0.07	0.11	1.06	0.01	0.01	0.00	0.00	100.04
CO233A	70.16	0.24	2.49	0.87	0.14	0.68	9.27	14.48	0.45	0.10	0.08	1.02	0.00	0.00	0.00	0.00	99.98
CO233B	68.77	0.09	2.53	1.82	1.12	0.98	6.53	16.22	0.62	0.14	0.30	0.81	0.00	0.00	0.00	0.00	99.91
CO233B	68.57	0.10	2.55	1.76	1.13	1.03	6.84	16.15	0.60	0.12	0.27	0.81	0.00	0.00	0.01	0.00	99.95
CO233B	68.36	0.19	2.59	1.83	1.04	1.00	6.72	16.33	0.60	0.13	0.26	0.83	0.02	0.00	0.04	0.00	99.93
CO233B	68.55	0.16	2.50	1.76	1.26	1.02	6.69	16.16	0.61	0.12	0.30	0.80	0.01	0.00	0.02	0.00	99.96
CO233B	68.45	0.12	2.59	1.68	1.24	1.06	6.79	16.20	0.63	0.11	0.26	0.83	0.00	0.00	0.02	0.00	99.97
CO233B	68.55	0.11	2.60	1.63	1.27	1.05	6.67	16.06	0.61	0.16	0.31	0.83	0.01	0.00	0.02	0.00	99.87
CO233B	68.45	0.17	2.59	1.63	1.11	1.05	6.66	16.43	0.61	0.13	0.28	0.81	0.00	0.00	0.04	0.00	99.96
CO233B	68.57	0.14	2.58	1.62	1.09	0.97	6.83	16.20	0.63	0.13	0.27	0.82	0.02	0.01	0.04	0.00	99.90
CO233B	68.72	0.17	2.54	1.83	1.14	1.02	6.64	16.16	0.57	0.11	0.25	0.83	0.02	0.02	0.02	0.00	100.02
CO233B	68.51	0.16	2.59	1.77	1.01	0.94	6.77	16.21	0.60	0.15	0.28	0.85	0.01	0.02	0.00	0.00	99.87

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO233B	68.33	0.21	2.51	1.73	1.11	0.97	6.90	16.31	0.66	0.12	0.25	0.84	0.01	0.03	0.00	0.00	99.98
CO233B	68.46	0.13	2.51	1.78	1.25	1.00	6.79	16.21	0.64	0.16	0.27	0.82	0.00	0.03	0.05	0.00	100.09
CO233B	68.56	0.13	2.56	1.89	1.14	0.96	6.73	16.11	0.61	0.10	0.28	0.82	0.03	0.03	0.00	0.00	99.94
CO233B	68.39	0.13	2.52	1.80	1.28	0.95	6.63	16.14	0.64	0.16	0.30	0.99	0.00	0.04	0.03	0.03	100.02
CO233B	68.63	0.17	2.54	1.76	1.06	0.99	6.78	16.21	0.59	0.09	0.26	0.80	0.01	0.04	0.02	0.00	99.94
CO233B	68.47	0.17	2.54	1.84	1.22	1.08	6.72	15.91	0.59	0.12	0.27	0.84	0.05	0.04	0.03	0.00	99.89
CO233B	68.20	0.17	2.64	1.66	1.05	1.13	6.90	16.24	0.63	0.14	0.27	0.83	0.04	0.05	0.05	0.02	100.03
CO233C	66.06	0.10	2.44	1.13	0.85	1.05	7.40	17.49	0.81	0.21	0.34	0.92	0.29	0.39	0.51	0.06	100.04
CO233C	66.12	0.12	2.43	1.09	0.79	0.98	7.22	17.60	0.77	0.21	0.29	0.84	0.29	0.55	0.52	0.06	99.88
CO233C	66.33	0.12	2.39	1.17	0.78	0.93	7.35	17.34	0.82	0.20	0.31	0.89	0.29	0.48	0.36	0.08	99.83
CO233C	66.26	0.13	2.40	1.09	0.80	1.02	7.36	17.37	0.80	0.20	0.29	0.87	0.31	0.49	0.51	0.05	99.92
CO233C	66.31	0.14	2.36	1.17	0.83	0.93	7.30	17.38	0.79	0.23	0.32	0.89	0.29	0.50	0.41	0.07	99.90
CO233C	66.40	0.14	2.37	1.05	0.77	1.05	7.25	17.28	0.75	0.20	0.31	0.87	0.32	0.53	0.50	0.06	99.85
CO233C	66.13	0.14	2.50	1.19	0.78	1.00	7.30	17.30	0.76	0.25	0.31	0.90	0.28	0.53	0.49	0.08	99.94
CO233C	66.55	0.08	2.41	1.02	0.66	0.92	7.34	17.36	0.79	0.18	0.31	0.82	0.29	0.55	0.54	0.05	99.85
CO233C	67.07	0.13	2.43	1.04	0.75	1.00	7.10	17.09	0.80	0.20	0.26	0.85	0.33	0.46	0.47	0.07	100.04
CO233C	66.21	0.14	2.46	1.11	0.82	1.09	7.51	17.01	0.76	0.31	0.36	0.83	0.35	0.58	0.41	0.12	100.08
CO233C	66.16	0.15	2.39	1.11	0.83	1.01	7.59	17.31	0.78	0.26	0.33	0.92	0.29	0.57	0.27	0.08	100.04
CO233C	66.44	0.14	2.36	1.06	0.77	1.01	7.41	17.12	0.76	0.18	0.32	0.89	0.33	0.57	0.51	0.14	100.00
CO233C	66.55	0.09	2.49	1.08	0.79	0.97	7.09	17.41	0.74	0.21	0.33	0.90	0.26	0.46	0.46	0.05	99.88
CO233C	66.26	0.17	2.48	1.13	0.77	1.01	7.20	17.29	0.78	0.25	0.36	0.90	0.28	0.58	0.49	0.09	100.04
CO233C	66.10	0.08	2.50	1.12	0.75	1.09	7.26	17.20	0.78	0.26	0.32	0.92	0.32	0.59	0.52	0.07	99.89
CO233C	66.29	0.12	2.47	1.14	0.78	0.99	7.29	17.21	0.74	0.24	0.34	0.86	0.26	0.55	0.50	0.07	99.86
CO325 db1	66.94	0.23	3.33	1.25	0.55	1.28	6.89	16.17	0.91	0.18	0.17	0.63	0.34	0.81	0.11	0.11	99.90
CO325 db2	67.03	0.12	2.68	1.07	0.58	1.07	7.30	16.45	0.89	0.17	0.27	0.82	0.25	0.94	0.22	0.08	99.94
CO325 db3	67.14	0.12	2.61	0.92	0.56	1.03	7.32	16.86	0.84	0.16	0.24	0.79	0.28	0.96	0.14	0.09	100.03
CO325 db4	67.29	0.17	2.59	1.16	0.59	1.67	6.85	16.43	0.88	0.17	0.20	0.57	0.24	0.98	0.17	0.07	100.00
CO325 lb1	67.25	0.18	2.57	0.88	0.59	1.01	7.41	16.41	0.85	0.20	0.25	0.78	0.27	1.01	0.12	0.24	99.98
CO325 lb2	67.23	0.13	2.64	0.95	0.57	1.08	7.43	16.40	0.83	0.19	0.23	0.83	0.26	1.03	0.17	0.00	99.95
CO325 lb3	66.86	0.14	2.64	1.39	0.53	1.94	6.63	16.54	0.86	0.18	0.22	0.68	0.23	1.09	0.10	0.00	100.04
CO325 lb4	66.88	0.12	2.69	0.90	0.58	1.22	7.44	16.55	0.83	0.20	0.23	0.80	0.24	1.07	0.19	0.00	99.94
CO325 lb5	66.30	0.13	2.46	0.95	0.65	1.01	7.27	16.85	0.82	0.18	0.28	0.86	0.26	1.37	0.13	0.34	99.87
CO325 lb6	67.02	0.14	2.60	1.00	0.58	1.12	7.31	16.43	0.80	0.23	0.24	0.81	0.28	1.06	0.10	0.20	99.93
CO325 lb7	66.56	0.12	2.63	0.94	0.58	1.29	7.30	16.68	0.93	0.17	0.22	0.79	0.25	1.12	0.19	0.21	99.97
CO325 lb8	67.29	0.16	2.66	0.99	0.52	1.00	7.25	16.22	0.82	0.19	0.25	0.86	0.30	1.06	0.20	0.24	100.00
CO325 lb9	66.94	0.15	2.58	0.92	0.51	1.01	7.22	16.50	0.87	0.19	0.26	0.84	0.27	1.15	0.20	0.26	99.86
CO325 lb10	67.13	0.15	2.76	0.90	0.55	1.12	7.15	16.47	0.85	0.19	0.27	0.80	0.26	1.15	0.11	0.23	100.08
CO325 lb11	66.12	0.15	2.59	1.06	0.56	0.98	7.37	16.58	0.82	0.22	0.33	0.89	0.31	1.49	0.13	0.43	100.03
CO365 db1	73.29	0.08	3.04	0.41	0.02	0.56	6.82	14.08	0.55	0.07	0.15	0.81	0.08	0.08	0.01	0.00	100.05
CO365 db2	73.27	0.07	2.86	0.44	0.07	0.60	6.86	14.04	0.58	0.08	0.14	0.78	0.04	0.08	0.01	0.07	99.98
CO365 db3	73.25	0.05	2.95	0.39	0.01	0.58	6.85	14.40	0.53	0.03	0.16	0.77	0.04	0.01	0.05	0.02	100.09
CO365 db4	73.34	0.08	2.99	0.46	0.05	0.56	6.65	14.24	0.53	0.05	0.16	0.76	0.04	0.08	0.02	0.00	100.01
CO365 db5	73.14	0.07	3.10	0.36	0.00	0.55	6.74	14.26	0.58	0.04	0.14	0.81	0.02	0.04	0.00	0.01	99.84
CO365 db6	73.31	0.09	3.02	0.39	0.02	0.52	6.78	14.33	0.49	0.07	0.12	0.76	0.00	0.05	0.00	0.00	99.96
CO365 db7	73.22	0.05	2.88	0.45	0.05	0.58	6.87	14.18	0.54	0.08	0.13	0.79	0.06	0.03	0.06	0.00	99.95
CO365 lb1	72.60	0.08	2.92	0.50	0.12	0.68	6.84	14.25	0.53	0.07	0.17	0.82	0.08	0.21	0.07	0.05	99.97
CO365 lb2	72.86	0.06	2.89	0.46	0.06	0.73	6.62	14.44	0.53	0.06	0.12	0.79	0.05	0.24	0.01	0.02	99.94
CO365 lb3	71.95	0.11	3.32	0.75	0.10	0.72	6.84	14.25	0.47	0.09	0.16	0.73	0.05	0.39	0.00	0.15	100.07
CO365 lb4	72.61	0.09	2.97	0.46	0.04	0.66	6.82	14.50	0.56	0.07	0.13	0.81	0.04	0.19	0.07	0.02	100.02
CO365 lb5	72.21	0.06	2.90	0.50	0.07	0.63	6.76	14.75	0.52	0.05	0.15	0.87	0.04	0.28	0.08	0.08	99.95
CO365 lb6	71.74	0.13	3.10	0.61	0.14	0.77	6.92	14.54	0.48	0.10	0.17	0.75	0.05	0.31	0.07	0.16	100.04
CO366	69.12	0.13	2.79	0.60	0.34	0.93	7.95	15.99	0.77	0.13	0.18	0.80	0.06	0.14	0.07	0.06	100.04
CO366	69.71	0.08	2.85	0.59	0.31	0.91	7.88	15.70	0.75	0.16	0.18	0.77	0.00	0.17	0.05	0.00	100.09
CO366	68.88	0.12	2.82	0.71	0.39	0.96	7.95	15.91	0.77	0.15	0.20	0.81	0.07	0.10	0.05	0.00	99.88
CO366	69.68	0.12	2.83	0.57	0.26	0.92	7.99	15.37	0.75	0.12	0.18	0.80	0.11	0.12	0.02	0.02	99.87
CO366	68.42	0.11	2.75	0.56	0.27	0.96	8.97	16.03	0.73	0.18	0.16	0.71	0.05	0.12	0.06	0.00	100.07
CO366	69.14	0.10	2.63	0.75	0.38	1.05	7.67	15.82	0.84	0.20	0.23	0.80	0.07	0.09	0.05	0.00	99.80
CO366	69.78	0.09	2.79	0.62	0.29	0.97	7.80	15.61	0.76	0.10	0.20	0.78	0.04	0.13	0.03	0.00	99.98
CO366	69.17	0.14	2.84	0.70	0.42	0.89	7.65	15.74	0.86	0.18	0.20	0.80	0.12	0.11	0.06	0.08	99.94
CO368	72.57	0.09	3.07	0.38	0.00	0.49	6.80	15.09	0.54	0.06	0.12	0.76	0.00	0.00	0.00	0.00	99.96
CO368	72.02	0.09	3.18	0.32	0.01	0.49	6.99	15.39	0.50	0.05	0.15	0.83	0.00	0.00	0.00	0.02	100.03
CO368	72.10	0.06	3.15	0.40	0.00	0.46	7.04	15.16	0.52	0.01	0.11	0.87	0.00	0.00	0.00	0.00	99.86
CO368	71.85	0.07	3.15	0.37	0.03	0.49	7.03	15.41	0.56	0.03	0.10	0.91	0.01	0.00	0.00	0.00	99.98
CO368	72.12	0.04	3.19	0.43	0.02	0.51	6.95	15.17	0.45	0.03	0.10	0.90	0.00	0.01	0.00	0.00	99.91
CO368	72.34	0.06	3.09	0.41	0.02	0.45	6.98	14.98	0.47	0.07	0.12	0.88	0.00	0.00	0.00	0.00	99.86
CO368	72.51	0.06	3.07	0.30	0.00	0.46	6.97	15.10	0.53	0.03	0.12	0.88	0.00	0.00	0.00	0.00	100.03
CO530 db1	67.51	0.11	2.90	0.94	0.37	0.89	8.09	14.83	0.85	0.14	0.14	0.79	0.82	1.32	0.05	0.19	99.91
CO530 db2	67.83	0.10	3.03	0.85	0.40	0.80	7.45	14.71	0.93	0.13	0.10	0.75	0.84	1.83	0.07	0.09	99.89
CO530 db3	69.27	0.05	3.03	0.63	0.18	0.70	7.37	14.82	0.90	0.06	0.13	0.73	0.82	0.97	0.06	0.29	100.00
CO530 mb1	65.72	0.10	2.74	1.33	0.55	1.00	7.55	14.57	0.85	0.17	0.19	0.74	0.87	2.58	0.05	0.91	99.90
CO530 mb2	65.92	0.12	2.72	1.32	0.56	1.01	7.59	14.88	0.79	0.12	0.21	0.75	0.89	2.49	0.03	0.53	99.92
CO530 mb3	65.70	0.12	2.87	1.32	0.62	1.10	7.68	14.78	0.87	0.14	0.18	0.71	0.81	2.28	0.03	0.77	99.97
CO530 mb4	65.56	0.11	2.68	1.33	0.63	0.94	7.62	14.80	0.91	0.15	0.21	0.74	0.92	2.37	0.06	1.00	100.03
CO530 mb5	65.88	0.11	2.78	1.28	0.53	0.94	7.50	14.81	0.87	0.19	0.18	0.73	0.89	2.48	0.06	0.64	99.88
CO530 mb6	66.27	0.12	2.78	1.26	0.58	0.97	7.44	15.09	0.82	0.17	0.18	0.73	0.87	2.45	0.06	0.29	100.08
CO530 mb7	65.77	0.13	2.86	1.45	0.65	1.07	7.58	14.31	0.84	0.17	0.20	0.70	0.93	2.58	0.04	0.66	99.93

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	CuO	PbO	Sb_2O_5	SnO_2	Total
CO530 lb1	64.80	0.14	2.84	1.24	0.62	0.98	7.72	15.33	0.84	0.16	0.18	0.76	0.94	2.62	0.02	0.77	99.96
CO530 lb2	65.85	0.13	2.82	1.30	0.60	1.06	7.53	14.50	0.83	0.18	0.21	0.73	0.93	2.61	0.07	0.74	100.08
CO530 lb3	66.02	0.14	2.75	1.36	0.59	0.93	7.42	14.98	0.87	0.19	0.17	0.74	0.94	2.62	0.04	0.33	100.09
CO530 lb4	65.08	0.12	2.77	1.46	0.60	1.04	7.68	15.14	0.83	0.18	0.21	0.74	0.94	2.64	0.03	0.45	99.89
CO530 lb5	65.65	0.14	2.73	1.27	0.58	0.95	7.56	14.60	0.90	0.21	0.21	0.72	0.94	2.63	0.01	0.99	100.07
CO530 lb6	65.15	0.09	2.74	1.42	0.62	0.97	7.48	14.96	0.86	0.21	0.18	0.75	0.97	2.71	0.03	0.78	99.92
CO530 lb7	65.98	0.09	2.78	1.22	0.59	1.03	7.50	14.84	0.84	0.23	0.16	0.72	0.93	2.56	0.09	0.48	100.03
CO530 lb8	65.86	0.11	2.77	1.27	0.57	1.05	7.49	14.79	0.86	0.19	0.20	0.72	0.91	2.50	0.02	0.65	99.95
CO530 lb9	64.69	0.12	2.73	1.43	0.60	0.98	7.73	14.97	0.81	0.20	0.21	0.71	0.95	2.86	0.00	1.04	100.02
CO530 lb10	65.66	0.14	2.85	1.32	0.65	0.97	7.46	14.91	0.83	0.18	0.19	0.75	0.97	2.60	0.05	0.55	100.08
CO530 lb11	65.78	0.14	2.81	1.39	0.56	0.99	7.52	14.88	0.79	0.22	0.20	0.74	0.96	2.68	0.08	0.37	100.09
CO530 wb1	62.47	0.15	2.75	1.58	0.66	1.04	7.55	15.22	0.81	0.28	0.22	0.71	1.59	3.62	0.04	1.19	99.89
CO530 wb2	62.37	0.15	2.68	1.87	0.61	0.99	7.56	14.83	0.80	0.31	0.23	0.73	1.04	4.62	0.03	1.11	99.91
CO530 wb3	62.22	0.16	2.78	2.72	0.57	1.12	7.36	14.93	0.79	0.23	0.21	0.71	1.04	3.96	0.02	1.08	99.89
CO530 wb4	62.39	0.11	2.65	1.74	0.57	0.91	7.01	14.69	0.85	0.23	0.20	0.71	1.28	4.92	0.04	1.76	100.04
CO530 wb5	62.66	0.14	2.67	1.75	0.57	0.94	7.36	14.55	0.74	0.26	0.23	0.74	1.02	4.41	0.02	1.88	99.93

Table S5. LA-ICP-MS: full data set. All values in ppm.

	CO23A				CO23B				CO25				
Li	9.2	<2.30	7.7	6.5	4.7	6.8	3.7	5.7	5.1	4.5	2.4	4.2	5.2
Be	3.9	5.6	3.6	<0.00	6.3	3.1	3.7	<2.90	3.4	<2.56	<0.00	<3.05	<3.11
B	127	126	119	109	60	58	50	53	164	143	195	185	154
Sc	4.3	4.4	3.9	4.0	2.5	2.6	3.0	2.3	2.6	2.6	2.4	2.5	2.3
Ti	874	922	884	885	468	409	434	407	422	455	417	454	464
V	23	25	23	23	8	8	8	7	17	18	17	18	16
Cr	35	42	33	41	9	9	13	12	11	9	9	9	12
Co	24	23	21	24	1	1	1	1	6	6	5	6	5
Ni	26	32	29	33	3	3	3	4	6	5	6	5	6
Cu	876	872	875	917	5	5	5	7	21	22	22	21	34
Zn	103	98	104	103	6	6	5	5	10	9	9	8	10
Ga	3.9	3.0	3.1	3.6	2.7	3.1	3.3	2.9	1.8	2.0	1.8	2.0	2.0
Ge	<0.91	<1.07	1.0	<0.91	<0.61	<0.61	0.8	0.5	1.0	1.1	<0.46	1.8	0.7
As	11.5	12.0	11.3	12.7	1.6	0.9	0.8	0.8	6.1	6.6	7.0	6.3	6.6
Rb	10.5	10.8	10.2	11.2	9.3	9.0	9.5	8.9	4.5	4.9	4.7	5.2	4.8
Sr	529	544	526	543	330	315	338	312	423	427	413	426	425
Y	8.2	9.1	7.9	8.2	6.2	5.7	5.6	5.5	5.2	5.2	4.9	5.6	5.5
Zr	87.1	92.9	84.1	87.5	40.4	38.2	40.1	36.6	42.3	42.0	41.1	44.2	41.9
Nb	2.35	2.91	2.44	2.22	1.48	1.38	1.77	1.41	1.45	1.30	1.23	1.37	1.34
Mo	1.70	1.89	1.31	2.29	0.41	0.28	0.36	0.34	0.50	0.51	0.78	0.12	0.35
Ag	1.41	1.13	1.78	1.51	0.04	<0.089	<0.065	3.79	0.08	0.22	<0.051	<0.033	<0.059
Cd	<0.60	<0.60	<0.45	<0.47	<0.34	<0.31	<0.39	<0.190	<0.163	<0.34	0.28	0.45	0.42
In	1.96	2.01	1.92	2.13	<0.0170	<0.0152	0.04	<0.0163	<0.0140	<0.0084	0.02	<0.0141	<0.0143
Sn	514	572	462	535	1	2	2	2	2	2	2	2	2
Sb	861	968	869	998	1	<0.28	<0.32	<0.224	228	226	228	229	231
Cs	0.224	0.175	0.123	0.139	0.096	0.080	0.110	0.081	0.060	0.067	0.040	0.060	0.057
Ba	313	319	308	310	214	200	209	199	403	407	394	398	398
La	8.162	8.344	7.898	7.766	5.984	5.435	5.774	5.615	5.597	5.336	5.386	5.336	5.587
Ce	13.241	13.951	14.123	13.363	11.499	10.670	11.379	10.899	9.345	10.199	9.044	9.295	9.426
Pr	1.888	1.729	1.732	1.762	1.372	1.341	1.321	1.333	1.123	1.118	1.145	1.122	1.120
Nd	8.679	8.881	6.773	8.141	5.684	6.304	6.034	5.525	4.833	4.934	5.024	4.853	4.783
Sm	1.328	1.338	1.997	1.805	1.229	1.109	1.339	0.979	1.005	0.794	1.015	1.246	1.035
Eu	0.458	0.550	0.547	0.382	0.387	0.420	0.466	0.320	0.254	0.304	0.257	0.340	0.116
Gd	1.237	1.744	1.156	1.105	0.999	0.899	1.019	1.049	0.894	0.773	0.645	0.995	0.784
Tb	0.251	0.259	0.208	0.211	0.140	0.154	0.189	0.194	0.165	0.149	0.167	0.116	0.105
Dy	1.490	1.724	1.024	0.963	0.803	0.803	1.119	0.900	0.916	1.045	1.024	0.796	0.855
Ho	0.259	0.330	0.323	0.308	0.183	0.216	0.163	0.170	0.177	0.141	0.244	0.181	0.224
Er	0.740	0.824	0.670	0.602	0.440	0.353	0.480	0.507	0.361	0.384	0.389	0.537	0.353
Tm	0.085	0.076	0.119	0.103	0.098	0.054	0.101	0.058	0.107	0.064	0.101	0.112	0.121
Yb	0.649	0.923	0.413	0.649	0.265	0.468	0.679	0.587	0.424	0.525	0.440	0.251	0.764
Lu	0.157	0.134	0.134	0.169	0.034	<0.025	0.075	0.103	0.099	0.058	0.055	0.064	0.077
Hf	2.535	2.200	2.129	2.535	0.909	0.759	1.359	0.969	1.196	0.975	1.115	1.517	1.156
Ta	0.122	0.129	0.203	0.111	0.070	0.101	0.061	0.071	0.060	0.047	0.086	0.046	0.087
W	0.403	0.459	0.562	0.345	<0.091	0.131	<0.103	<0.082	0.090	0.288	0.066	0.097	<0.063
Au	0.557	0.343	0.363	0.438	0.018	<0.037	0.041	<0.032	<0.028	0.040	<0.036	0.038	<0.035
Tl	0.030	0.076	0.073	0.076	<0.028	0.024	<0.044	<0.0153	0.009	0.037	<0.0246	0.009	0.025
Pb	4125	4085	3956	4137	6	6	6	6	15	16	16	16	19
Bi	0.298	0.612	0.468	0.290	0.060	<0.0207	0.037	0.036	<0.029	<0.025	<0.0177	<0.033	0.035
Th	1.467	1.534	1.467	1.315	0.736	0.650	0.846	0.713	0.787	0.807	0.539	0.894	0.773
U	1.014	1.114	1.156	1.114	0.660	0.491	0.780	0.752	0.829	0.705	0.805	0.781	0.781

	CO58				CO58B				CO58C					
Li	4.7	6.2	3.6	6.9	6.9	6.0	3.3	7.5	4.0	5.2	4.1	5.1	6.1	4.8
Be	<4.95	3.8	<3.03	<5.16	<4.78	<2.81	<3.07	<4.16	<5.09	2.8	-	<4.87	<7.18	5.5
B	78	87	68	109	159	139	136	143	49	58	71	71	52	53
Sc	3.9	3.8	3.1	2.6	3.4	3.6	3.8	4.0	3.2	3.9	3.3	4.4	3.8	3.8
Ti	690	667	660	555	755	810	907	901	491	544	547	583	511	519
V	15	15	15	16	22	24	25	27	10	12	12	13	11	10
Cr	21	22	16	14	14	23	25	25	32	51	43	53	47	45
Co	16	17	15	16	36	37	37	37	14	15	13	16	17	17
Ni	10	10	9	10	16	19	17	19	94	126	112	128	146	134
Cu	798	812	780	1602	1093	1157	1125	1122	102	123	114	109	95	90
Zn	127	45	40	190	129	139	143	157	32	40	42	44	34	32
Ga	2.9	3.5	3.1	2.7	3.0	3.0	2.9	2.9	3.2	2.8	3.5	3.5	2.8	3.4
Ge	<0.82	1.5	<0.77	<0.62	<0.75	1.4	1.0	1.6	1.0	<0.86	0.8	1.4	2.8	1.1
As	11.7	11.0	7.3	19.7	30.4	26.1	21.9	23.8	1.7	3.1	2.4	2.4	2.2	2.0
Rb	10.6	10.9	11.0	16.8	12.8	12.4	12.6	12.4	16.0	17.8	17.8	18.2	19.4	18.2
Sr	404	425	399	424	522	522	507	517	261	302	286	280	243	235
Y	6.4	7.3	6.6	5.8	7.4	7.7	7.0	7.7	6.4	6.3	6.2	7.0	6.4	6.3
Zr	55.3	61.8	55.7	50.8	68.5	72.2	81.0	82.5	47.7	50.6	47.4	50.6	53.0	53.2
Nb	1.80	1.71	1.85	1.84	3.43	2.37	2.27	2.35	1.86	1.55	1.59	2.04	1.57	1.55
Mo	0.54	0.87	0.70	0.57	1.60	2.16	2.01	1.86	0.33	0.33	0.37	0.25	<0.097	0.34
Ag	1.22	1.09	1.08	4.80	0.02	0.08	0.02	0.07	0.34	0.55	0.57	0.53	0.47	0.27
Cd	<0.52	<0.52	0.16	<0.52	<0.83	0.70	<0.33	0.59	0.18	0.16	0.31	<0.55	<0.65	<0.40
In	1.27	1.20	1.43	9.69	2.59	2.71	2.22	2.69	0.59	0.67	0.73	0.84	0.65	0.67
Sn	341	316	313	2378	687	664	623	697	168	197	207	217	158	152
Sb	1078	1037	976	1667	3296	2913	2179	2193	43	42	49	49	36	33
Cs	0.087	0.142	0.124	0.179	0.204	0.231	0.210	0.193	0.295	0.434	0.409	0.416	0.467	0.479
Ba	242	240	237	203	300	297	285	293	138	157	152	155	138	130
La	6.695	7.268	6.856	6.725	8.063	8.454	7.973	7.501	5.912	5.730	5.377	6.134	5.408	5.458
Ce	12.134	12.526	12.124	10.319	13.920	13.589	13.569	13.127	11.037	11.199	11.360	12.399	10.583	10.694
Pr	1.468	1.699	1.508	1.167	1.625	1.605	1.775	1.785	1.352	1.301	1.523	1.544	1.362	1.261
Nd	6.163	6.846	6.595	5.215	7.301	6.769	7.030	7.150	5.821	5.761	5.680	6.195	4.893	5.630
Sm	1.046	1.126	1.106	1.349	1.625	1.946	1.294	1.464	1.382	1.453	1.574	1.614	1.049	0.787
Eu	0.293	0.408	0.317	0.379	0.413	0.489	0.466	0.566	0.383	0.428	0.272	0.306	0.415	0.358
Gd	0.865	1.538	1.015	1.168	1.093	1.444	1.484	1.294	1.059	1.110	0.878	0.817	0.827	1.251
Tb	0.197	0.187	0.104	0.171	0.216	0.191	0.194	0.240	0.168	0.204	0.198	0.212	0.148	0.124
Dy	0.886	1.035	1.116	1.023	1.354	1.274	1.133	1.444	0.878	1.009	0.859	0.797	0.999	0.898
Ho	0.222	0.230	0.185	0.258	0.319	0.263	0.279	0.212	0.241	0.139	0.229	0.234	0.200	0.257
Er	0.635	0.855	0.509	0.799	0.739	0.558	0.769	0.824	0.684	0.718	0.693	0.601	0.726	0.680
Tm	0.089	0.131	0.069	0.052	0.069	0.125	0.116	0.128	0.051	0.093	0.076	0.080	0.079	0.052
Yb	0.653	0.623	0.653	0.695	0.622	0.572	0.589	1.073	0.696	0.542	0.585	0.656	0.736	0.535
Lu	0.118	0.087	0.096	0.093	0.128	0.079	0.160	0.119	0.049	0.082	0.065	0.093	0.060	0.104
Hf	1.558	1.337	0.975	1.218	1.855	1.855	2.036	1.494	1.463	1.322	1.180	1.735	0.999	1.180
Ta	0.078	0.061	0.136	0.085	0.128	0.106	0.095	0.139	0.104	0.144	0.075	0.085	0.114	0.102
W	0.375	0.318	0.338	0.325	0.643	0.852	0.613	0.872	0.063	0.108	<0.120	<0.136	0.224	<0.071
Au	0.607	0.585	0.694	6.574	0.515	0.802	0.842	0.560	0.101	0.524	0.179	0.475	0.429	0.169
Tl	0.027	<0.035	0.032	0.174	0.049	0.054	0.118	0.102	<0.033	<0.043	<0.042	<0.038	<0.045	<0.039
Pb	1818	2017	1741	15123	7233	6846	6203	5830	297	328	336	318	242	247
Bi	0.241	0.207	0.275	6.473	0.778	0.536	0.630	0.532	0.114	0.090	0.233	0.155	<0.066	0.103
Th	0.833	1.014	0.996	1.026	1.294	1.284	1.344	1.324	0.895	0.928	1.019	1.026	0.793	1.024
U	0.995	1.136	1.035	0.846	1.073	1.143	1.103	1.153	0.786	0.835	1.059	0.918	0.797	0.812

	CO88				CO92					CO94		
Li	6.9	<2.59	6.9	7.2	6.9	4.7	5.2	7.3	5.9	5.4	5.9	3.3
Be	<5.16	<4.24	<2.99	1.7	<2.99	4.4	<2.17	<1.93	2.7	<3.47	<7.76	<3.65
B	109	123	140	88	140	168	152	134	148	87	81	71
Sc	2.6	2.9	4.1	2.1	4.1	4.4	4.7	3.8	3.8	2.7	2.1	2.2
Ti	555	584	1079	523	1079	1075	1062	1041	1035	362	358	386
V	16	14	29	13	29	29	29	30	29	7	7	8
Cr	14	20	23	12	23	22	26	21	28	14	11	15
Co	16	17	73	16	73	72	71	71	68	1	1	1
Ni	10	12	28	12	28	28	27	27	29	6	3	5
Cu	1602	1743	3142	1498	3142	3245	3195	3130	3191	12	12	13
Zn	190	216	621	167	621	607	606	571	539	8	5	6
Ga	2.7	2.9	3.8	2.0	3.8	3.3	3.8	3.4	3.8	2.8	2.8	2.5
Ge	<0.62	0.8	1.1	<0.74	1.1	1.6	1.6	2.0	1.6	1.2	<0.79	1.1
As	19.7	23.3	38.6	16.4	38.6	39.1	43.0	41.6	40.0	1.0	1.0	<0.87
Rb	16.8	10.5	11.3	10.7	11.3	10.8	10.2	10.8	10.9	7.7	7.9	8.0
Sr	424	443	603	441	603	612	600	602	609	351	361	346
Y	5.8	6.4	8.1	6.3	8.1	8.8	8.1	8.4	9.0	5.3	5.6	5.5
Zr	50.8	53.8	95.7	52.8	95.7	95.0	104.7	113.1	91.5	39.1	36.2	37.6
Nb	1.84	1.53	2.93	1.45	2.93	2.86	2.84	2.87	2.77	1.39	1.35	1.21
Mo	0.57	0.92	2.14	0.93	2.14	2.62	2.04	2.50	1.99	0.25	<0.122	0.21
Ag	4.80	5.44	9.29	3.95	9.29	9.76	8.79	9.36	8.99	<0.065	<0.132	<0.083
Cd	<0.52	<0.64	<0.43	<0.33	<0.43	<0.39	<0.25	<0.22	<0.49	<0.57	0.92	<0.48
In	9.69	8.50	8.87	8.54	8.87	9.78	8.98	9.14	8.89	0.03	0.04	<0.0134
Sn	2378	2299	2890	2118	2890	2904	2849	2885	2845	2	2	2
Sb	1667	1878	3384	1360	3384	3515	3544	3243	3324	<0.54	-	-
Cs	0.179	0.211	0.170	0.254	0.170	0.230	0.179	0.177	0.247	0.061	0.108	0.059
Ba	203	216	336	204	336	333	327	330	323	175	180	177
La	6.725	7.188	8.998	6.614	8.998	8.827	8.386	8.486	8.556	5.684	5.311	5.724
Ce	10.319	20.668	15.026	12.222	15.026	14.565	14.615	14.455	14.635	10.914	9.876	10.511
Pr	1.167	1.388	1.986	1.255	1.986	1.816	1.826	1.986	1.856	1.240	1.270	1.199
Nd	5.215	6.534	8.346	5.779	8.346	8.225	7.694	7.543	8.085	5.452	5.522	5.129
Sm	1.349	1.158	1.575	1.158	1.575	1.775	1.545	1.595	1.515	1.068	1.149	1.139
Eu	0.379	0.395	0.453	0.356	0.453	0.504	0.375	0.442	0.391	0.290	0.350	0.308
Gd	1.168	1.057	1.465	1.369	1.465	2.046	1.354	1.555	1.575	0.907	0.887	1.149
Tb	0.171	0.199	0.250	0.127	0.250	0.266	0.270	0.198	0.255	0.148	0.180	0.115
Dy	1.023	1.399	1.364	1.349	1.364	1.174	1.304	1.775	1.595	0.967	1.078	0.897
Ho	0.258	0.235	0.293	0.190	0.293	0.304	0.322	0.314	0.277	0.188	0.266	0.173
Er	0.799	0.809	0.917	0.693	0.917	0.768	0.875	1.037	0.624	0.569	0.433	0.624
Tm	0.052	0.087	0.160	0.065	0.160	0.126	0.105	0.127	0.128	0.063	0.086	0.081
Yb	0.695	0.602	0.883	0.469	0.883	0.873	0.768	0.493	0.804	0.816	0.220	0.409
Lu	0.093	0.142	0.082	0.091	0.082	0.125	0.084	0.089	0.122	0.112	0.066	0.086
Hf	1.218	1.420	2.799	1.228	2.799	2.257	2.508	2.427	2.137	0.967	0.877	1.028
Ta	0.085	0.095	0.214	0.166	0.214	0.139	0.171	0.187	0.177	0.089	0.097	0.061
W	0.325	0.516	0.560	0.343	0.560	0.398	0.474	0.282	0.492	0.048	<0.074	0.126
Au	6.574	7.561	2.327	5.738	2.327	2.718	3.090	2.779	2.859	<0.045	<0.057	<0.080
Tl	0.174	0.233	0.328	0.162	0.328	0.270	0.186	0.225	0.232	0.062	<0.027	<0.044
Pb	15123	16830	17630	13483	17630	18162	17870	17635	17119	13	12	13
Bi	6.473	4.712	3.762	3.785	3.762	3.210	3.360	3.711	3.019	<0.032	<0.058	<0.054
Th	1.026	1.102	1.535	0.975	1.535	1.404	1.374	1.354	1.505	0.730	0.738	0.718
U	0.846	1.017	1.274	0.869	1.274	1.334	1.224	1.194	1.204	0.704	0.577	0.525

	CO95				CO96				CO99				CO100A db			
Li	2.2	3.8	4.1	4.1	7.9	9.0	4.9	5.4	2.3	6.9	5.0	2.0	7.3	6.8	8.6	5.4
Be	<6.90	1.8	1.6	<7.71	<5.77	<6.00	<3.65	<3.81	1.6	3.5	<8.15	<3.71	<2.21	<3.94	2.8	1.0
B	170	145	145	160	143	134	140	160	226	226	215	233	102	83	78	104
Sc	4.0	3.3	3.1	3.7	3.0	3.3	3.3	2.9	7.3	7.3	6.7	7.2	4.5	4.3	4.6	5.1
Ti	948	924	936	941	846	862	882	909	3342	3402	3459	3329	815	826	766	906
V	25	26	26	25	24	25	25	24	57	58	60	59	19	19	17	20
Cr	22	23	22	21	23	19	26	26	72	70	69	68	26	22	20	28
Co	36	27	28	28	41.3	43.7	41.0	45.3	16	16	17	17	25	23	19	29
Ni	15	15	15	14	19	22	25	26	19	18	17	16	21	19	21	133
Cu	1801	1775	1851	1792	2503	2513	2578	2721	86	83	85	83	2000	1815	1499	2486
Zn	78	67	76	72	134	177	228	207	30	30	31	28	105	151	144	280
Ga	3.3	3.2	2.8	2.8	3.0	3.2	3.2	3.3	4.6	4.0	4.4	4.9	3.1	3.8	3.0	3.8
Ge	1.7	2.0	1.3	0.8	<0.80	1.3	1.4	1.3	1.6	2.1	1.7	2.0	1.0	0.8	1.5	1.3
As	20.0	21.2	20.0	19.0	18.7	24.1	27.2	21.8	12.1	10.5	11.9	11.6	13.7	13.4	11.2	30.0
Rb	9.8	9.1	9.5	9.3	12.8	11.7	11.9	14.1	5.9	5.4	5.3	5.2	14.3	16.0	16.6	13.5
Sr	502	498	500	500	539	521	526	527	410	418	424	417	429	449	430	445
Y	8.1	8.0	8.1	7.8	7.7	7.5	7.6	8.2	12.2	13.1	13.3	13.2	7.6	7.7	7.9	7.5
Zr	94.5	92.5	92.5	90.9	80.7	82.1	84.8	86.1	297.4	296.2	298.5	298.7	67.4	71.1	67.9	74.8
Nb	2.43	2.25	2.18	2.32	2.44	2.48	2.53	2.35	5.75	6.34	5.99	5.89	2.10	2.60	2.07	2.40
Mo	1.99	1.65	1.86	2.34	2.32	2.83	2.63	1.98	3.24	3.75	3.25	4.57	1.02	1.13	0.91	1.52
Ag	2.15	1.85	2.06	1.75	2.73	3.04	2.98	2.74	<0.059	<0.046	0.06	<0.041	2.20	1.93	1.72	1.01
Cd	<0.46	0.73	<0.35	0.35	<0.48	<0.33	<0.49	0.10	<0.36	0.36	<0.47	<0.43	0.12	<0.59	<0.50	<0.61
In	1.48	1.30	1.53	1.50	2.72	3.78	4.01	3.46	<0.0216	<0.0171	0.03	0.05	2.35	2.73	2.11	6.30
Sn	408	354	373	388	675	969	1034	904	1	1	1	1	583	692	553	1620
Sb	1776	1714	1756	1732	1274	1317	1236	1223	-		1	<0.31	960	1001	762	1122
Cs	0.182	0.127	0.119	0.156	0.129	0.101	0.124	0.125	0.134	0.128	0.122	0.122	0.174	0.149	0.268	0.262
Ba	324	322	322	316	294	301	314	311	842	844	845	838	253	269	256	266
La	8.096	8.016	7.776	7.776	7.967	7.967	8.118	8.148	11.976	11.532	12.570	12.076	6.998	7.430	7.390	7.681
Ce	13.700	13.000	12.940	12.850	13.661	13.027	13.500	13.429	19.217	19.489	20.416	19.499	12.902	13.655	13.274	14.509
Pr	1.613	1.658	1.646	1.538	1.648	1.622	1.728	1.929	2.760	2.589	2.740	2.830	1.496	1.677	1.667	1.707
Nd	7.466	7.225	7.305	7.456	6.961	7.444	7.957	7.957	10.263	10.989	10.878	10.535	6.135	6.918	7.350	7.259
Sm	1.851	1.881	1.631	1.641	1.479	1.298	1.388	2.072	2.528	2.649	2.337	1.894	1.125	2.018	1.185	1.345
Eu	0.439	0.409	0.361	0.354	0.287	0.409	0.512	0.435	0.578	0.615	0.614	0.728	0.282	0.455	0.325	0.359
Gd	0.991	1.601	1.651	1.461	1.137	1.660	1.549	1.257	1.924	2.045	2.427	2.196	1.145	1.115	0.864	1.145
Tb	0.201	0.266	0.228	0.216	0.234	0.158	0.209	0.207	0.335	0.411	0.416	0.403	0.200	0.234	0.182	0.266
Dy	0.951	1.121	1.005	1.531	1.418	1.107	1.589	1.630	2.417	2.236	2.055	2.296	1.356	1.396	1.175	1.325
Ho	0.282	0.309	0.358	0.299	0.299	0.265	0.288	0.388	0.472	0.441	0.456	0.529	0.323	0.264	0.226	0.304
Er	0.891	0.570	0.815	0.719	0.768	0.793	0.847	0.702	1.269	1.662	1.188	1.319	0.489	0.657	0.673	0.517
Tm	0.142	0.095	0.113	0.066	0.127	0.102	0.112	0.098	0.234	0.178	0.205	0.207	0.093	0.134	0.094	0.086
Yb	0.931	0.630	0.881	0.640	0.915	0.636	0.724	0.518	1.511	1.400	1.350	1.541	0.495	0.823	0.743	0.661
Lu	0.094	0.129	0.099	0.088	0.138	0.098	0.149	0.143	0.215	0.215	0.228	0.194	0.075	0.080	0.092	0.115
Hf	2.432	1.911	1.751	2.712	2.183	2.344	2.394	2.424	6.496	7.232	7.272	7.050	1.627	1.757	1.797	1.717
Ta	0.179	0.190	0.205	0.162	0.137	0.171	0.134	0.105	0.335	0.408	0.422	0.389	0.094	0.124	0.061	0.124
W	0.679	0.862	0.916	1.001	0.716	0.540	0.665	1.137	1.033	1.168	1.068	1.138	0.372	0.396	0.192	0.431
Au	0.388	0.487	0.389	0.326	1.358	1.620	0.790	0.788	0.035	<0.034	0.054	<0.00	0.914	0.723	0.681	0.620
Tl	0.127	0.042	0.095	0.073	0.033	0.108	0.089	0.113	<0.029	<0.0227	<0.022	<0.028	<0.024	0.062	0.058	0.108
Pb	4661	4539	4642	4571	4441	5936	7421	5917	7	7	8	8	5049	4119	2925	7702
Bi	0.320	0.312	0.372	0.348	0.571	0.659	0.649	0.623	0.140	0.054	0.072	0.029	0.380	0.540	0.495	0.622
Th	1.331	1.395	1.580	1.337	1.371	1.368	1.404	1.429	2.437	2.447	2.538	2.437	1.145	1.179	1.074	1.285
U	1.033	0.987	1.001	1.006	1.013	0.972	1.070	0.988	1.225	1.292	1.273	1.291	1.094	1.034	1.205	1.044

	CO100A lb			CO100B				CO121A				CO121B			CO121C			
Li	6.2	7.0	3.9	3.2	3.8	5.4	2.0	7.8	6.7	8.4	9.6	3.5	9.5	8.5	3.9	7.5	3.8	<3.06
Be	<4.59	<2.57	<5.00	<2.82	1.3	5.8	<2.78	<5.71	<3.68	<3.29	1.3	<5.67	<4.19	<5.65	<7.38	<4.09	<6.87	<4.85
B	91	104	99	120	124	143	127	151	134	139	140	156	149	136	135	142	128	160
Sc	4.8	5.3	4.6	2.3	2.3	3.1	2.8	2.6	3.2	2.8	3.4	3.1	3.2	2.7	3.0	2.7	3.1	2.2
Ti	898	888	867	623	616	625	599	896	904	845	949	762	819	689	636	636	610	654
V	19	19	19	22	19	20	19	24	24	24	24	19	22	17	18	17	17	18
Cr	25	32	21	19	17	20	20	23	26	23	30	29	25	20	18	14	16	14
Co	40	39	25	18	<1.06	20	19	28	27	24	25	29	22	21	14	13	14	13
Ni	31	32	19	21	21	17	20	16	21	19	18	18	18	13	12	12	10	10
Cu	2735	2763	2490	1554	1608	1559	1470	1263	1245	1200	1224	1957	1762	1927	1443	1511	1520	1490
Zn	446	441	135	32	33	33	33	64	77	83	65	91	87	66	49	61	58	61
Ga	3.4	3.5	2.8	2.3	2.8	2.6	2.3	2.7	2.7	3.1	3.3	3.0	2.9	2.9	2.7	2.9	2.5	2.4
Ge	1.5	<0.74	<1.02	1.5	0.7	1.3	<0.40	0.8	2.0	<0.62	<0.66	0.9	1.4	<0.70	<0.69	1.0	<0.81	1.5
As	57.8	60.4	13.0	17.4	18.7	18.3	18.0	15.8	15.8	16.3	15.1	16.1	16.0	14.4	15.7	13.8	14.3	17.9
Rb	12.5	12.6	12.3	8.0	7.5	8.0	7.8	9.0	9.4	8.7	9.0	10.7	14.5	10.1	8.3	9.2	8.8	8.8
Sr	425	428	442	427	431	429	424	456	465	456	470	458	435	436	426	425	442	451
Y	7.5	7.5	7.6	5.9	5.9	6.1	6.0	7.5	7.1	6.8	7.6	7.4	7.8	6.7	5.9	6.5	7.2	6.9
Zr	73.6	76.3	72.0	54.6	58.2	56.1	53.4	76.9	83.4	74.5	87.0	68.1	67.3	61.7	56.9	56.6	58.5	59.7
Nb	2.36	2.45	2.26	1.88	1.65	1.71	1.81	2.32	2.22	2.05	2.29	2.04	2.42	1.96	1.72	1.74	1.67	1.85
Mo	1.21	1.14	1.18	2.02	1.69	1.52	1.31	1.84	2.29	1.77	2.55	1.62	1.28	1.03	1.61	1.32	1.50	1.39
Ag	2.44	2.58	2.08	2.06	2.45	2.05	1.67	1.28	1.19	1.20	1.40	2.14	1.28	1.88	1.38	0.94	1.03	1.39
Cd	0.77	<0.64	1.14	<0.22	<0.60	<0.21	<0.19	<0.65	<0.68	<0.43	<0.49	<0.61	0.46	<0.49	0.32	0.26	<0.93	0.43
In	14.59	15.39	2.55	0.69	0.75	0.82	0.75	1.47	2.75	2.80	2.10	1.77	1.54	1.82	0.98	1.64	1.17	0.86
Sn	3933	4034	597	174	182	210	202	354	736	706	504	475	406	449	262	428	279	250
Sb	955	990	983	1432	1357	1447	1379	1278	1243	1120	1114	1425	1302	1439	1432	1549	1655	1429
Cs	0.161	0.235	0.169	0.154	0.152	0.178	0.190	0.199	0.212	0.118	0.129	0.214	0.269	0.140	0.243	0.176	0.178	0.115
Ba	255	257	259	263	258	267	252	313	312	310	313	260	251	247	284	259	276	295
La	7.551	7.641	7.088	5.921	6.062	6.162	5.901	7.149	7.502	6.714	7.199	7.098	8.019	6.418	6.756	6.896	6.816	7.117
Ce	13.382	13.624	12.719	11.079	10.668	11.320	11.210	12.389	12.257	12.379	12.671	12.705	13.836	11.994	11.762	11.300	12.325	10.998
Pr	1.790	1.739	1.860	1.234	1.405	1.505	1.254	1.642	1.686	1.656	1.598	1.522	1.722	1.442	1.468	1.498	1.478	1.417
Nd	6.988	6.696	7.350	5.791	6.463	4.948	5.299	6.411	7.573	7.785	7.098	6.938	7.549	6.848	5.961	6.203	6.183	6.615
Sm	1.106	1.709	1.840	1.014	1.174	1.014	0.933	1.434	1.575	1.535	1.939	1.592	1.211	1.572	1.216	1.448	1.025	1.046
Eu	0.417	0.459	0.445	0.197	0.222	0.250	0.274	0.465	0.422	0.492	0.372	0.400	0.431	0.355	0.224	0.364	0.339	0.333
Gd	1.186	1.589	1.458	1.194	1.044	1.104	0.903	1.272	1.928	1.515	1.111	1.191	1.261	1.121	0.945	1.387	1.216	0.875
Tb	0.192	0.260	0.148	0.143	0.142	0.128	0.130	0.125	0.256	0.228	0.221	0.160	0.214	0.144	0.149	0.186	0.218	0.195
Dy	1.327	1.398	1.367	1.194	0.874	0.933	0.932	1.181	1.333	1.535	1.131	1.261	1.292	1.041	1.035	0.829	0.965	1.739
Ho	0.225	0.289	0.330	0.187	0.217	0.193	0.183	0.258	0.358	0.256	0.266	0.235	0.244	0.239	0.262	0.231	0.273	0.204
Er	0.734	0.804	0.680	0.437	0.567	0.401	0.635	0.749	0.671	0.504	0.870	0.981	0.770	0.702	0.632	0.807	0.640	0.675
Tm	0.082	0.108	0.115	0.067	0.073	0.116	0.066	0.079	0.117	0.105	0.139	0.102	0.132	0.095	0.068	0.121	0.080	0.075
Yb	0.744	0.693	0.346	0.702	0.556	0.413	0.502	0.670	0.596	0.737	0.939	0.841	0.589	0.273	0.724	0.694	0.519	0.533
Lu	0.098	0.078	0.098	0.047	0.080	0.054	0.072	0.126	0.104	0.120	0.089	0.040	0.064	0.146	0.111	0.072	0.098	0.091
Hf	1.971	2.142	2.071	1.566	1.435	1.184	1.465	1.817	1.979	1.918	1.797	1.372	2.233	1.282	1.629	1.639	1.518	1.598
Ta	0.143	0.158	0.134	0.145	0.098	0.108	0.112	0.116	0.122	0.118	0.113	0.121	0.137	0.190	0.079	0.180	0.083	0.155
W	0.427	0.329	0.217	0.490	0.548	0.639	0.743	0.705	0.592	0.467	0.509	0.704	0.700	0.871	0.518	1.136	0.701	0.855
Au	0.672	0.955	0.784	1.425	1.425	1.475	1.746	0.515	0.625	0.510	0.449	0.904	1.251	0.981	0.765	0.439	0.724	0.844
Tl	0.141	0.125	<0.044	0.054	0.050	0.061	0.056	0.055	0.097	0.087	0.046	0.072	0.020	0.069	0.096	0.052	0.081	<0.027
Pb	13132	13006	4340	2501	2569	2647	3082	3005	3343	3484	3543	4656	3611	3981	3014	3683	3669	3215
Bi	0.914	0.860	0.347	0.221	0.253	0.230	0.220	0.202	0.214	0.149	0.206	0.348	0.308	0.178	0.165	3.418	1.151	0.283
Th	1.097	1.119	1.327	0.749	0.988	0.892	0.842	1.158	1.276	1.228	1.154	1.230	1.422	1.302	1.216	1.237	1.176	1.146
U	1.207	1.056	1.076	1.044	0.803	0.953	0.863	1.033	0.732	1.132	0.989	0.958	0.903	1.036	1.045	1.116	1.034	1.004

	CO121D				CO121E				CO122			CO184A		
Li	5.1	7.1	3.7	8.8	<2.15	4.3	4.0	3.9	7.6	3.2	4.0	5.6	6.0	4.0
Be	<3.78	<6.77	<3.06	4.6	1.7	<0.00	<7.39	3.7	<6.89	<5.54	<5.14	<3.73	<5.12	<3.33
B	191	160	157	162	155	171	181	159	132	153	170	146	139	146
Sc	2.9	3.0	2.9	3.7	2.7	2.5	2.1	3.0	3.1	2.5	2.2	3.2	3.4	3.3
Ti	757	809	747	810	562	572	569	563	719	552	573	834	848	860
V	22	24	23	23	16	16	16	16	21	17	17	24	23	23
Cr	19	22	15	23	12	11	8	9	19	18	28	32	31	28
Co	40	39	38	42	4	5	5	4	264	285	278	42	40	41
Ni	15	16	14	17	8	7	9	7	27	23	31	24	24	21
Cu	2603	2514	2590	2494	15	16	16	15	2353	2671	2423	1899	1962	1864
Zn	93	91	86	97	18	22	18	23	71	79	64	161	177	161
Ga	2.8	2.8	2.9	2.7	2.8	2.6	2.9	2.2	3.4	3.5	3.3	2.8	3.1	3.9
Ge	<0.74	1.5	<0.53	0.8	1.2	<0.69	1.0	1.5	1.5	<0.77	1.9	2.2	<0.61	0.8
As	24.5	22.5	24.6	27.0	21.1	24.4	22.4	24.3	18.3	24.2	30.0	21.3	21.4	23.4
Rb	9.4	9.2	9.2	8.9	5.4	5.4	5.0	4.3	10.8	10.8	11.4	12.6	11.7	11.9
Sr	485	482	477	483	425	420	426	426	486	481	450	458	460	458
Y	6.9	7.2	6.9	7.7	6.3	6.3	6.3	6.3	7.2	6.8	6.6	7.7	7.2	7.1
Zr	73.6	75.6	70.8	74.2	54.3	54.3	54.1	52.2	127.0	54.7	55.4	75.9	73.9	75.3
Nb	2.04	2.26	2.30	1.98	1.85	1.79	1.68	1.86	1.93	1.78	1.58	2.48	2.20	2.17
Mo	2.31	1.66	1.81	2.22	0.46	0.45	0.40	0.55	1.85	2.17	2.05	1.71	1.48	1.35
Ag	6.45	6.97	6.74	6.33	<0.080	0.06	<0.091	<1.43	1.44	1.07	1.28	1.66	1.75	2.04
Cd	<0.49	<0.48	<0.48	0.26	<0.46	<0.47	<0.37	<0.33	0.14	<0.35	<0.32	<0.68	<0.46	<0.52
In	1.55	1.77	1.43	1.79	<0.025	0.04	<0.0145	<0.0244	1.13	0.84	0.78	2.66	2.66	2.67
Sn	415	438	370	446	2	2	2	2	234	153	158	714	657	640
Sb	2868	2806	2725	2875	2060	1998	2002	2015	4842	6631	7561	1922	1876	1919
Cs	0.123	0.181	0.229	0.178	0.078	0.046	0.066	0.098	0.208	0.108	0.139	0.173	0.215	0.250
Ba	290	290	282	292	181	179	175	174	220	230	227	284	274	276
La	7.482	6.830	7.192	7.533	6.608	6.518	6.809	6.558	6.694	6.765	6.592	7.421	7.250	7.149
Ce	11.494	12.367	11.946	12.136	11.319	11.299	10.917	11.218	11.724	11.214	11.520	12.358	12.348	12.921
Pr	1.474	1.594	1.655	1.459	1.456	1.486	1.355	1.377	1.582	1.510	1.351	1.629	1.609	1.800
Nd	6.399	6.058	6.018	6.148	6.458	7.060	5.735	6.568	6.877	6.092	5.969	7.632	6.315	7.019
Sm	1.174	1.424	1.113	1.324	0.944	1.637	1.165	1.255	0.837	1.378	1.398	1.096	1.187	1.086
Eu	0.380	0.334	0.316	0.423	0.300	0.259	0.298	0.414	0.392	0.284	0.371	0.270	0.341	0.328
Gd	1.274	1.194	0.993	1.374	1.055	1.306	1.105	0.714	1.265	0.857	1.153	1.579	1.126	1.569
Tb	0.152	0.182	0.168	0.238	0.181	0.162	0.142	0.140	0.218	0.137	0.213	0.231	0.203	0.231
Dy	1.224	1.585	0.993	1.184	1.145	1.125	1.115	1.145	1.092	1.214	1.214	1.126	1.247	1.217
Ho	0.164	0.292	0.216	0.232	0.245	0.184	0.218	0.182	0.289	0.274	0.260	0.223	0.309	0.308
Er	0.597	0.743	0.627	0.660	0.639	0.672	0.725	0.594	0.379	0.737	0.722	0.723	0.728	0.726
Tm	0.089	0.098	0.088	0.105	0.079	0.043	0.080	0.094	0.082	0.111	0.076	0.113	0.083	0.132
Yb	0.542	0.832	0.625	0.298	1.024	0.543	0.333	0.502	0.442	0.714	0.765	0.585	0.599	1.076
Lu	0.098	0.091	0.091	0.109	0.069	0.049	0.068	0.126	0.130	0.123	0.118	0.153	0.054	0.120
Hf	1.414	1.535	1.996	1.896	0.954	1.547	1.527	0.653	3.490	1.500	1.429	2.102	2.242	1.931
Ta	0.168	0.127	0.125	0.088	0.077	0.080	0.102	0.088	0.095	0.089	0.098	0.141	0.127	0.095
W	1.093	0.791	0.629	1.204	0.158	<0.130	0.094	0.203	0.361	0.395	0.424	0.746	0.739	0.726
Au	0.877	1.053	0.864	1.131	<0.043	<0.044	<0.097	0.301	0.309	0.583	0.540	1.227	1.136	1.498
Tl	<0.045	0.055	0.081	0.087	0.039	<0.031	0.009	0.043	0.038	0.081	0.030	0.088	0.048	0.026
Pb	4778	4699	4379	4684	22	23	22	21	2300	2205	2799	5190	5386	5359
Bi	0.359	0.358	0.238	0.396	<0.037	0.085	0.090	0.064	0.269	0.308	0.372	0.563	0.528	0.577
Th	1.113	1.413	1.154	1.248	0.964	1.055	0.965	0.897	1.125	1.219	1.114	1.238	1.306	1.200
U	1.070	1.016	0.847	0.936	0.858	0.852	0.820	0.712	0.962	0.929	0.935	0.849	0.889	1.028

	CO184B				CO184C				CO230				CO233A			
Li	4.2	4.5	2.7	5.5	2.5	7.3	4.9	4.4	1.7	5.1	7.9	4.2	5.1	<2.75	3.1	3.7
Be	<7.27	<4.75	<3.49	<0.00	<6.25	3.1	<3.94	<8.26	<4.52	<7.80	<4.30	4.8	<5.74	<4.33	<7.16	3.5
B	165	146	160	153	182	143	153	153	108	74	98	105	98	113	86	97
Sc	3.1	2.8	2.2	2.8	3.1	3.2	2.6	2.9	2.5	2.9	2.7	2.5	3.5	3.8	4.3	3.3
Ti	691	729	545	702	805	798	765	777	533	528	543	571	1568	1540	1516	1520
V	20	19	15	21	23	23	21	21	11	10	11	11	20	22	21	21
Cr	19	16	17	19	27	26	22	18	17	23	31	24	31	31	25	23
Co	25	26	19	27	51	50	44	45	8	7	6	9	6	7	6	7
Ni	13	12	10	12	22	19	16	15	11	14	12	19	7	7	8	7
Cu	2230	2259	1691	2213	2068	2107	2041	2010	580	571	623	654	25	26	24	23
Zn	61	63	44	62	128	133	99	95	110	120	177	371	26	32	26	33
Ga	2.6	3.0	2.9	2.3	2.7	3.2	3.2	2.7	2.4	3.2	2.3	2.8	3.1	3.2	3.0	3.1
Ge	0.8	2.0	<0.40	1.5	0.7	1.0	0.9	0.8	<1.03	1.2	1.4	2.1	2.0	2.1	1.6	<0.70
As	21.7	22.0	18.6	25.2	29.0	29.5	23.5	24.7	6.8	7.2	9.5	19.5	1.1	0.9	0.8	1.1
Rb	9.1	8.8	19.6	8.5	8.5	8.2	8.0	8.5	9.8	8.7	9.2	9.2	5.8	5.8	5.3	6.7
Sr	459	468	432	460	458	457	456	462	417	398	395	410	179	179	169	177
Y	7.1	6.7	4.9	6.9	7.2	6.9	7.1	7.1	6.4	6.2	6.5	6.6	6.6	6.7	6.2	6.3
Zr	64.6	65.7	60.9	64.6	72.6	73.8	70.9	71.3	50.5	49.4	51.0	49.7	178.0	180.2	176.9	171.5
Nb	2.05	1.82	1.72	2.13	2.15	2.02	2.13	1.96	1.56	1.45	1.64	1.92	3.54	3.55	3.57	3.19
Mo	1.75	1.58	1.21	1.74	1.73	2.04	1.80	2.23	0.99	0.34	0.36	0.67	<0.207	0.41	0.51	0.22
Ag	1.44	2.14	1.26	1.81	2.23	2.13	1.98	2.34	0.90	0.97	1.44	0.70	<0.110	0.14	0.19	0.11
Cd	0.43	0.74	<0.35	<0.38	0.34	<0.40	0.50	0.28	<0.45	<0.77	0.56	0.66	<0.55	<0.41	<0.56	0.44
In	0.95	1.16	1.12	1.10	2.07	2.25	1.43	1.26	2.92	2.54	2.81	5.14	0.04	0.03	0.05	<0.034
Sn	249	277	265	252	488	495	366	337	747	664	788	1295	4	5	3	4
Sb	2307	2340	1823	2314	2576	2616	2110	2070	325	171	180	161	14	17	8	17
Cs	0.200	0.185	0.275	0.222	0.134	0.134	0.112	0.136	0.167	0.114	0.164	0.108	0.057	0.067	0.078	0.092
Ba	279	284	241	287	291	288	289	288	207	199	201	200	168	172	161	167
La	7.088	6.947	4.836	6.585	6.673	6.763	6.833	6.844	6.082	5.831	6.273	6.002	6.602	6.944	6.420	6.692
Ce	11.371	11.803	10.064	12.004	12.082	11.770	11.419	11.660	11.362	11.040	10.298	10.980	13.123	13.002	13.183	13.465
Pr	1.508	1.538	1.317	1.568	1.475	1.646	1.495	1.515	1.405	1.564	1.215	1.354	1.553	1.606	1.463	1.574
Nd	6.223	7.158	4.182	6.967	6.432	6.392	6.663	6.081	7.507	6.604	5.982	5.018	6.088	6.823	6.783	6.632
Sm	1.739	1.196	0.714	1.146	1.034	1.395	1.425	1.355	1.194	1.204	1.325	1.074	1.469	1.348	1.057	1.369
Eu	0.314	0.373	0.274	0.404	0.362	0.450	0.254	0.310	0.515	0.325	0.333	0.355	0.286	0.334	0.217	0.328
Gd	0.985	1.136	1.036	1.357	1.385	1.274	1.024	1.264	1.064	1.686	1.124	1.034	1.208	1.067	1.077	0.896
Tb	0.154	0.148	0.126	0.298	0.181	0.141	0.228	0.192	0.176	0.166	0.140	0.164	0.175	0.081	0.142	0.198
Dy	1.217	1.106	0.965	1.267	0.943	1.034	1.234	1.194	0.903	1.345	1.345	0.792	1.187	1.238	1.177	1.198
Ho	0.250	0.258	0.137	0.250	0.290	0.202	0.243	0.209	0.256	0.209	0.199	0.169	0.214	0.218	0.188	0.261
Er	0.804	0.646	0.468	0.915	0.407	0.913	0.516	0.782	0.649	0.763	0.509	0.429	0.539	0.687	0.631	0.751
Tm	0.118	0.105	0.085	0.068	0.054	0.062	0.081	0.128	0.064	0.095	0.094	0.074	0.072	0.134	0.097	0.093
Yb	0.513	0.804	0.258	0.379	0.560	0.803	0.733	0.722	0.474	0.322	0.763	0.763	0.615	1.127	0.684	0.575
Lu	0.099	0.094	0.063	<0.027	0.115	0.136	0.094	0.151	0.099	0.077	0.104	0.079	0.125	0.123	0.114	0.089
Hf	1.669	1.679	2.312	1.920	1.866	1.666	1.415	1.696	1.425	0.913	1.295	0.923	4.931	4.166	3.713	3.864
Ta	0.137	0.121	0.243	0.109	0.134	0.184	0.137	0.111	0.104	0.114	0.127	0.103	0.194	0.251	0.267	0.208
W	0.530	0.739	0.684	0.744	0.710	0.719	0.550	0.721	0.354	0.173	0.162	0.081	0.102	<0.125	0.206	0.109
Au	1.438	1.548	0.925	1.106	1.204	0.933	0.859	0.538	0.678	0.231	0.117	0.302	<0.00	0.061	<0.052	<0.067
Tl	0.106	<0.053	0.059	0.111	0.121	0.046	0.040	0.053	0.073	0.088	0.052	0.135	0.040	<0.027	<0.036	0.032
Pb	4549	4693	3776	4539	5351	5381	4217	3952	3250	3079	3488	4200	44	49	36	46
Bi	0.252	0.411	0.246	0.245	0.438	0.426	0.382	0.417	0.482	0.802	0.928	1.066	<0.037	<0.023	0.041	0.034
Th	1.146	1.156	0.828	1.086	1.063	1.315	1.154	1.144	0.892	0.932	0.968	1.056	1.509	1.550	1.268	1.291
U	0.939	0.911	0.918	0.919	1.145	0.894	0.807	0.998	0.931	0.873	0.979	0.791	1.014	0.978	1.031	1.020

	CO233B			CO233C				CO325				CO365				
Li	6.2	7.2	9.4	6.7	5.2	6.3	6.7	9.8	4.4	4.3	6.5	2.6	5.1	4.8	7.5	5.4
Be	<2.59	<0.00	<3.11	1.5	<4.26	3.1	9.7	<3.40	<5.10	<4.88	<3.22	<5.76	<4.11	<4.28	<5.02	<6.34
B	179	182	153	180	177	190	169	128	135	111	143	46	784	49	43	50
Sc	3.2	3.2	3.5	3.0	3.3	3.3	3.0	3.2	3.4	2.7	2.7	3.4	2.8	2.7	3.0	2.9
Ti	806	828	838	727	723	710	804	834	807	754	725	442	461	423	419	436
V	32	29	32	21	21	22	22	21	20	21	19	8	9	8	8	9
Cr	14	15	17	22	21	19	23	33	20	23	17	23	15	17	12	18
Co	9	8	8	432	437	435	465	36	31	23	17	2	3	2	2	2
Ni	20	15	19	66	64	64	63	35	24	19	21	6	5	4	5	6
Cu	51	47	46	2067	2085	2053	2189	2093	2058	1903	1892	106	111	261	306	243
Zn	27	25	23	89	86	81	90	341	321	251	155	18	21	17	22	19
Ga	2.8	3.0	3.2	3.9	3.7	4.1	4.1	2.4	2.8	3.5	3.0	2.7	2.6	3.2	3.0	3.2
Ge	0.7	1.4	0.6	3.3	2.6	3.3	1.4	1.7	<0.69	0.7	1.3	<0.67	<0.95	0.9	1.3	<0.79
As	15.6	14.1	14.8	29.3	25.8	21.4	23.6	21.5	17.3	14.1	9.5	2.1	3.2	2.8	1.8	1.7
Rb	7.7	7.0	7.5	8.6	9.1	8.6	9.7	12.2	9.7	9.6	9.0	9.3	9.4	9.2	9.0	8.9
Sr	612	612	611	528	545	531	568	487	529	517	519	366	394	383	381	377
Y	9.8	9.3	10.0	6.8	7.3	6.9	7.8	7.2	7.1	7.1	7.0	6.2	6.3	6.0	6.4	6.6
Zr	81.5	83.1	82.5	69.2	70.5	71.8	75.0	74.8	74.6	70.2	67.8	42.5	45.3	42.7	41.1	41.8
Nb	2.54	2.54	2.47	1.82	2.00	2.20	2.00	2.40	2.37	1.96	2.06	1.58	1.47	1.14	1.29	1.54
Mo	1.92	1.53	1.93	3.10	3.53	2.93	3.52	1.66	1.56	1.32	1.27	0.45	0.24	0.43	0.26	0.29
Ag	0.03	0.11	0.10	1.36	1.01	1.06	1.22	2.69	2.89	3.11	3.58	0.51	0.41	0.39	0.45	0.66
Cd	<0.24	<0.56	<0.29	<0.60	0.62	<0.67	<0.70	0.55	<0.35	<0.58	<0.62	<0.68	<0.59	<0.75	<0.62	<0.51
In	0.04	0.03	0.02	2.35	2.62	2.65	2.77	4.93	5.59	4.50	3.42	0.51	0.92	0.28	0.46	0.32
Sn	5	5	5	490	504	511	586	1296	1481	1144	891	135	263	78	127	81
Sb	100	100	102	3326	3350	3281	3439	927	850	626	468	63	155	43	45	57
Cs	0.051	0.112	0.112	0.152	0.121	0.180	0.180	0.201	0.080	0.117	0.136	0.121	0.160	0.055	0.141	0.098
Ba	370	358	378	238	242	241	255	248	256	248	242	213	220	223	221	218
La	10.962	11.032	11.173	7.347	7.016	7.091	7.465	7.221	6.860	6.840	7.101	6.212	6.373	6.121	6.010	6.151
Ce	13.439	13.098	13.840	12.492	12.342	12.887	13.465	12.775	12.333	12.042	11.942	11.264	11.556	11.203	10.982	11.133
Pr	2.337	2.146	2.307	1.403	1.463	1.491	1.538	1.418	1.578	1.462	1.433	1.361	1.452	1.472	1.412	1.392
Nd	10.250	10.059	9.959	6.716	6.663	6.417	6.834	7.121	6.167	6.508	7.081	5.778	6.081	5.395	5.193	5.516
Sm	1.956	2.307	2.347	1.027	1.700	1.059	1.230	1.547	1.989	1.296	1.255	0.746	1.331	0.978	1.261	1.624
Eu	0.567	0.582	0.631	0.400	0.374	0.437	0.440	0.298	0.336	0.385	0.474	0.290	0.386	0.435	0.431	0.367
Gd	1.775	1.705	2.046	1.412	0.973	1.251	1.444	1.286	0.924	1.306	1.456	0.988	1.392	0.787	1.129	0.918
Tb	0.263	0.313	0.283	0.196	0.182	0.202	0.218	0.199	0.226	0.139	0.207	0.215	0.201	0.132	0.156	0.138
Dy	1.504	1.725	2.026	1.078	1.123	1.401	1.134	1.406	1.195	1.125	0.971	1.129	1.301	1.170	1.139	0.825
Ho	0.316	0.440	0.426	0.226	0.212	0.206	0.292	0.230	0.264	0.243	0.253	0.244	0.236	0.196	0.210	0.246
Er	0.979	0.846	1.153	0.438	0.692	0.760	0.526	0.944	0.892	0.776	0.536	0.576	0.867	0.505	0.867	0.825
Tm	0.145	0.132	0.124	0.095	0.087	0.077	0.103	0.111	0.105	0.112	0.065	0.073	0.075	0.071	0.075	0.071
Yb	1.143	1.073	1.153	0.406	0.421	0.543	0.984	0.548	0.864	0.376	0.824	0.746	0.746	0.645	0.736	0.595
Lu	0.160	0.114	0.105	0.044	0.143	0.111	0.098	0.101	0.158	0.090	0.103	0.122	0.075	0.112	0.074	0.045
Hf	1.815	1.795	1.835	1.818	1.658	1.561	1.818	1.707	1.868	1.416	1.707	1.059	1.049	1.301	1.099	1.059
Ta	0.149	0.117	0.109	0.108	0.128	0.181	0.127	0.143	0.134	0.095	0.132	0.098	0.066	0.055	0.094	0.116
W	0.322	0.438	0.383	0.158	0.332	0.251	0.121	0.342	0.325	0.259	0.239	<0.00	0.151	0.129	<0.063	<0.111
Au	<0.046	<0.033	0.014	0.185	0.169	0.074	0.163	0.630	0.694	0.624	0.744	0.050	0.136	<0.133	<0.085	0.146
Tl	<0.027	0.082	0.035	0.067	0.074	0.093	0.083	0.048	0.211	0.077	0.114	0.024	<0.0276	<0.029	<0.023	0.030
Pb	80	81	80	4114	4202	4150	4589	8970	10088	8788	9134	380	670	691	873	636
Bi	0.070	<0.024	0.045	0.519	0.468	0.590	0.470	1.241	1.938	1.888	1.658	0.083	<0.071	0.081	0.103	0.435
Th	1.368	1.263	1.304	1.264	1.241	1.218	1.455	1.278	1.285	1.199	1.073	0.902	0.972	0.819	0.809	0.802
U	1.265	1.331	1.394	1.151	1.046	1.129	0.886	0.927	0.892	0.862	0.983	0.816	0.708	0.988	0.815	0.827

	CO366				CO368			CO530db			CO530lb		
Li	4.3	5.5	2.4	3.4	1.8	4.3	3.9	5.7	5.8	2.5	7.8	3.0	5.3
Be	<6.25	<5.54	3.2	<7.05	<2.68	2.5	1.3	<5.13	4.0	<4.11	<2.89	<3.00	<0.00
B	99	101	107	87	46	55	29	96	133	98	94	101	104
Sc	2.8	2.4	2.9	2.2	2.8	2.9	2.8	3.2	2.8	3.0	3.4	3.2	2.9
Ti	543	568	581	529	360	394	373	717	737	708	776	673	702
V	13	14	15	12	7	8	8	21	21	20	22	20	22
Cr	19	17	19	12	6	14	11	17	15	18	17	17	18
Co	9	9	8	9	2	1	2	69	71	71	85	66	69
Ni	8	9	9	8	3	3	4	151	158	155	206	150	152
Cu	311	305	376	399	4	3	3	7132	7249	7174	8941	7746	7592
Zn	42	47	42	42	3	3	2	2320	2317	2320	3181	2247	2269
Ga	2.9	3.1	2.4	3.0	3.3	2.8	3.2	3.4	3.3	3.9	3.0	2.8	2.9
Ge	<0.63	0.7	<0.78	<0.67	0.7	1.7	1.3	1.4	1.7	0.9	1.8	1.1	1.0
As	3.4	3.5	4.7	4.3	1.3	1.0	1.2	111.4	118.5	115.5	203.3	108.4	113.9
Rb	8.9	8.2	8.8	8.4	8.3	8.7	9.4	9.1	8.6	9.3	8.8	9.1	8.5
Sr	447	441	452	434	370	375	362	537	539	537	536	527	519
Y	6.0	5.9	6.0	5.7	5.4	5.9	4.9	7.5	7.2	7.7	7.9	7.4	7.4
Zr	52.0	51.9	53.2	50.3	32.9	32.8	31.5	61.0	62.2	59.7	65.5	61.2	59.7
Nb	1.78	1.50	1.56	1.80	1.19	1.35	1.27	2.20	2.04	2.29	2.28	2.04	2.09
Mo	0.81	0.68	1.03	0.92	0.42	0.60	0.24	1.71	1.47	2.35	1.76	1.67	1.97
Ag	0.72	0.61	0.59	0.88	0.03	<0.053	<0.0272	2.62	2.35	2.37	6.99	2.53	2.39
Cd	0.28	<0.49	<0.37	<0.36	<0.27	<0.19	0.41	<0.47	0.48	0.92	0.36	0.21	0.61
In	0.64	0.64	0.78	0.72	0.02	0.01	<0.0078	22.42	22.62	22.77	29.98	21.03	22.01
Sn	190	189	200	207	1	1	1	5836	5878	5931	11644	8306	8631
Sb	271	274	281	268	-	<0.154	<0.144	238	236	240	300	235	238
Cs	0.105	0.142	0.142	0.199	0.118	0.086	0.100	0.181	0.167	0.180	0.150	0.156	0.187
Ba	221	214	218	215	216	226	211	247	251	250	248	243	242
La	5.985	6.005	6.256	5.473	5.399	5.731	5.560	7.363	7.315	6.883	7.207	6.806	6.911
Ce	10.956	11.227	11.117	10.795	10.939	11.945	10.899	12.451	12.748	12.960	12.629	11.474	12.324
Pr	1.336	1.285	1.617	1.265	1.478	1.387	1.257	1.661	1.603	1.603	1.623	1.470	1.556
Nd	5.443	6.557	5.603	5.413	5.651	4.876	5.248	7.613	6.960	7.814	6.959	7.131	6.482
Sm	1.165	0.934	0.823	1.165	0.915	1.619	1.146	1.622	1.565	1.267	1.594	1.566	1.480
Eu	0.303	0.473	0.169	0.359	0.320	0.289	0.289	0.454	0.381	0.438	0.459	0.481	0.435
Gd	0.954	0.924	0.663	1.105	0.784	0.975	1.327	1.421	1.286	1.738	1.394	1.136	1.365
Tb	0.199	0.137	0.165	0.187	0.120	0.172	0.132	0.230	0.237	0.234	0.225	0.149	0.225
Dy	0.866	0.954	0.763	0.818	1.056	1.166	0.773	1.498	1.546	1.613	1.499	1.422	1.327
Ho	0.218	0.231	0.204	0.196	0.158	0.211	0.180	0.353	0.274	0.204	0.249	0.224	0.261
Er	0.537	0.606	0.420	0.803	0.523	0.675	0.723	0.703	0.623	0.634	0.695	0.964	0.839
Tm	0.076	0.023	0.062	0.102	0.043	0.091	0.073	0.096	0.143	0.088	0.107	0.060	0.095
Yb	0.384	0.555	0.643	0.673	0.523	0.720	0.470	0.720	0.691	0.682	0.678	0.678	0.599
Lu	0.095	0.053	0.115	0.101	0.073	0.113	0.047	0.107	0.135	0.103	0.098	0.112	0.085
Hf	1.326	1.506	1.225	1.326	0.607	0.749	0.845	1.872	1.603	1.402	1.060	2.052	1.499
Ta	0.120	0.100	0.095	0.123	0.116	0.079	0.070	0.131	0.137	0.097	0.164	0.137	0.147
W	0.165	0.146	0.151	0.069	0.196	0.152	0.049	0.514	0.438	0.274	2.444	0.557	0.553
Au	0.160	0.187	0.251	0.187	<0.042	0.052	<0.0268	0.062	0.086	<0.071	<0.063	<0.065	0.071
Tl	<0.0205	<0.026	0.027	0.028	0.014	<0.0177	<0.022	0.242	0.302	0.308	0.287	0.312	0.267
Pb	894	870	920	886	4	5	5	23807	23918	24025	47056	35154	36052
Bi	0.196	0.176	0.169	0.179	0.025	<0.026	<0.0155	1.920	1.814	1.930	2.654	1.890	1.957
Th	0.881	0.810	1.014	0.821	0.469	0.668	0.757	1.162	0.998	1.018	1.098	1.021	1.088
U	1.004	0.854	0.924	0.864	0.675	0.819	0.715	0.941	0.854	1.018	0.897	0.907	0.983

Table S6. The composition of wollastonite crystals measured by EMPA.

	9	10	14	15	18
SiO_2	52.11	52.46	52.32	54.75	51.61
Al_2O_3	0.37	0.98	1.32	0.16	1.06
FeO	1.11	0.93	0.82	1.75	0.87
MnO	0.27	0.30	0.27	0.35	0.35
MgO	3.43	1.82	1.36	1.94	1.32
CaO	41.22	40.38	40.96	32.74	42.43
Na_2O	0.73	2.28	2.48	7.07	1.81
K_2O	0.05	0.08	0.09	0.22	0.07
Total	99.24	99.75	99.20	99.59	99.37
			Number of ions on the basis of 9O		
SiO_2	3.005	3.028	3.014	3.148	2.990
Al_2O_3	0.025	0.067	0.090	0.011	0.073
FeO	0.054	0.045	0.039	0.084	0.042
MnO	0.013	0.015	0.013	0.017	0.017
MgO	0.295	0.157	0.116	0.166	0.114
CaO	2.547	2.497	2.528	2.017	2.634
Na_2O	0.123	0.379	0.410	1.135	0.301
K_2O	0.004	0.006	0.006	0.016	0.005

Table S7. The composition of clinopyroxenes measured by EMPA.

	3	4	6	7	11	12	13	17	19
SiO_2	55.50	55.95	53.81	51.37	53.89	54.15	54.38	53.26	53.63
TiO_2	0.14	0.14	0.27	0.37	0.18	0.28	0.17	0.26	0.20
Al_2O_3	2.20	1.32	2.32	5.63	2.45	1.26	4.10	1.75	1.91
FeO	3.43	2.65	3.30	4.24	3.88	4.06	3.81	4.76	2.66
MnO	0.09	0.14	0.15	0.17	0.29	0.30	0.30	0.29	0.32
MgO	11.55	12.79	13.39	10.18	13.76	15.33	12.05	13.91	13.38
CaO	24.12	23.36	22.26	20.20	20.73	22.38	18.44	21.72	22.34
Na_2O	2.11	2.61	3.99	6.70	3.89	1.89	6.24	2.85	4.75
K_2O	0.11	0.14	0.20	0.16	0.11	0.02	0.18	0.06	0.20
Total	99.25	99.10	99.69	99.01	99.18	99.67	99.68	98.87	99.39
					Number of ions on the basis of 6O				
SiO_2	2.040	2.053	1.983	1.922	1.991	1.990	1.994	1.984	1.986
TiO_2	0.004	0.004	0.008	0.010	0.005	0.008	0.005	0.007	0.006
Al_2O_3	0.095	0.057	0.101	0.248	0.107	0.055	0.177	0.077	0.083
FeO	0.105	0.081	0.102	0.133	0.120	0.125	0.117	0.148	0.082
MnO	0.003	0.004	0.005	0.005	0.009	0.009	0.009	0.009	0.010
MgO	0.633	0.700	0.735	0.568	0.758	0.840	0.659	0.773	0.739
CaO	0.950	0.918	0.879	0.810	0.820	0.881	0.725	0.867	0.886
Na_2O	0.227	0.278	0.417	0.696	0.408	0.200	0.643	0.303	0.494
K_2O	0.005	0.007	0.009	0.008	0.005	0.001	0.008	0.003	0.009

Table S8a. The reference and compositional groups used for comparison.

#Table S9b	Group	Used compositional range from
1	*Apollonia*	Freestone et al. 2000
2	Jalame	Brill 1988
4	HIMT	Freestone 1994
5	Foy 1	Foy et al. 2003
6	HIMT1	Foster and Jackson 2009
7	HIMTa	Ceglia et al. 2015
8	strong HIMT	Rosenow and Rehren 2014
9	Egypt 2 (low Na_2O)	Schibille et al. 2019
10	Magby	De Juan Ares et al. 2019
11	Foy 2.1	Foy et al. 2003
12	Foy 2.1	Schibille 2022
13	Foy 3.2	Foy et al. 2003
14	Foy 3.2	Schibille 2022
15	Foy 3.2	Cholakova and Rehren (2018)
16	HIMT2	Foster and Jackson 2009

Table S8b. The composition of reference and compositional groups listed in Tables S9a.

	LEVANT						**EGYPT-HIMT**									
# Table S9a	*1*		2		3		4		5		6		7		8	
Group	*Apollonia*		Jalame		Jalame		HIMT		Foy 1		HIMT1		HIMTa		Strong HIMT	
Measurements n=	48		53		33		3		43		123		13		28	
Chronology	6th-7th		4th		4th		4th-6th		5th-8th		4th-5th		5th-7th		2nd-7th	
	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.
SiO_2 (av.)	71.38	1.6	69.74	1.6	68.19	2.0	64.86	1.1	64.49	1.4	67.34	1.7	66.22	1.5	64.76	1.6
TiO_2 (av.)	0.11	0.1	0.09	-	0.05	-	0.56	0.1	0.49	0.1	0.33	0.1	0.47	0.2	0.50	0.1
Al_2O_3_av	3.28	0.5	2.74	0.2	2.80	0.1	3.18	0.3	2.88	0.3	2.49	0.3	2.95	0.3	2.70	0.2
FeO_av	0.49	0.3	0.41	0.2	0.34	0.1	2.40	0.7	2.05	0.8	1.22	0.2	1.56	0.3	1.84	0.7
MnO (av.)	0.02	-	0.63	0.9	0.77	0.9	2.25	0.6	2.02	0.4	1.71	0.3	2.02	0.5	2.01	0.4
MgO (av.)	0.66	0.2	0.58	0.1	0.49	0.1	1.21	0.1	1.23	0.2	0.98	0.2	1.06	0.2	1.03	0.1
CaO (av.)	8.19	1.0	8.69	0.6	8.76	0.8	5.63	0.8	6.22	0.9	6.08	0.6	5.95	1.0	5.70	0.5
Na_2O (av.)	14.21	1.4	15.74	0.9	15.63	0.8	17.72	0.7	19.12	1.4	19.11	1.1	18.32	1.1	18.15	1.1
K_2O (av.)	0.61	0.2	0.78	0.1	0.78	0.1	0.45	-	0.41	0.1	0.50	0.1	0.44	0.1	0.42	0.1
P_2O_5 (av.)	0.05	-	0.14	-	0.09	-	0.10	-	0.11	-	0.05	-	0.06	-	0.06	-
SO_3 (av.)	0.16	0.1	-	-	0.13	0.1	0.21	0.1	-	-	-	-	0.25	0.1	0.25	0.1
Cl (av.)	0.81	0.1	-	-	0.90	0.2	0.99	0.1	-	-	-	-	1.00	0.1	1.00	0.1

(continued)

	EGYPT SERIES		**MAGBY**		**G2.1**				**G3.2**							
# Table S9a	9		10		11		12		13		14		15		16	
Group	Egypt 2		-		Foy 2.1		Foy 2.1		Foy 3.2		Foy 3.2		Foy 3.2		HIMT2	
Measurements n=	24		25		51		157/180		19		64/99		42		221	
Chronology	9th-12th		5th-8th		5th-9th		5th-7th		1st-6th		4th-5th		4th-6th		3rd-5th	
	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.	av.	sd.
SiO_2 (av.)	70.09	1.4	64.84	1.5	64.42	1.1	65.7	1.7	68.36	1.7	68.1	1.7	68.15	1.87	68.77	1.6
TiO_2 (av.)	0.27	-	0.15	-	0.16	-	0.15	0.02	0.09	-	0.10	0.03	0.09	0.02	0.12	-
Al_2O_3_av	2.52	0.2	2.03	0.3	2.54	0.2	2.53	0.23	1.93	0.2	1.94	0.19	1.93	0.21	2.25	0.2
FeO_av	1.06	0.3	1.23	0.5	1.22	0.6	1.04	0.5	0.64	0.1	0.61	0.24	0.54	0.12	0.65	0.1
MnO (av.)	0.44	0.5	1.53	0.8	1.60	0.4	1.41	0.44	0.91	0.4	0.83	0.27	0.84	0.20	0.98	0.2
MgO (av.)	0.70	0.2	1.90	0.2	1.23	0.1	1.12	0.25	0.66	0.2	0.64	0.21	0.56	0.15	0.76	0.1
CaO (av.)	9.57	0.5	9.29	0.7	7.78	0.7	8.12	0.92	6.88	0.8	6.61	0.86	6.59	0.91	6.00	0.6
Na_2O (av.)	13.39	0.6	16.12	0.9	18.50	1.2	17.7	1.3	18.63	1.0	19.0	1.1	19.04	1.01	19.65	1.0
K_2O (av.)	0.51	0.3	1.48	0.2	0.79	0.1	0.75	0.19	0.43	0.1	0.47	0.16	0.42	0.07	0.58	0.1
P_2O_5 (av.)	0.11	0.1	0.38	0.1	0.18	-	0.16	0.10	0.08	-	0.05	0.03	0.04	0.02	0.05	-
SO_3 (av.)	-	-	-	-	-	-	-	-	-	-	-	-	0.21	0.09	-	-
Cl (av.)	1.04	0.10	0.66	0.13	-	-	0.83	0.11	-	-	1.23	0.24	1.16	0.21	-	-

Table S9. The overall collection from Comacchio and the results of the provenance investigation.

Reference	Publ.no.	Analytical techniques	Context chronology	Type	Colour	Bertini et al. (2020)	Area	Compositional group
Bertini et al. 2020	Com01	EMPA+LA-ICP-MS	7th (mid)	Waster	Blue-green	Intermediate*	Egypt	Intermediate
Bertini et al. 2020	Com02	EMPA+LA-ICP-MS	7th (mid)	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com03	EMPA	7th (mid)	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com04	EMPA	7th (mid)	Waster	Blue-green	Intermediate*	-	Intermediate
Bertini et al. 2020	Com06	EMPA+LA-ICP-MS	10th-11th	Tessera	Colourless	Foy 2	Egypt	G2.1/G2.2
Bertini et al. 2020	Com08	EMPA	8th-9th	Waster	Colourless	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com10	EMPA	7th (mid)	Fragment	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com11	EMPA+LA-ICP-MS	7th (mid)	Fragment	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com12	EMPA	7th (mid)	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com13	EMPA	7th (mid)	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com14	EMPA+LA-ICP-MS	7th (mid)	Goblet	Blue-green	Intermediate*	Egypt	Magby
Bertini et al. 2020	Com15	EMPA+LA-ICP-MS	7th (mid)	Goblet	Blue-green	Levantine A - Apollonia type	Levant	Jalame/*Apollonia*
Bertini et al. 2020	Com16	EMPA+LA-ICP-MS	7th (mid)	Goblet	Blue-green	Levantine B - Jalame type	Levant	*Apollonia*/Jalame
Bertini et al. 2020	Com18	EMPA+LA-ICP-MS	7th (1st half) - 8th (early)	Fragment	Yellow	Foy 2	Egypt	G2.1/G2.2
Bertini et al. 2020	Com19	EMPA+LA-ICP-MS	7th (1st half)	Goblet/lamp	Blue-green	Levantine B - Jalame type	Levant	Jalame-like
Bertini et al. 2020	Com20	EMPA+LA-ICP-MS	7th (1st half)	Goblet/lamp	Blue-green	Levantine B - Jalame type	Levant	Jalame-like
Bertini et al. 2020	Com24	EMPA+LA-ICP-MS	7th (mid)	Fragment	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com26	EMPA+LA-ICP-MS	7th (mid)	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com27	EMPA	7th (mid)	Waster	Blue-green	Intermediate*	Egypt	Intermediate
Bertini et al. 2020	Com28	EMPA	7th (mid)	Fragment	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com29	EMPA+LA-ICP-MS	7th (mid)	Fragment	Yellow	Foy 2	Egypt	G2.1/G2.2
Bertini et al. 2020	Com30	EMPA	7th (mid)	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com31	EMPA	7th (mid)	Waster	Red	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com34	EMPA+LA-ICP-MS	7th (1st half)	Goblet	Green olive	Levantine B - Jalame type	Levant	Jalame/*Apollonia*
Bertini et al. 2020	Com35	EMPA	7th (1st half)	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com36	EMPA+LA-ICP-MS	7th (1st half)	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com37	EMPA	7th (1st half)	Unknown	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com38	EMPA	7th (1st half)	Waster	Red	Intermediate*	Egypt	~ G2.1HFe
Bertini et al. 2020	Com39	EMPA+LA-ICP-MS	7th (mid)	Window	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com40	EMPA+LA-ICP-MS	7th (mid)	Waster	Blue-green	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com41	EMPA	7th (mid)	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com42	EMPA+LA-ICP-MS	7th (mid)	Goblet	Blue-green	Intermediate*	Levant	Jalame
Bertini et al. 2020	Com44	EMPA+LA-ICP-MS	7th (1st half)	Window	Blue-green	Levantine A - Apollonia type	Levant	*Apollonia*-like
Bertini et al. 2020	Com45	EMPA+LA-ICP-MS	7th (1st half)	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com46	EMPA+LA-ICP-MS	7th (1st half)	Beaker	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com47	EMPA	7th (1st half)	Crucible	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com48	EMPA+LA-ICP-MS	11th	Lamp	Blue-green	Intermediate*	Egypt	Intermediate
Bertini et al. 2020	Com50	EMPA+LA-ICP-MS	7th (mid)	Goblet	Blue-green	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com51	EMPA+LA-ICP-MS	7th (mid)	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2

Reference	Publ.no.	Analytical techniques	Context chronology	Type	Colour	Bertini et al. (2020)	Area	Compositional group
Bertini et al. 2020	Com52	EMPA	7^{th} (mid)	Lamp	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com53	EMPA+LA-ICP-MS	7^{th} (mid)	Waster	Blue-green	Levantine A - Apollonia type	Levant	*Apollonia*-like
Bertini et al. 2020	Com55	EMPA+LA-ICP-MS	7^{th} (mid)	Waster	Blue-green	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com56	EMPA+LA-ICP-MS	7^{th} (mid)	Fragment	Blue-green	Levantine A - Apollonia type	Levant	*Apollonia*
Bertini et al. 2020	Com57	EMPA	7^{th} (mid)	Waster	Blue-green	Levantine A - Apollonia type	Levant	*Apollonia*
Bertini et al. 2020	Com58	EMPA	7^{th} (mid)	Waster	Blue-green	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com59	EMPA+LA-ICP-MS	7^{th} (1^{st} half)	Fragment	Grey light	Levantine A - Apollonia type	Levant	*Apollonia*-like
Bertini et al. 2020	Com60	EMPA+LA-ICP-MS	7^{th} (1^{st} half)	Fragment	Grey light	Levantine A - Apollonia type	Levant	*Apollonia*-like
Bertini et al. 2020	Com61	EMPA+LA-ICP-MS	7^{th} (end) - 8^{th}	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com62	EMPA	7^{th} (end) - 8^{th}	Tessera	Colourless	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com63	EMPA	7^{th} (end) - 8^{th}	Waster	Blue-green	Intermediate*	Egypt	Intermediate
Bertini et al. 2020	Com64	EMPA+LA-ICP-MS	7^{th} (end) - 8^{th}	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com65	EMPA+LA-ICP-MS	7^{th} (end) - 8^{th}	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com66	EMPA	7^{th} (end) - 8^{th}	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com68	EMPA+LA-ICP-MS	7^{th} (mid)	Lamp	Blue-green	Levantine B - Jalame type	Levant	Jalame-like
Bertini et al. 2020	Com69	EMPA+LA-ICP-MS	8^{th}-9^{th}	Tessera	Blue dark	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com70	EMPA+LA-ICP-MS	8^{th}-9^{th}	Tessera	Red	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com71	EMPA+LA-ICP-MS	8^{th}-9^{th}	Waster	Blue-green	Intermediate*	Egypt	G3.2-like (/G2.1)
Bertini et al. 2020	Com72	EMPA	8^{th}-9^{th}	Bottle/jug	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com73	EMPA+LA-ICP-MS	8^{th}-9^{th}	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com74	EMPA+LA-ICP-MS	8^{th}-9^{th}	Waster	Green olive	HIMT strong	Egypt	HIMTa
Bertini et al. 2020	Com75	EMPA+LA-ICP-MS	8^{th}-9^{th}	Fragment	Green olive	HIMT strong	Egypt	HIMTa
Bertini et al. 2020	Com76	EMPA+LA-ICP-MS	8^{th}-9^{th}	Goblet	Blue-green	Levantine A - Apollonia type	Levant	Jalame-like
Bertini et al. 2020	Com77	EMPA+LA-ICP-MS	8^{th}-9^{th}	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com78	EMPA+LA-ICP-MS	8^{th}-9^{th}	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com81	EMPA	8^{th}-9^{th}	Crucible	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com82	EMPA+LA-ICP-MS	8^{th}-9^{th}	Crucible	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com85	EMPA+LA-ICP-MS	7^{th} (mid)	Fragment	Yellow	Foy 2	Egypt	G2.1HFe
Bertini et al. 2020	Com86	EMPA+LA-ICP-MS	7^{th} (mid)	Waster	Colourless	Intermediate*	Egypt	G3.2-like (/G2.1)
Bertini et al. 2020	Com87	EMPA+LA-ICP-MS	7^{th} (mid)	Tessera	Colourless	Intermediate*	Egypt	G3.2
Bertini et al. 2020	Com88	EMPA	7^{th} (mid)	Tessera	Blue dark	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com89	EMPA+LA-ICP-MS	7^{th} (mid)	Tessera	Blue-green	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com90	EMPA+LA-ICP-MS	7^{th} (mid)	Waster	Blue dark	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com91	EMPA+LA-ICP-MS	7^{th} (mid)	Tessera	White	Intermediate*	Egypt	G3.2-like (/G2.1)
Bertini et al. 2020	Com92	EMPA+LA-ICP-MS	7^{th} (mid)	Tessera	Red	Intermediate*	Egypt	Intermediate
Bertini et al. 2020	Com93	EMPA+LA-ICP-MS	10^{th}	Crucible	Green olive	Intermediate*	Egypt	Egypt
Bertini et al. 2020	Com94	EMPA	10^{th}	Crucible	Green olive	Intermediate*	Egypt	~ G2.1HFe
Bertini et al. 2020	Com95	EMPA+LA-ICP-MS	7^{th} (mid)	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2

Reference	Publ.no.	Analytical techniques	Context chronology	Type	Colour	Bertini et al. (2020)	Area	Compositional group
Bertini et al. 2020	Com96a	EMPA+LA-ICP-MS	8^{th}-9^{th}	Goblet	Blue-green	Intermediate*	-	Intermediate
Bertini et al. 2020	Com96b	EMPA	8^{th}-9^{th}	Goblet	White	Levantine A - Apollonia type	Levant?	-
Bertini et al. 2020	Com97	EMPA+LA-ICP-MS	9^{th}	Waster	Blue-green	Intermediate*	Egypt	G2.1/G2.2
Bertini et al. 2020	Com98	EMPA+LA-ICP-MS	8^{th}-9^{th}	Goblet	Blue-green	Intermediate*	Egypt	G2.1/G2.2
This study	CO23A	EMPA+LA-ICP-MS	8^{th}	Fluidity test	Green		Egypt	G2.1/G2.2
This study	CO23B	EMPA+LA-ICP-MS	8^{th}	Fluidity test	Blue-aqua		Levant	*Apollonia*
This study	CO24	EMPA+LA-ICP-MS	8^{th}	Block	Blue		Egypt	G2.1/G2.2
This study	CO25	EMPA+LA-ICP-MS	8^{th}	*Tessera*	Colourless		Egypt	G3.2
This study	CO58A	EMPA+LA-ICP-MS	9^{th}	Block	Green		Egypt	Intermediate
This study	CO58B	EMPA+LA-ICP-MS	9^{th}	Drop	Green		Egypt	G2.1/G2.2
This study	CO58C	EMPA+LA-ICP-MS	9^{th}	Glass on crucible	Green		Levant	-
This study	CO88	EMPA+LA-ICP-MS	8^{th}	Marbled wall	Green light		Egypt	G3.2-like (/G2.1)
This study	CO92	EMPA+LA-ICP-MS	8^{th}	Goblet	Green light		Egypt	G2.1/G2.2
This study	CO93	EMPA+LA-ICP-MS	8^{th}	Goblet	Green		Egypt	G2.1/G2.2
This study	CO94	EMPA+LA-ICP-MS	8^{th}	Goblet	Green light		Levant	Jalame/*Apollonia*
This study	CO95	EMPA+LA-ICP-MS	8^{th}	Goblet	Green		Egypt	G2.1/G2.2
This study	CO96	EMPA+LA-ICP-MS	8^{th}	Goblet	Green light		Egypt	G2.1/G2.2
This study	CO99	EMPA+LA-ICP-MS	8^{th}	Unknown	Green olive		Egypt	HIMTa
This study	CO100A	EMPA+LA-ICP-MS	8^{th}	Collar	Green-red		Egypt	G2.1/G2.2
This study	CO100B	EMPA+LA-ICP-MS	8^{th}	Block	Green		Egypt	G3.2-like (/G2.1)
This study	CO121A	EMPA+LA-ICP-MS	9^{th}	Drop	Green light		Egypt	G2.1/G2.2
This study	CO121B	EMPA+LA-ICP-MS	9^{th}	Drop	Green light		Egypt	G2.1/G2.2
This study	CO121C	EMPA+LA-ICP-MS	9^{th}	Collar	Green light		Egypt	Intermediate
This study	CO121D	EMPA+LA-ICP-MS	9^{th}	Collar	Green light		Egypt	G2.1/G2.2
This study	CO121E	EMPA+LA-ICP-MS	9^{th}	Block	Green light		Egypt	G3.2-like (/G2.1)
This study	CO122	EMPA+LA-ICP-MS	9^{th}	Block	Blue		Egypt	G2.1/G2.2
This study	CO184A	EMPA+LA-ICP-MS	8^{th}	Cut	Green		Egypt	G2.1/G2.2
This study	CO184B	EMPA+LA-ICP-MS	8^{th}	Block	Green		Egypt	G2.1/G2.2
This study	CO184C	EMPA+LA-ICP-MS	8^{th}	Wall	Green		Egypt	G2.1/G2.2
This study	CO230	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Collar	Green		Levant	*Apollonia*-like
This study	CO233A	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Window	Green		Egypt	Egypt 2 low Na_2O
This study	CO233B	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Window	Green		Egypt	G2.1HFe
This study	CO233C	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Window	Blue		Egypt	G2.1/G2.2
This study	CO325	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Goblet	Green		Egypt	G2.1/G2.2
This study	CO365	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Waste	Green		Levant	*Apollonia*-like
This study	CO366	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Goblet	Green-blue		Levant	*Apollonia*/Jalame
This study	CO368	EMPA+LA-ICP-MS	7^{th} (2^{st} half)	Goblet	Green-aqua		Levant	*Apollonia*
This study	CO530	EMPA+LA-ICP-MS	12^{th}-14^{th}	Lamp?	Green-red		Egypt	G2.1/G2.2

*In Bertini et al. (2020), “Intermediate” means "Heavy recycled/mixed natron (first half 7^{th} to 11^{th} century CE)".

Table S10. Discussion of the Sn-Pb correlation. For converting elements to oxides, the following factors have been used: 1.07722 for Pb to PbO and 1.1347999 for Sn to SnO_2. The lines filled in grey are those corresponding to R^2=0.969.

		Raw values				Alloy/compound calculation		Conversion elements to oxides		
Sample ID	**Colour**	**Sn (ppm)**	**Pb (ppm)**	**Sn/Pb**	**Pb/Sn**	**Sn %**	**Pb %**	**PbO (wt%)**	**SnO_2 (wt%)**	**PbO/SnO_2**
CO58C	Green	183	295	0.62	1.61	38	62	0.032	0.021	1.53
Com89	Blue-green	741	1646	0.45	2.22	31	69	0.177	0.084	2.11
Com58	Blue-green	354	805	0.44	2.27	31	69	0.087	0.040	2.15
Com63	Blue-green	861	2414	0.36	2.80	26	74	0.260	0.098	2.66
Com48	Blue-green	6507	23647	0.28	3.63	22	78	2.547	0.738	3.45
CO230	Green	874	3504	0.25	4.01	20	80	0.377	0.099	3.81
CO100A	Green-red	1801	7719	0.23	4.29	19	81	0.831	0.204	4.07
Com80	Blue-green	278	1245	0.22	4.48	18	82	0.134	0.032	4.25
CO530	Green-red	5277	23672	0.22	4.49	18	82	2.550	0.599	4.26
Com66	Blue-green	2833	12755	0.22	4.50	18	82	1.374	0.321	4.27
CO366	Green-blue	196	893	0.22	4.55	18	82	0.096	0.022	4.31
CO365	Green	137	650	0.21	4.75	17	83	0.070	0.016	4.51
Com93	Green olive	194	927	0.21	4.78	17	83	0.100	0.022	4.54
Com08	Colourless	1124	5793	0.19	5.15	16	84	0.624	0.128	4.89
Com94	Green olive	5883	30604	0.19	5.20	16	84	3.297	0.668	4.94
CO58A	Green	343	1866	0.18	5.44	16	84	0.201	0.039	5.17
Com64	Blue-green	152	834	0.18	5.47	15	85	0.090	0.017	5.19
Com98	Blue-green	2599	14780	0.18	5.69	15	85	1.592	0.295	5.40
Com96a	Blue-green	842	4883	0.17	5.80	15	85	0.526	0.096	5.51
CO121A	Green light	575	3344	0.17	5.81	15	85	0.360	0.065	5.52
CO92	Green light	2875	17683	0.16	6.15	14	86	1.905	0.326	5.84
CO93	Green	706	4578	0.15	6.48	13	87	0.493	0.080	6.15
CO88	Green light	2201	14546	0.15	6.61	13	87	1.567	0.250	6.27
CO96	Green light	896	5929	0.15	6.62	13	87	0.639	0.102	6.28
Com25	Blue-green	424	2807	0.15	6.62	13	87	0.302	0.048	6.28
Com65	Blue-green	193	1283	0.15	6.65	13	87	0.138	0.022	6.31
Com03	Blue-green	2578	17533	0.15	6.80	13	87	1.889	0.293	6.46
Com30	Blue-green	672	4629	0.15	6.89	13	87	0.499	0.076	6.54
Com72	Blue-green	872	6269	0.14	7.19	12	88	0.675	0.099	6.83
Com50	Blue-green	691	4972	0.14	7.20	12	88	0.536	0.078	6.83
Com40	Blue-green	656	4983	0.13	7.60	12	88	0.537	0.074	7.21
CO325	Green	1203	9245	0.13	7.69	12	88	0.996	0.137	7.30
Com02	Blue-green	1700	13267	0.13	7.80	11	89	1.429	0.193	7.41
CO23A	Green	521	4076	0.13	7.83	11	89	0.439	0.059	7.43
CO184A	Green	670	5311	0.13	7.92	11	89	0.572	0.076	7.52
Com36	Blue-green	219	1739	0.13	7.95	11	89	0.187	0.025	7.55
CO233C	Blue	523	4264	0.12	8.16	11	89	0.459	0.059	7.74
Com45	Blue-green	596	4863	0.12	8.16	11	89	0.524	0.068	7.75
Com46	Blue-green	596	4863	0.12	8.16	11	89	0.524	0.068	7.75
Com24	Blue-green	194	1608	0.12	8.30	11	89	0.173	0.022	7.88
Com61	Blue-green	630	5508	0.11	8.74	10	90	0.593	0.072	8.29
Com26	Blue-green	449	3963	0.11	8.82	10	90	0.427	0.051	8.37
Com13	Blue-green	2339	20701	0.11	8.85	10	90	2.230	0.265	8.40
Com01	Blue-green	333	3061	0.11	9.19	10	90	0.330	0.038	8.72
CO121B	Green light	444	4083	0.11	9.20	10	90	0.440	0.050	8.74
Com55	Blue-green	106	979	0.11	9.22	10	90	0.105	0.012	8.75
Com52	Blue-green	840	7795	0.11	9.28	10	90	0.840	0.095	8.81
Com04	Blue-green	2392	22311	0.11	9.33	10	90	2.403	0.271	8.85
CO58B	Green	668	6528	0.10	9.78	9	91	0.703	0.076	9.28
Com39	Blue-green	3250	32277	0.10	9.93	9	91	3.477	0.369	9.43
Com95	Blue-green	4052	42290	0.10	10.44	9	91	4.556	0.460	9.91
Com51	Blue-green	446	4787	0.09	10.74	9	91	0.516	0.051	10.20
Com37	Blue-green	848	9152	0.09	10.79	8	92	0.986	0.096	10.24
Com73	Blue-green	348	3774	0.09	10.83	8	92	0.407	0.040	10.28
CO121D	Green light	417	4635	0.09	11.11	8	92	0.499	0.047	10.55
CO121C	Green light	305	3395	0.09	11.14	8	92	0.366	0.035	10.57
Com78	Blue-green	396	4426	0.09	11.18	8	92	0.477	0.045	10.61
CO184C	Green	421	4725	0.09	11.21	8	92	0.509	0.048	10.64
Com82	Blue-green	183	2081	0.09	11.36	8	92	0.224	0.021	10.79
Com90	Blue dark	208	2480	0.08	11.92	8	92	0.267	0.024	11.31
CO95	Green	381	4603	0.08	12.09	8	92	0.496	0.043	11.48

CO122	Blue	182	2435	0.07	13.39	7	93	0.262	0.021	12.71
Com88	Blue dark	252	3441	0.07	13.65	7	93	0.371	0.029	12.96
Com77	Blue-green	359	4902	0.07	13.67	7	93	0.528	0.041	12.98
CO100B	Green	192	2700	0.07	14.07	7	93	0.291	0.022	13.35
Com97	Blue-green	244	3492	0.07	14.30	7	93	0.376	0.028	13.57
Com71	Blue-green	112	1745	0.06	15.62	6	94	0.188	0.013	14.82
CO184B	Green	261	4389	0.06	16.83	6	94	0.473	0.030	15.98
Com11	Blue-green	315	5717	0.06	18.17	5	95	0.616	0.036	17.25
CO24	Blue	178	3381	0.05	18.95	5	95	0.364	0.020	17.99
Com12	Blue-green	126	2479	0.05	19.68	5	95	0.267	0.014	18.68
Com10	Blue-green	126	3963	0.03	31.47	3	97	0.427	0.014	29.87
Com69	Blue dark	56	1970	0.03	35.14	3	97	0.212	0.006	33.36
Com47	Blue-green	72	2927	0.02	40.84	2	98	0.315	0.008	38.77
Com54	Blue-green	158	17452	0.01	110.79	1	99	1.880	0.018	105.17

Table S11. Discussion of the Cu-Sb correlation.

		Raw values				Ratio		Figure
Sample ID	**Colour**	**Cu (ppm)**	**Sb (ppm)**	**Cu/Sb**	**Sb/Cu**	**Cu%**	**Sb%**	**6B**
Com26	Blue-green	246	2559	0.10	10.40	9	91	
Com69	Blue dark	1937	12740	0.15	6.58	13	87	
Com71	Blue-green	1877	6927	0.27	3.69	21	79	
Com55	Blue-green	216	788	0.27	3.65	22	78	
CO24	Blue	2133	6991	0.31	3.28	23	77	
Com90	Blue dark	2562	6563	0.39	2.56	28	72	
CO122	Blue	2482	6345	0.39	2.56	28	72	
CO58B	Green	1124	2645	0.42	2.35	30	70	
Com58	Blue-green	256	590	0.43	2.31	30	70	
Com12	Blue-green	1603	2582	0.62	1.61	38	62	
CO233C	Blue	2099	3349	0.63	1.60	39	61	
Com30	Blue-green	2535	3631	0.70	1.43	41	59	
Com25	Blue-green	1161	1650	0.70	1.42	41	59	blue
Com24	Blue-green	153	205	0.75	1.34	43	57	blue
Com80	Blue-green	565	711	0.79	1.26	44	56	blue
Com78	Blue-green	2259	2666	0.85	1.18	46	54	blue
Com51	Blue-green	2160	2506	0.86	1.16	46	54	blue
CO184C	Green	2057	2343	0.88	1.14	47	53	blue
Com77	Blue-green	1677	1896	0.88	1.13	47	53	blue
CO121D	Green light	2550	2819	0.90	1.11	48	52	blue
Com50	Blue-green	2175	2346	0.93	1.08	48	52	blue
CO92	Green light	3180	3402	0.93	1.07	48	52	blue
Com45	Blue-green	2930	3113	0.94	1.06	48	52	blue
Com46	Blue-green	2930	3113	0.94	1.06	48	52	blue
Com61	Blue-green	2003	2126	0.94	1.06	49	51	blue
CO184B	Green	2098	2196	0.96	1.05	49	51	blue
CO23A	Green	885	924	0.96	1.04	49	51	blue
Com81	Blue-green	1840	1909	0.96	1.04	49	51	blue
Com47	Blue-green	1427	1473	0.97	1.03	49	51	blue
CO88	Green light	1561	1608	0.97	1.03	49	51	blue
CO93	Green	1742	1788	0.97	1.03	49	51	blue
CO121C	Green light	1491	1516	0.98	1.02	50	50	blue
CO58A	Green	797	797	1.00	1.00	50	50	blue
CO184A	Green	1908	1906	1.00	1.00	50	50	blue
Com36	Blue-green	475	469	1.01	0.99	50	50	blue
Com97	Blue-green	1877	1849	1.02	0.98	50	50	blue
Com73	Blue-green	2134	2083	1.02	0.98	51	49	blue
CO95	Green	1805	1745	1.03	0.97	51	49	blue
CO121A	Green light	1233	1189	1.04	0.96	51	49	blue
Com72	Blue-green	2932	2795	1.05	0.95	51	49	blue
Com10	Blue-green	2112	1982	1.07	0.94	52	48	blue
Com27	Blue-green	2476	2251	1.10	0.91	52	48	blue
Com01	Blue-green	1443	1311	1.10	0.91	52	48	blue
CO100B	Green	1548	1404	1.10	0.91	52	48	blue
Com11	Blue-green	1830	1580	1.16	0.86	54	46	blue
Com82	Blue-green	730	609	1.20	0.83	55	45	blue
CO366	Green-blue	348	273	1.27	0.79	56	44	blue
Com52	Blue-green	3709	2775	1.34	0.75	57	43	
CO121B	Green light	1882	1389	1.36	0.74	58	42	
Com40	Blue-green	900	574	1.57	0.64	61	39	
Com37	Blue-green	3667	2185	1.68	0.60	63	37	
Com98	Blue-green	2574	1468	1.75	0.57	64	36	

Com64	Blue-green	203	106	1.91	0.52	66	34
Com39	Blue-green	2779	1429	1.94	0.51	66	34
CO96	Green light	2579	1263	2.04	0.49	67	33
CO100A	Green-red	2290	1100	2.08	0.48	68	32
Com66	Blue-green	2184	1039	2.10	0.48	68	32
Com65	Blue-green	189	86	2.19	0.46	69	31
Com63	Blue-green	1134	504	2.25	0.44	69	31
Com96a	Blue-green	1278	519	2.46	0.41	71	29
CO58C	Green	105	42	2.51	0.40	72	28
Com54	Blue-green	6950	2634	2.64	0.38	73	27
CO325	Green	1986	718	2.77	0.36	73	27
CO365	Green	205	73	2.83	0.35	74	26
CO230	Green	607	209	2.90	0.34	74	26
Com13	Blue-green	2532	775	3.27	0.31	77	23
Com95	Blue-green	11823	2448	4.83	0.21	83	17
Com94	Green olive	4474	825	5.42	0.18	84	16
Com02	Blue-green	2148	237	9.08	0.11	90	10
CO530	Green-red	7270	301	24.14	0.04	96	4
Com48	Blue-green	7813	248	31.52	0.03	97	3
Com89	Blue-green	1679	36	46.26	0.02	98	2

Table S12. Discussion of the Sb-Pb correlation.

		Raw data				Ratio		Figure 6C
Sample ID	**Colour**	**Sb (ppm)**	**Pb (ppm)**	**Pb/Sb**	**Sb/Pb**	**Sb%**	**Pb%**	
Com48	Blue-green	248	23647	95.39	0.01	1	99	
CO530	Green-red	301	23672	78.62	0.01	1	99	
Com02	Blue-green	237	13267	56.08	0.02	2	98	
Com89	Blue-green	36	1646	45.35	0.02	2	98	
Com94	Green olive	825	30604	37.10	0.03	3	97	
Com13	Blue-green	775	20701	26.70	0.04	4	96	
Com39	Blue-green	1429	32277	22.58	0.04	4	96	
Com95	Blue-green	2448	42290	17.27	0.06	5	95	
CO230	Green	209	3504	16.76	0.06	6	94	
Com65	Blue-green	86	1283	14.86	0.07	6	94	
Com93	Green olive	67	927	13.85	0.07	7	93	
CO325	Green	718	9245	12.88	0.08	7	93	
Com66	Blue-green	1039	12755	12.28	0.08	8	92	
Com98	Blue-green	1468	14780	10.07	0.10	9	91	
Com96a	Blue-green	519	4883	9.42	0.11	10	90	
CO88	Green light	1608	14546	9.05	0.11	10	90	
CO365	Green	73	650	8.96	0.11	10	90	
Com40	Blue-green	574	4983	8.69	0.12	10	90	
Com24	Blue-green	205	1608	7.84	0.13	11	89	
Com64	Blue-green	106	834	7.83	0.13	11	89	
CO100A	Green-red	1100	7719	7.02	0.14	12	88	
CO58C	Green	42	295	7.01	0.14	12	88	
Com54	Blue-green	2634	17452	6.62	0.15	13	87	
CO92	Green light	3402	17683	5.20	0.19	16	84	
Com63	Blue-green	504	2414	4.79	0.21	17	83	
CO96	Green light	1263	5929	4.70	0.21	18	82	
CO23A	Green	924	4076	4.41	0.23	18	82	
Com37	Blue-green	2185	9152	4.19	0.24	19	81	
Com36	Blue-green	469	1739	3.71	0.27	21	79	
Com11	Blue-green	1580	5717	3.62	0.28	22	78	
Com82	Blue-green	609	2081	3.42	0.29	23	77	red
CO366	Green-blue	273	893	3.26	0.31	23	77	red
CO121B	Green light	1389	4083	2.94	0.34	25	75	red
CO121A	Green light	1189	3344	2.81	0.36	26	74	red
Com52	Blue-green	2775	7795	2.81	0.36	26	74	red
CO184A	Green	1906	5311	2.79	0.36	26	74	red
CO95	Green	1745	4603	2.64	0.38	27	73	red
Com61	Blue-green	2126	5508	2.59	0.39	28	72	red
Com77	Blue-green	1896	4902	2.59	0.39	28	72	red
CO93	Green	1788	4578	2.56	0.39	28	72	red
CO58B	Green	2645	6528	2.47	0.41	29	71	red
CO58A	Green	797	1866	2.34	0.43	30	70	red
Com01	Blue-green	1311	3061	2.33	0.43	30	70	red
Com72	Blue-green	2795	6269	2.24	0.45	31	69	red
CO121C	Green light	1516	3395	2.24	0.45	31	69	red
Com50	Blue-green	2346	4972	2.12	0.47	32	68	orange
CO184C	Green	2343	4725	2.02	0.50	33	67	orange
Com10	Blue-green	1982	3963	2.00	0.50	33	67	orange
CO184B	Green	2196	4389	2.00	0.50	33	67	orange
Com47	Blue-green	1473	2927	1.99	0.50	33	67	orange
Com27	Blue-green	2251	4369	1.94	0.52	34	66	orange
CO100B	Green	1404	2700	1.92	0.52	34	66	orange
Com51	Blue-green	2506	4787	1.91	0.52	34	66	orange
Com97	Blue-green	1849	3492	1.89	0.53	35	65	orange
Com73	Blue-green	2083	3774	1.81	0.55	36	64	orange
Com80	Blue-green	711	1245	1.75	0.57	36	64	orange
Com25	Blue-green	1650	2807	1.70	0.59	37	63	orange
Com78	Blue-green	2666	4426	1.66	0.60	38	62	orange
CO121D	Green light	2819	4635	1.64	0.61	38	62	orange
Com81	Blue-green	1909	3017	1.58	0.63	39	61	yellow
Com45	Blue-green	3113	4863	1.56	0.64	39	61	yellow
Com46	Blue-green	3113	4863	1.56	0.64	39	61	yellow
Com26	Blue-green	2559	3963	1.55	0.65	39	61	yellow
Com58	Blue-green	590	805	1.36	0.73	42	58	yellow
Com30	Blue-green	3631	4629	1.28	0.78	44	56	yellow

CO233C	Blue	3349	4264	1.27	0.79	44	56	yellow
Com55	Blue-green	788	979	1.24	0.80	45	55	yellow
Com12	Blue-green	2582	2479	0.96	1.04	51	49	
CO233B	Green	101	80	0.80	1.25	56	44	
CO24	Blue	6991	3381	0.48	2.07	67	33	
CO122	Blue	6345	2435	0.38	2.61	72	28	
Com90	Blue dark	6563	2480	0.38	2.65	73	27	
Com71	Blue-green	6927	1745	0.25	3.97	80	20	
Com69	Blue dark	12740	1970	0.15	6.47	87	13	
CO121E	Green light	2019	22	0.01	91.61	99	1	

Table S13. Calculation of bronze and brass hypothetical alloys.

Sample ID	Zn	Cu%	Zn%
Com54	161	98	2
Com46	128	96	4
Com61	104	95	5
Com72	142	95	5
CO184C	114	95	5
Com39	158	95	5
Com90	150	94	6
Com95	723	94	6
CO96	187	93	7
Com37	287	93	7
Com97	131	93	7
Com81	147	93	7
Com25	102	92	8
Com50	182	92	8
CO184A	166	92	8
Com45	265	92	8
Com27	217	92	8
Com52	364	91	9
Com73	214	91	9
Com78	222	91	9
CO23A	102	90	10
CO100A	255	90	10
Com47	161	90	10
CO88	186	89	11
CO58B	142	89	11
Com10	268	89	11
Com12	190	89	11
CO325	267	88	12
Com11	246	88	12
Com51	285	88	12
Com71	246	88	12
Com77	252	87	13
Com13	428	86	14
CO92	589	84	16
Com98	482	84	16
Com94	905	83	17
Com66	506	81	19
Com02	527	80	20
Com40	230	80	20
Com96a	316	80	20
Com82	220	77	23
CO230	194	76	24
Com48	2455	76	24
Com36	161	75	25
CO530	2442	75	25
Com58	153	63	37
Com89	1154	59	41
Com24	142	52	48
Com26	241	51	49
Com64	198	51	49
Com55	206	51	49
Com65	364	34	66

Sample ID	Sn	Cu%	Sn%
Com54	158	98	2
Com10	126	94	6
Com71	112	94	6
CO122	182	93	7
Com12	126	93	7
CO24	178	92	8
Com90	208	92	8
CO100B	192	89	11
CO184B	261	89	11
Com97	244	88	12
CO121D	417	86	14
Com73	348	86	14
Com11	315	85	15
Com78	396	85	15
Com45	596	83	17
Com46	596	83	17
CO121C	305	83	17
CO184C	421	83	17
CO95	381	83	17
Com51	446	83	17
Com52	840	82	18
Com77	359	82	18
CO121B	444	81	19
Com01	333	81	19
Com37	848	81	19
CO233C	523	80	20
Com82	183	80	20
Com30	672	79	21
Com72	872	77	23
Com50	691	76	24
Com61	630	76	24
CO184A	670	74	26
CO96	896	74	26
Com95	4052	74	26
Com25	424	73	27
CO93	706	71	29
CO58A	343	70	30
Com89	741	69	31
CO121A	575	68	32
Com36	219	68	32
Com55	106	67	33
Com80	278	67	33
CO366	196	64	36
CO23A	521	63	37
CO58B	668	63	37
CO325	1203	62	38
CO365	137	60	40
Com96a	842	60	40
Com40	656	58	42
CO530	5277	58	42
Com64	152	57	43
Com63	861	57	43
Com02	1700	56	44
CO100A	1801	56	44
Com48	6507	55	45
CO92	2875	53	47
Com13	2339	52	48
Com98	2599	50	50
Com65	193	49	51
Com39	3250	46	54
Com24	194	44	56
Com66	2833	44	56
Com94	5883	43	57
Com58	354	42	58
CO88	2201	41	59
CO230	874	41	59
CO58C	183	37	63
Com26	449	35	65

Sample ID	Cu%	Zn%	Sn%
Com54	96	2	2
Com47	86	10	4
Com10	84	11	5
Com71	84	11	5
CO122	91	3	7
Com90	88	5	7
Com12	84	10	7
CO24	90	2	8
CO100B	87	2	11
CO184B	87	2	11
Com97	83	6	11
Com73	79	8	13
Com11	77	10	13
CO121D	83	3	14
Com78	79	8	14
Com51	75	10	15
CO121C	80	3	16
Com46	80	4	16
CO184C	79	4	16
Com45	77	7	16
Com77	73	11	16
Com82	64	19	16
CO95	80	3	17
Com52	75	7	17
CO121B	78	3	18
Com01	79	3	18
Com37	76	6	18
CO233C	78	3	19
Com55	41	39	20
Com89	47	32	21
Com72	74	4	22
Com61	73	4	23
Com50	71	6	23
Com95	71	4	24
CO96	70	5	24
CO184A	70	6	24
Com25	69	6	25
Com36	56	19	26
Com65	25	49	26
CO93	69	3	28
CO58A	66	5	28
Com64	37	36	28
Com80	62	8	30
CO121A	66	4	31
CO366	59	7	33
CO23A	59	7	35
CO58B	58	7	35
CO325	57	8	35
Com96a	52	13	35
CO530	48	16	35
Com40	50	13	37
CO365	57	5	38
Com02	49	12	39
Com48	47	15	39
Com24	31	29	40
CO100A	53	6	41
CO92	48	9	43
Com13	48	8	44
Com98	46	9	46
Com58	34	20	46
Com26	26	26	48
Com66	40	9	51
Com94	40	8	52
CO230	36	12	52
Com39	45	3	53
CO88	40	5	56
CO58C	32	11	56

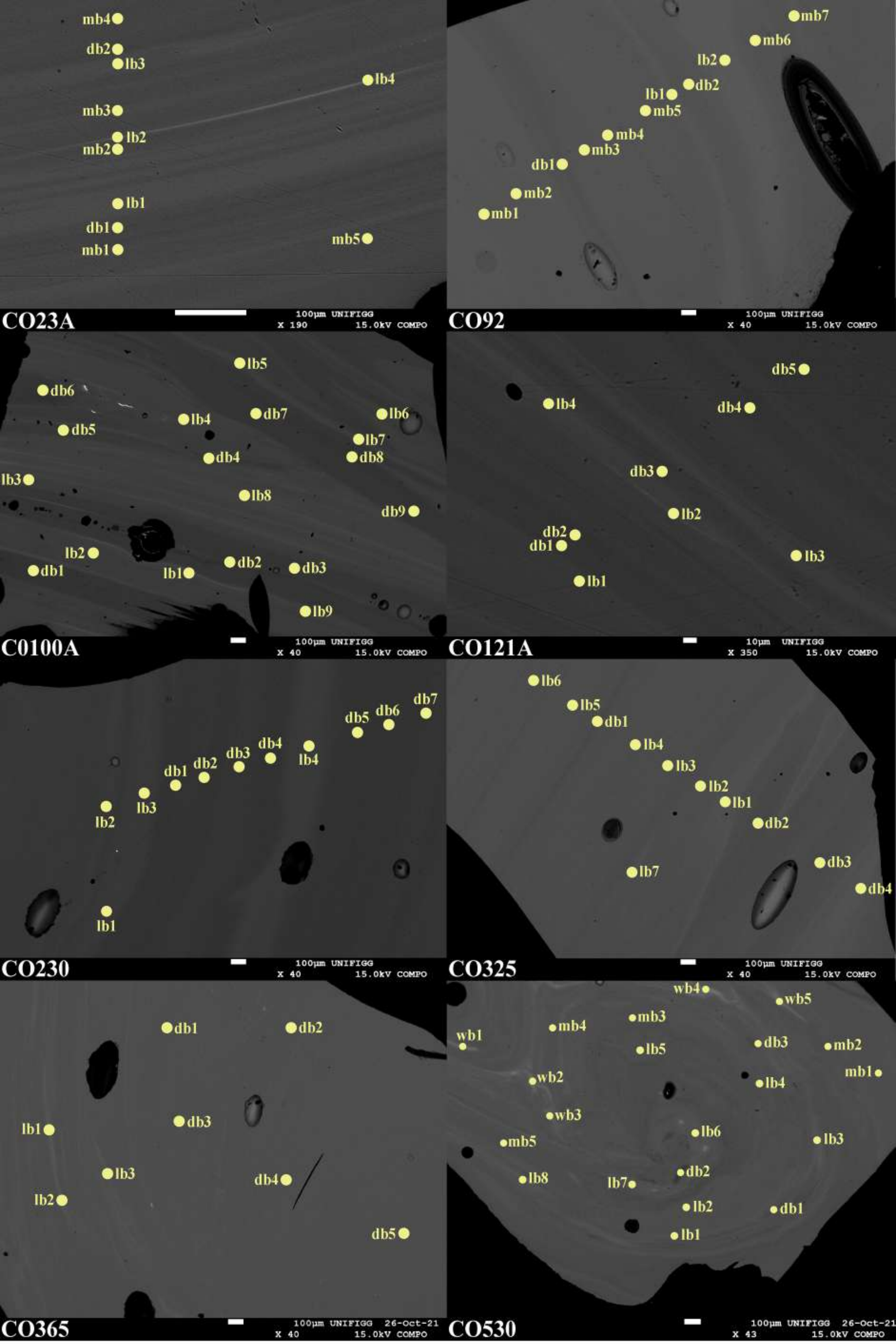

Figure S1. Banded samples CO23A, 92, 100A, 121A, 230, 325, 365 and 530. The spot analysis is reported in Supplementary Table S4.

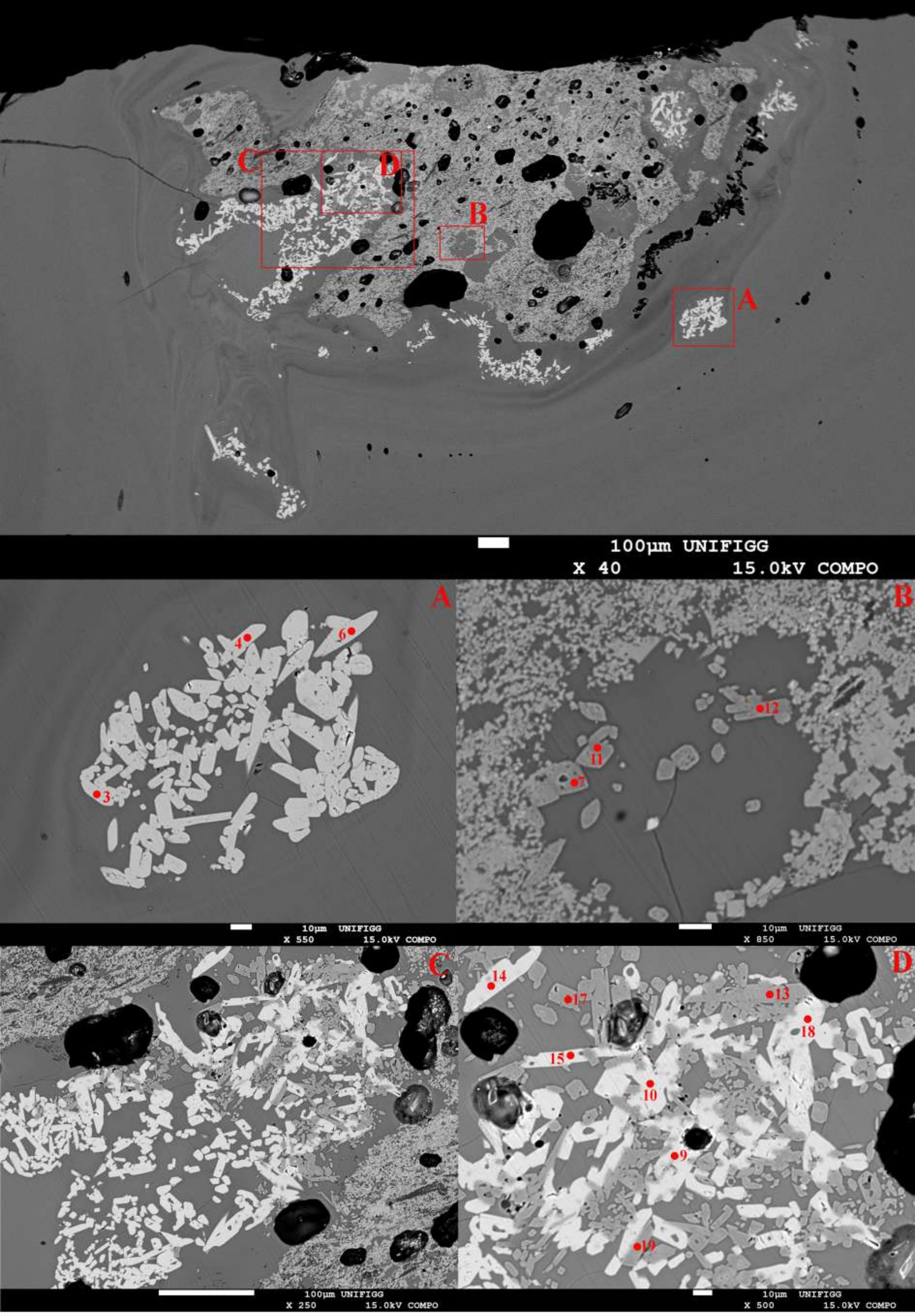

Figure S2. The sample CO23. Spot analyses are provided in Tables S6 and S7.

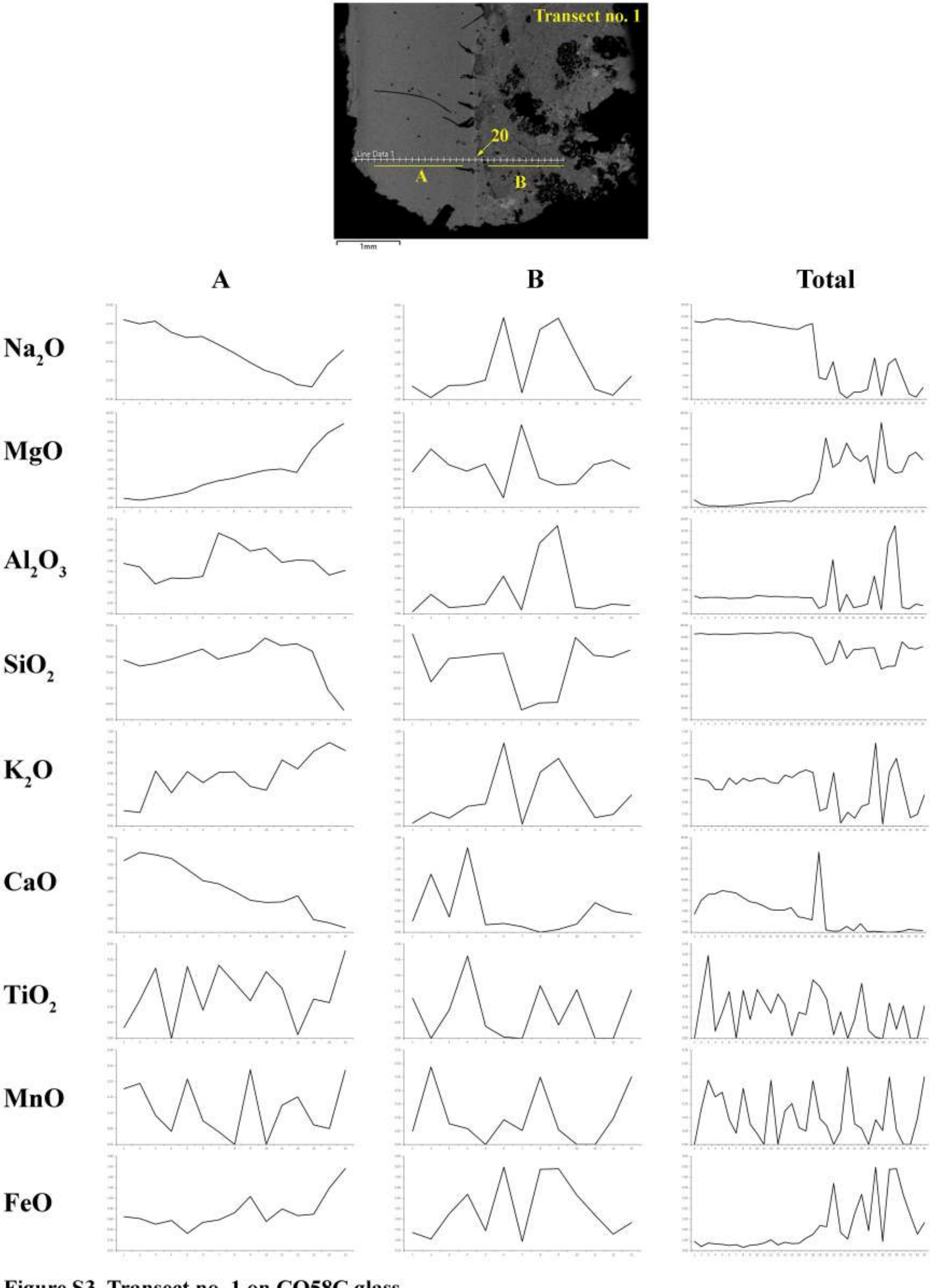

Figure S3. Transect no. 1 on CO58C glass.

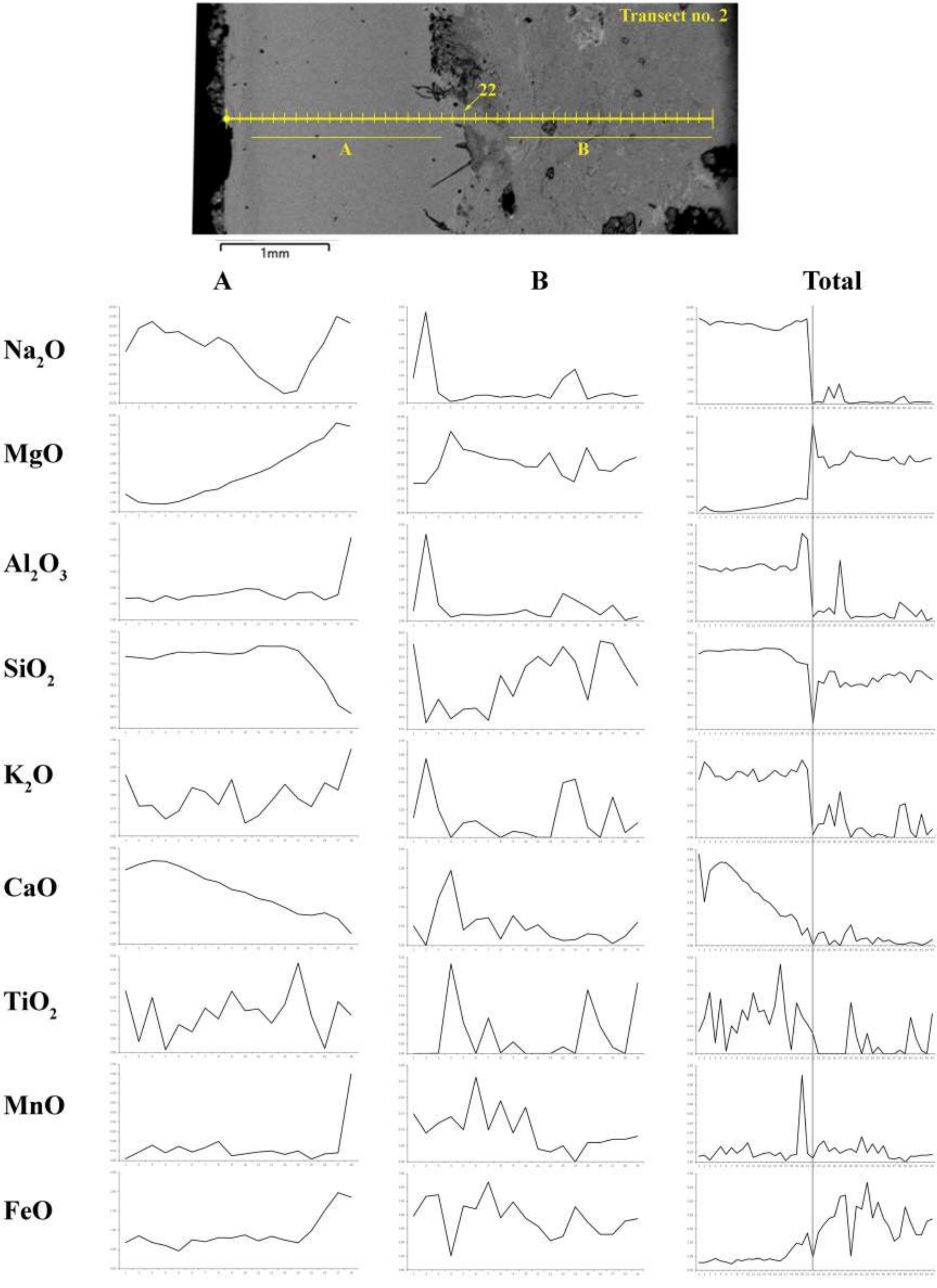

Figure S4. Transect no. 2 on CO58C glass.

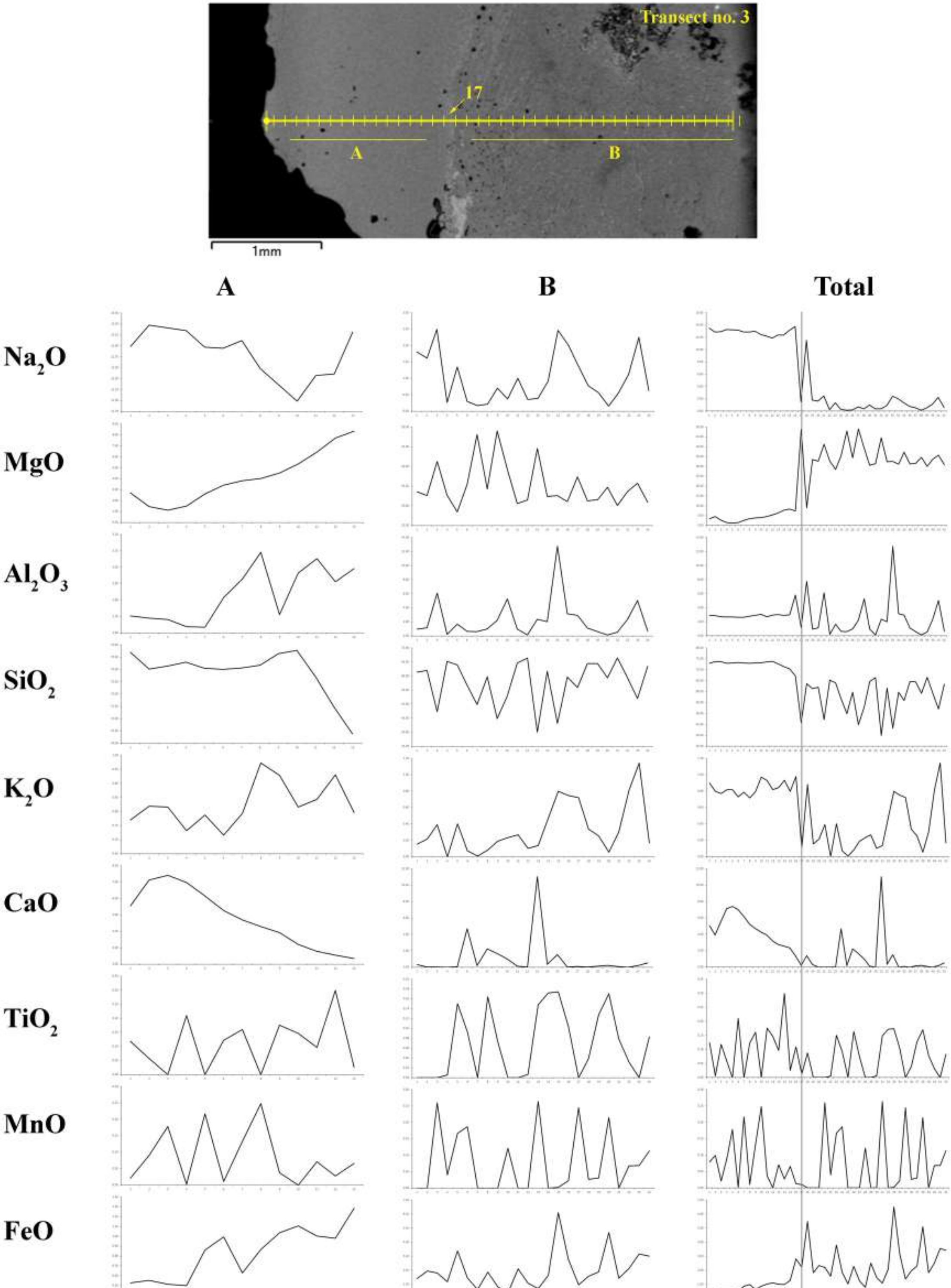

Figure S5. Transect no. 3 on CO58C glass.

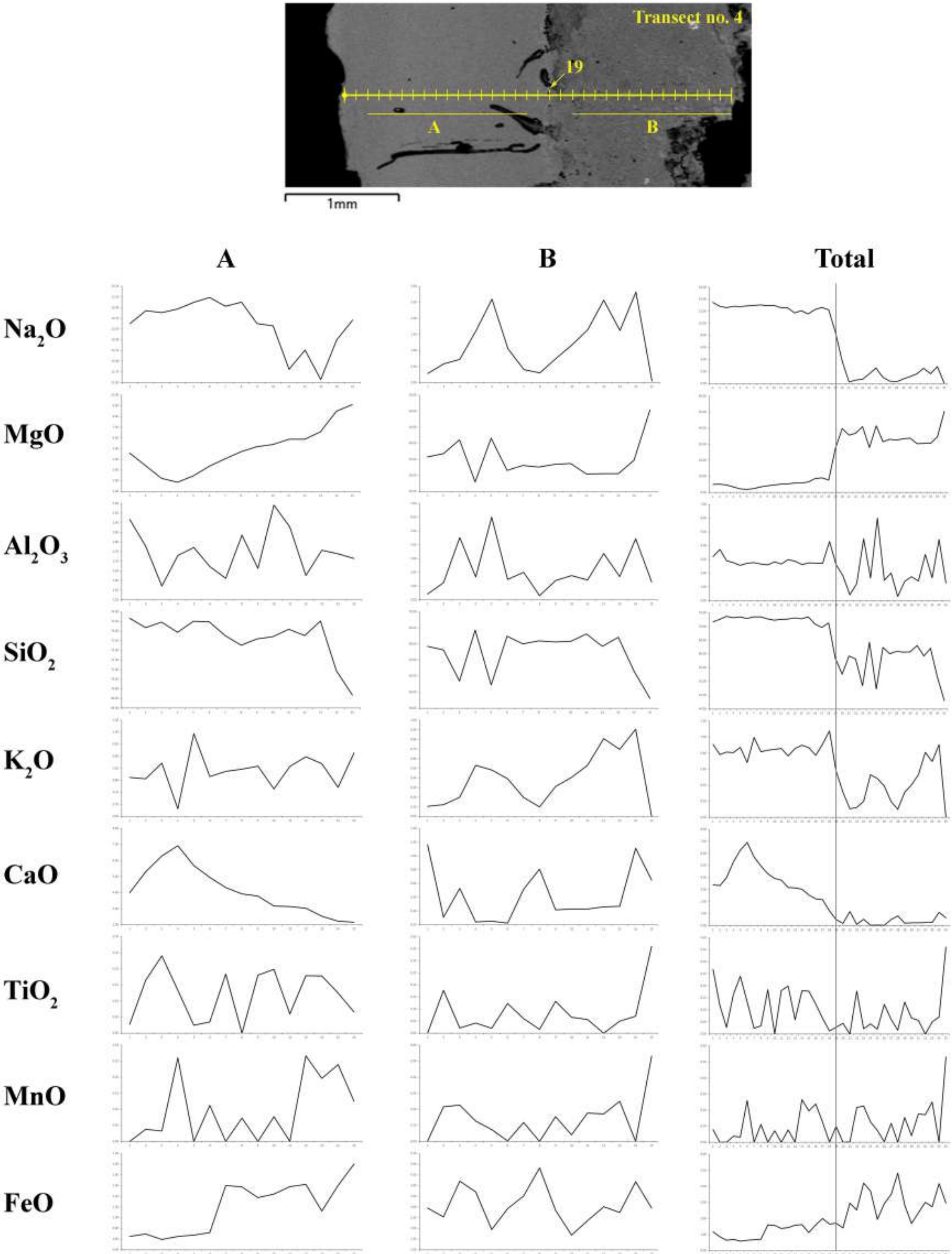

Figure S6. Transect no. 4 on CO58C glass.

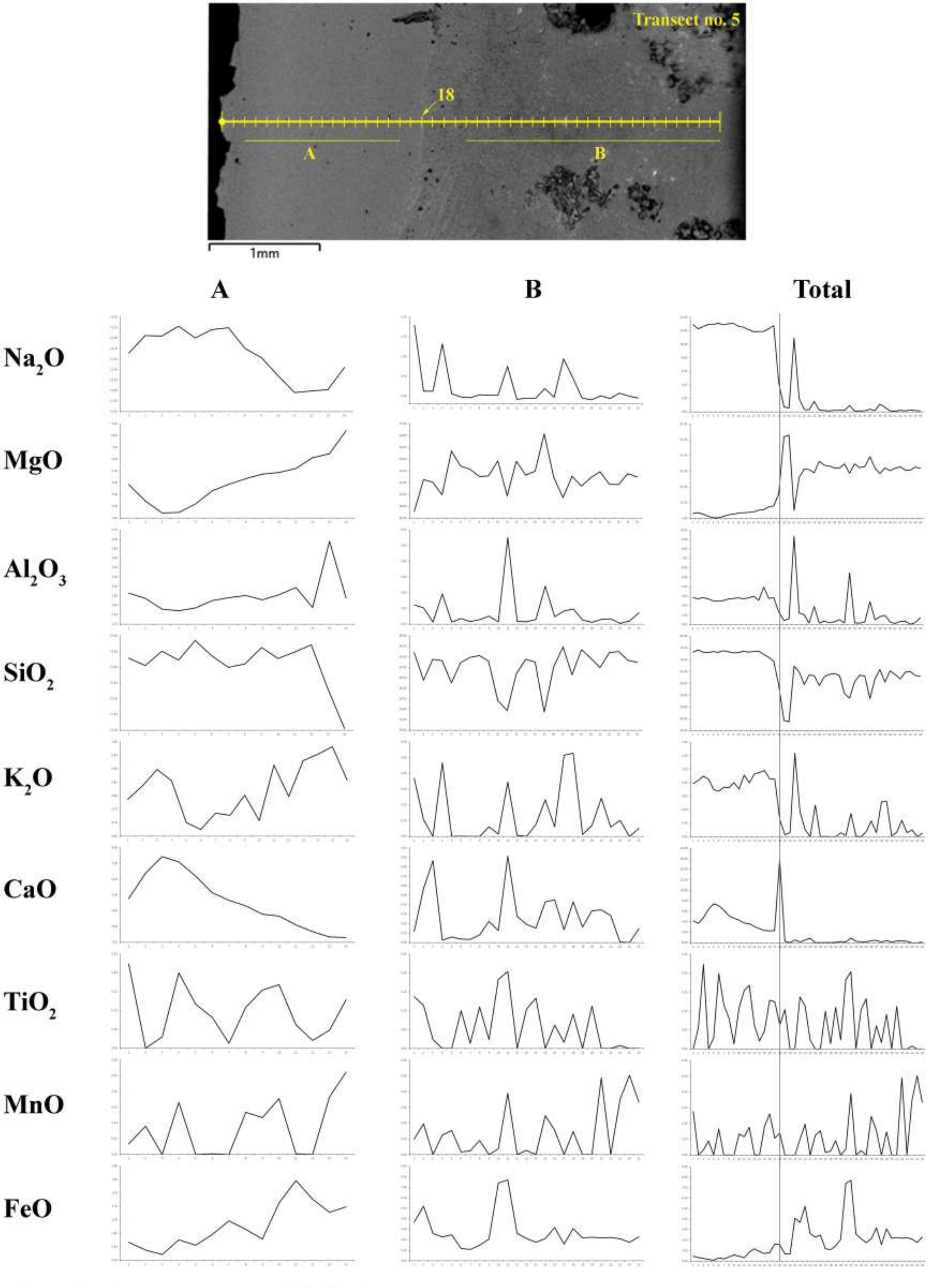

Figure S7. Transect no. 5 on CO58C glass.

Appendix.

In the following pages, Cu, Zn, Sn, Sb and Pb values have been recalculated, assuming they were introduced as unalloyed copper, bronze, brass, ternary Cu-Zn-Sn alloy (indicated as gunmetal), lead antimonate and lead stannate.

The observed correlations are also specified next to the sample number at the top of the page.

In the table, each row corresponds to a possible combination (indicated in the last column on the right) and the numbers indicate the percentages of each compound. The “raw” alloys -calculated based on the absolute element contents are listed in the first raw in blue, orange, red and black.

As for the colours:

- blue text means the calculated alloy is reasonable.
- orange text indicates that alloying is possible but not frequent or unlikely.
- red text means that the calculated alloy is not reasonable.
- orange highlighting distinguishes values obtained using constraint no. 1, *i.e.* arbitrarily fixing the composition of the bronze alloy to $Cu_{90}Sn_{10}$.
- green highlighting is for values obtained using constraint no. 2, *i.e*. arbitrarily fixing the composition of Pb antimonate to $Sb_{42}Pb_{58}$.
- blue highlighting marks the values obtained with constraint no. 3, *i.e.* arbitrarily fixing both the composition of the bronze alloy to $Cu_{90}Sn_{10}$and the composition of the Pb antimoniate to $Sb_{42}Pb_{58}$.
- Dark orange highlighting is used for the calculation of a gunmetal alloy where the Sn value is brought to match that of Zn (*i.e.* to the lowest value).

The last rows outside the table specify how much Pb and Sn remain free after setting the I, II and III constraints, respectively.

Lastly, the vertical thick lines at the end of the last column indicates which combinations were considered the most reasonable and reported in the summary tables at the end of the sheets provided for each sample.

Com01 – Correlations Cu/Sb (1.10), SnPb, red group lead antimonates ($Sb_{30}Pb_{70}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	1443	51	333	1311	3061	6199

						Pb									
			Sn												
	Cu								Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 51 ppm Zn content as "natural")	
			$Cu_{81}Sn_{19}$	$Cu_{90}Sn_{10}$		$Sn_{10}Pb_{90}$			$Sb_{42}Pb_{58}$	$Sb_{30}Pb_{70}$					
Unalloyed	23					55					21	100	✓		Unalloyed Cu + SnPb + Sb
	23							50			21	95	x	333 ppm Sn	Unalloyed Cu + Pb + Sb
	23									71		95	x	333 ppm Sn	Unalloyed Cu + SbPb
	23							20	51			95	x	333 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{21}Pb_{79}$								
	23						26		51			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			29			55					21	105	✓	[Sn counted twice]	Bronze + SnPb + Sb
			29					50			21	100	✓		Bronze + Pb + Sb
			29							71		100	✓		Bronze + SbPb
			29					20	51			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{21}Pb_{79}$								
			29				26		51			105	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							$Sn_{5}Pb_{95}$								
				26			43				21	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{12}Pb_{88}$								
				26			23		51			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 41% Pb free (1250 ppm)
II costraint $Cu_{90}Sn_{10}$ → 52% Sn free (173 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com02 – Correlation strong SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	2148	527	1700	237	13267	17878

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 527 ppm Zn content as "non natural")		
		$Cu_{80}Zn_{20}$	$Cu_{56}Sn_{44}$	$Cu_{90}Sn_{10}$	$Cu_{49}Sn_{39}Zn_{12}$	$Cu_{67}Sn_{16}Zn_{16}$	$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	Sb_2Pb_{98}					
Unalloyed	12						84					1	97	x	527 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	12								74			1	88	x	1700 ppm Sn + 527 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	12										76		88	x	1700 ppm Sn + 527 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	12								72	3			88	x	1700 ppm Sn + 527 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{12}Pb_{88}$								
Unalloyed	12							82		3			97	x	527 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		15					84					1	100	✓		Brass + SnPb + Sb
Brass		15							74			1	90	x	1700 ppm Sn	Brass + Pb + Sb
Brass		15									76		90	x	1700 ppm Sn	Brass + SbPb
Brass		15							72*	3			90	x	1700 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		15						82		3			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			22				84					1	107	x	527 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			22						74			1	97	x	527 ppm Zn	Bronze + Pb + Sb
Bronze			22								76		97	x	527 ppm Zn	Bronze + SbPb
Bronze			22						72*	3			97	x	527 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{12}Pb_{88}$								
Bronze			22					82		3			107	x	527 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{10}Pb_{90}$								
Bronze				13				82				1	97	x	527 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{10}Pb_{90}$								
Bronze				13				81		3			97	x	527 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					24		84					1	110	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					24				74			1	100	✓		Gunmetal + Pb + Sb
Gunmetal					24						76		100	✓		Gunmetal + SbPb
Gunmetal					24				72*	3			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_8Pb_{92}								
Gunmetal						18		79		3			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 98% Pb free (12940 ppm)
II costraint $Cu_{90}Sn_{10}$ → 86% Sn free (1461 ppm)
III costraint : gunmetal with Sn=Zn → 69% Sn free (1173 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com10 – Correlations Cu/Sb (1.07), SnPb, orange group lead antimonates.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2112	268	126	1982	3963	8451

									Pb							
					Sn						Sb					
				Cu												
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 268 ppm Zn content as "non natural")	
		$Cu_{89}Zn_{11}$	$Cu_{94}Sn_{6}$	$Cu_{90}Sn_{10}$	$Cu_{84}Sn_{5}Zn_{11}$	$Cu_{80}Sn_{10}Zn_{10}$	$Sn_{3}Pb_{97}$			$Sb_{42}Pb_{58}$	$Sb_{33}Pb_{67}$					
Unalloyed	25						48					23	97	x	268 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	25								47			23	95	x	126 ppm Sn + 268 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	25										70		95	x	126 ppm Sn + 268 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	25								15	56			95	x	126 ppm Sn + 268 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{9}Pb_{91}$								
Unalloyed	25							16		56			97	x	268 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		28					48					23	100	✓		Brass + SnPb + Sb
Brass		28							47			23	99	x	126 ppm Sn	Brass + Pb + Sb
Brass		28									70		99	x	126 ppm Sn	Brass + SbPb
Brass		28							15*	56			99	x	126 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		28						16		56			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				48					23	98	x	268 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			26						47			23	97	x	268 ppm Zn	Bronze + Pb + Sb
Bronze			26								70		97	x	268 ppm Zn	Bronze + SbPb
Bronze			26						15*	56			97	x	268 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{9}Pb_{91}$								
Bronze			26					16		56			98	x	268 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Low Sn								
Bronze				28				-				23	-	x	-	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Low Sn								
Bronze				28				-		56				x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					30		48					23	101	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					30				47			23	100	✓		Gunmetal + Pb + Sb
Gunmetal					30						70		100	✓		Gunmetal + SbPb
Gunmetal					30				15*	56			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Sn								
Gunmetal						31		-		56			100	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 31% Pb free (1226 ppm)
II costraint $Cu_{90}Sn_{10}$ → 86% Sn less (109 ppm missing)
III costraint : gunmetal with Sn=Zn → 113% Sn less (142 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com11 – Correlations Cu/Sb (1.16), SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	1830	246	315	1580	5717	9687

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 246 ppm Zn content as "non natural")	
		$Cu_{88}Zn_{12}$	$Cu_{85}Sn_{15}$	$Cu_{90}Sn_{10}$	$Cu_{77}Sn_{13}Zn_{10}$	$Cu_{79}Sn_{11}Zn_{11}$	Sn_5Pb_{95}			$Sb_{42}Pb_{58}$	$Sb_{22}Pb_{78}$					
Unalloyed	19						62					16	97	x	246 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	19								59			16	94	x	315 ppm Sn + 246 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	19										75		94	x	315 ppm Sn + 246 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	19								37	39			94	x	315 ppm Sn + 246 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	19							Sn_8Pb_{92} 40		39			97	x	246 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		21					62					16	100	✓		Brass + SnPb + Sb
Brass		21							59			16	97	x	315 ppm Sn	Brass + Pb + Sb
Brass		21									75		97	x	315 ppm Sn	Brass + SbPb
Brass		21							37*	39			97	x	315 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		21						40		39			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			22				62					16	101	x	246 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			22						59			16	97	x	246 ppm Zn	Bronze + Pb + Sb
Bronze			22								75		97	x	246 ppm Zn	Bronze + SbPb
Bronze			22						36*	39			97	x	246 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			22					Sn_8Pb_{92} 40		39			101	x	246 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				21				Sn_2Pb_{98} 60				16	97	x	246 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				21				Sn_3Pb_{97} 38		39			97	x	246 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					25		62					16	103	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					25				59			16	100	✓		Gunmetal + Pb + Sb
Gunmetal					25						75		100	✓		Gunmetal + SbPb
Gunmetal					25				36*	39			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						24		Sn_2Pb_{98} 37		39			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 62% Pb free (3535 ppm)
II costraint $Cu_{90}Sn_{10}$ → 35% Sn free (111 ppm)
III costraint : gunmetal with Sn=Zn → 22% Sn free (68 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com12 – Correlation SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	1603	190	126	2582	2479	6980

	Cu	Cu	Cu	Cu	Cu	Cu	Sn	Sn / Pb	Pb	Pb / Sb	Sb	Sb				
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 190 ppm Zn content as “non natural”)	
		$Cu_{89}Zn_{11}$	$Cu_{93}Sn_{7}$	$Cu_{90}Sn_{10}$	$Cu_{84}Sn_{7}Zn_{10}$	$Cu_{81}Sn_{10}Zn_{10}$	$Sn_{5}Pb_{95}$			$Sb_{42}Pb_{58}$	$Sb_{51}Pb_{49}$					
Unalloyed	23						37					37	97	x	190 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	23								36			37	95	x	126 ppm Sn + 190 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	23										73		95	x	126 ppm Sn + 190 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	23								-	Low Pb			96	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								Low Sn								
Unalloyed	23							-		Low Pb				x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		26					37					37	100	✓		Brass + SnPb + Sb
Brass		26							36			37	98	x	126 ppm Sn	Brass + Pb + Sb
Brass		26									73		98	x	126 ppm Sn	Brass + SbPb
Brass		26							-	Low Pb			98	x	-	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		26						-		Low Pb			100	x	-	Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			25				37					37	99	x	190 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			25						36			37	97	x	190 ppm Zn	Bronze + Pb + Sb
Bronze			25								73		97	x	190 ppm Zn	Bronze + SbPb
Bronze			25						-	Low Pb			-	x	190 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Sn								
Bronze			25					-		Low Pb			-	x	190 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Low Sn								
Bronze				26				-				37	-	x	190 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				26				-		Low Pb			-	x	190 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					27		37					37	102	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					27				36			37	100	✓		Gunmetal + Pb + Sb
Gunmetal					27						73		100	✓		Gunmetal + SbPb
Gunmetal					27				-	Low Pb			100	x	-	Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						28		-		Low Pb			100	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 44% Pb less (1087 ppm missing)
II costraint $Cu_{90}Sn_{10}$ → 41% Sn less (52 ppm missing)
III costraint : gunmetal with Sn=Zn → 51% Sn less (64 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com13 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	2532	428	2339	775	20701	26777

								Pb								
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 428 ppm Zn content as “non natural”)	
		$Cu_{86}Zn_{14}$	$Cu_{52}Sn_{48}$	$Cu_{90}Sn_{10}$	$Cu_{48}Sn_{44}Zn_{8}$	$Cu_{75}Sn_{13}Zn_{13}$	$Sn_{10}Pb_{90}$			$Sb_{42}Pb_{58}$	$Sb_{4}Pb_{96}$					
Unalloyed	9						86					3	98	x	428 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	9								77			3	90	x	2339 ppm Sn + 428 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	9										80		90	x	2339 ppm Sn + 428 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	9								73	7			90	x	2339 ppm Sn + 428 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{11}Pb_{89}$								
Unalloyed	9							82		7			98	x	428 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		11					86					3	100	✓		Brass + SnPb + Sb
Brass		11							77			3	91	x	2339 ppm Sn	Brass + Pb + Sb
Brass		11									80		91	x	2339 ppm Sn	Brass + SbPb
Brass		11							73	7			91	x	2339 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		11						82		7			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			18				86					3	107	x	428 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			18						77			3	98	x	428 ppm Zn	Bronze + Pb + Sb
Bronze			18								80		98	x	428 ppm Zn	Bronze + SbPb
Bronze			18						73	7			98	x	428 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{11}Pb_{89}$								
Bronze			18					82		7			107	x	428 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{9}Pb_{91}$								
Bronze				11				85				3	98	x	428 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{9}Pb_{91}$								
Bronze				11				81		7			98	x	428 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					20		86					3	109	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					20				77			3	100	✓		Gunmetal + Pb + Sb
Gunmetal					20						80		100	✓		Gunmetal + SbPb
Gunmetal					20				73	7			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{9}Pb_{91}$								
Gunmetal						13		80		7			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 95% Pb free (19631 ppm)
II costraint $Cu_{90}Sn_{10}$ → 88% Sn free (2058 ppm)
III costraint : gunmetal with Sn=Zn → 82% Sn free (1911 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com24 – Correlations Cu/Sb (0.75), strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	153	142	194	205	1608	2301

									Pb							
				Sn												
			Cu								Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 142 ppm Zn content as “non natural”)	
		$Cu_{52}Zn_{48}$	$Cu_{44}Sn_{56}$	$Cu_{90}Sn_{10}$	$Cu_{31}Sn_{40}Zn_{29}$	$Cu_{35}Sn_{32}Zn_{32}$	$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	$Sb_{11}Pb_{89}$					
Unalloyed	7						78					9	94	x	142 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	7								70			9	85	x	194 ppm Sn + 142 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	7										79		85	x	194 ppm Sn + 142 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	7								58	21			85	x	194 ppm Sn + 142 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{13}Pb_{87}$								
	7							66		21			94	x	142 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		13					78					9	100	✓		Brass + SnPb + Sb
Brass		13							70			9	92	x	194 ppm Sn	Brass + Pb + Sb
Brass		13									79		92	x	194 ppm Sn	Brass + SbPb
Brass		13							58*	21			92	x	194 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		13						66		21			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			15				78					9	102	x	142 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			15						70			9	94	x	142 ppm Zn	Bronze + Pb + Sb
Bronze			15								79		94	x	142 ppm Zn	Bronze + SbPb
Bronze			15						58*	21			94	x	142 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{13}Pb_{87}$								
Bronze			15					66		21			102	x	142 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{10}Pb_{90}$								
Bronze				7				78				9	94	x	142 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{12}Pb_{88}$								
Bronze				7				65		21			94	x	142 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					21		78					9	108	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					21				70			9	100	✓		Gunmetal + Pb + Sb
Gunmetal					21						79		100	✓		Gunmetal + SbPb
Gunmetal					21				58*	21			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						unreliable		-		-			-	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 82% Pb free (1325 ppm)
II costraint $Cu_{90}Sn_{10}$ → 91% Sn free (177 ppm)
III costraint : gunmetal with Sn=Zn → 27% Sn free (52 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com25 – Correlations Cu/Sb (0.70), strong SnPb, orange correlation lead antimonates ($Sb_{37}Pb_{63}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	1161	102	424	1650	2807	6143

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 102 ppm Zn content as "non natural")	
		$Cu_{92}Zn_8$	$Cu_{73}Sn_{27}$	$Cu_{90}Sn_{10}$	$Cu_{69}Sn_{25}Zn_6$	$Cu_{86}Sn_7Zn_7$	$Sn_{13}Pb_{87}$			$Sb_{42}Pb_{58}$	$Sb_{37}Pb_{63}$					
Unalloyed	19						53					27	98	x	102 ppm Zn	Unalloyed Cu + SnPb + Sb
	19								46			27	91	x	424 ppm Sn + 102 ppm Zn	Unalloyed Cu + Pb + Sb
	19										73		91	x	424 ppm Sn + 102 ppm Zn	Unalloyed Cu + SbPb
	19								9	64			91	x	424 ppm Sn + 102 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{45}Pb_{55}$								
	19							16		64			98	x	102 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		21					53					27	100	✓		Brass + SnPb + Sb
		21							46			27	93	x	424 ppm Sn	Brass + Pb + Sb
		21									73		93	x	424 ppm Sn	Brass + SbPb
		21							9*	64			93	x	424 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		21						16		64			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				53					27	105	x	102 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			26						46			27	98	x	102 ppm Zn	Bronze + Pb + Sb
			26								73		98	x	102 ppm Zn	Bronze + SbPb
			26						9*	64			98	x	102 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{45}Pb_{55}$								
			26					16		64			105	x	102 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{10}Pb_{90}$								
				21				50				27	98	x	102 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{36}Pb_{64}$								
				21				13		64			98	x	102 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					27		53					27	107	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					27				46			27	100	✓		Gunmetal + Pb + Sb
					27						73		100	✓		Gunmetal + SbPb
					27				9*	64			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{38}Pb_{62}$								
						22		14		64			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 19% Pb free (528 ppm)
II costraint $Cu_{90}Sn_{10}$ → 70% Sn free (295 ppm)
III costraint : gunmetal with Sn=Zn → 76% Sn free (322 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com26 – Correlations strong SnPb, yellow correlation lead antimonates ($Sb_{39}Pb_{61}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	246	241	449	2559	3963	7458

									Pb							
					Sn											
				Cu							Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 241 ppm Zn content as "non natural")	
		$Cu_{51}Zn_{49}$	$Cu_{35}Sn_{65}$	$Cu_{90}Sn_{10}$	$Cu_{26}Sn_{48}Zn_{26}$	$Cu_{34}Sn_{33}Zn_{33}$	$Sn_{10}Pb_{90}$			$Sb_{42}Pb_{58}$	$Sb_{39}Pb_{61}$					
Unalloyed	3						59					34	97	x	241 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	3								53			34	91	x	449 ppm Sn + 241 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	3										87		91	x	449 ppm Sn + 241 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	3								6	82			91	x	449 ppm Sn + 241 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{51}Pb_{49}$								
Unalloyed	3							12		82			97	x	241 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		7					59					34	100	✓		Brass + SnPb + Sb
Brass		7							53			34	94	x	449 ppm Sn	Brass + Pb + Sb
Brass		7									87		94	x	449 ppm Sn	Brass + SbPb
Brass		7							6	82			94	x	449 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		7						12		82			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			9				59					34	103	x	241 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			9						53			34	97	x	241 ppm Zn	Bronze + Pb + Sb
Bronze			9								87		97	x	241 ppm Zn	Bronze + SbPb
Bronze			9						6	82			97	x	241 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{51}Pb_{49}$								
Bronze			9					12		82			103	x	241 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{10}Pb_{90}$								
Bronze				4				59				34	97	x	241 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{50}Pb_{50}$								
Bronze				4				11		82			97	x	241 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					13		59					34	106	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					13				53			34	100	✓		Gunmetal + Pb + Sb
Gunmetal					13						87		100	✓		Gunmetal + SbPb
Gunmetal					13				6	82			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						unreliable		-		-			-	x		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 11% Pb free (430 ppm)
II costraint $Cu_{90}Sn_{10}$ → 94% Sn free (422 ppm)
III costraint : gunmetal with Sn=Zn → not calculated
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com36 – Correlations Cu/Sb (1.01), strong SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	475	161	219	469	1739	3063

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 161 ppm Zn content as "non natural")	
		$Cu_{75}Zn_{25}$	$Cu_{68}Sn_{32}$	$Cu_{90}Sn_{10}$	$Cu_{56}Sn_{26}Zn_{19}$	$Cu_{60}Sn_{20}Zn_{20}$	$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	$Sb_{21}Pb_{79}$					
Unalloyed	16						64					15	95	x	161 ppm Zn	Unalloyed Cu + SnPb + Sb
	16								57			15	88	x	219 ppm Sn + 161 ppm Zn	Unalloyed Cu + Pb + Sb
	16										72		88	x	219 ppm Sn + 161 ppm Zn	Unalloyed Cu + SbPb
	16								36	36			88	x	219 ppm Sn + 161 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{17}Pb_{83}$								
	16							43		36			95	x	161 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		21					64					15	100	✓		Brass + SnPb + Sb
		21							57			15	93	x	219 ppm Sn	Brass + Pb + Sb
		21									72		93	x	219 ppm Sn	Brass + SbPb
		21							36	36			93	x	219 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		21						43		36			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			23				64					15	102	x	161 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			23						57			15	95	x	161 ppm Zn	Bronze + Pb + Sb
			23								72		95	x	161 ppm Zn	Bronze + SbPb
			23						36	36			95	x	161 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$								
			23					43		36			102	x	161 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{9}Pb_{91}$								
				17				62				15	95	x	161 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{13}Pb_{87}$								
				17				41		36			95	x	161 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					28		64					15	107	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					28				57			15	100	✓		Gunmetal + Pb + Sb
					28						72		100	✓		Gunmetal + SbPb
					28				36	36			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{5}Pb_{95}$								
						26		38		36			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 63% Pb free (1092 ppm)
II costraint $Cu_{90}Sn_{10}$ → 76% Sn free (166 ppm)
III costraint : gunmetal with Sn=Zn → 27% Sn free (58 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com37 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	3667	287	848	2185	9152	16139

									Pb							
					Sn											
				Cu						Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 287 ppm Zn content as "non natural")	
		$Cu_{93}Zn_7$	$Cu_{81}Sn_{19}$	$Cu_{90}Sn_{10}$	$Cu_{76}Sn_{18}Zn_6$	$Cu_{86}Sn_7Zn_7$	Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{19}Pb_{81}$					
Unalloyed	23						62					14	98	x	287 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	23								57			14	93	x	848 ppm Sn + 287 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	23										70		93	x	848 ppm Sn + 287 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	23								38	32			93	x	848 ppm Sn + 287 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{12}Pb_{88}$								
Unalloyed	23							43		32			98	x	287 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		24					62					14	100	✓		Brass + SnPb + Sb
Brass		24							57			14	95	x	848 ppm Sn	Brass + Pb + Sb
Brass		24									70		95	x	848 ppm Sn	Brass + SbPb
Brass		24							38	32			95	x	848 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		24						43		32			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			28				62					14	103	x	287 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			28						57			14	98	x	287 ppm Zn	Bronze + Pb + Sb
Bronze			28								70		98	x	287 ppm Zn	Bronze + SbPb
Bronze			28						38	32			98	x	287 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{12}Pb_{88}$								
Bronze			28					43		32			103	x	287 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_5Pb_{95}								
Bronze				25				59				14	98	x	287 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Sn_7Pb_{93}								
Bronze				25				41		32			98	x	287 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					30		62					14	105	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					30				57			14	100	✓		Gunmetal + Pb + Sb
Gunmetal					30						70		100	✓		Gunmetal + SbPb
Gunmetal					30				38	32			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_8Pb_{92}								
Gunmetal						26		41		32			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 67% Pb free (6134 ppm)
II costraint $Cu_{90}Sn_{10}$ → 52% Sn free (441 ppm)
III costraint : gunmetal with Sn=Zn → 66% Sn free (561 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com39 – Correlation SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2779	158	3250	1429	32277	39892

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 158 ppm Zn content as "non natural")	
		$Cu_{95}Zn_5$	$Cu_{46}Sn_{54}$	$Cu_{90}Sn_{10}$	$Cu_{45}Sn_{53}Zn_3$	$Cu_{90}Sn_5Zn_5$	Sn_9Pb_{91}			$Sb_{42}Pb_{58}$	Sb_4Pb_{96}					
Unalloyed	7						89					4	100	x	158 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	7								81			4	91	x	3250 ppm Sn + 158 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	7										84		91	x	3250 ppm Sn + 158 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	7								76	9			91	x	3250 ppm Sn + 158 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{10}Pb_{90}$								
Unalloyed	7							84		9			100	x	158 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		7					89					4	100	✓		Brass + SnPb + Sb
Brass		7							81			4	92	x	3250 ppm Sn	Brass + Pb + Sb
Brass		7									84		92	x	3250 ppm Sn	Brass + SbPb
Brass		7							76	9			92	x	3250 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		7						84		9			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			15				89					4	108	x	158 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			15						81			4	100	x	158 ppm Zn	Bronze + Pb + Sb
Bronze			15								84		100	x	158 ppm Zn	Bronze + SbPb
Bronze			15						76	9			100	x	158 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{10}Pb_{90}$								
Bronze			15					84		9			108	x	158 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_8Pb_{92}								
Bronze				8				88				4	100	x	158 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Sn_9Pb_{91}								
Bronze				8				83		9			100	x	158 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					16		89					4	108	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					16				81			4	100	✓		Gunmetal + Pb + Sb
Gunmetal					16						84		100	✓		Gunmetal + SbPb
Gunmetal					16				76	9			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_9Pb_{91}								
Gunmetal						8		84		9			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 94% Pb free (30303 ppm)
II costraint $Cu_{90}Sn_{10}$ → 90% Sn free (2941 ppm)
III costraint : gunmetal with Sn=Zn → 95% Sn free (3092 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com40 – Correlation strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	900	230	656	574	4983	7343

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 230 ppm Zn content as "non natural")	
		$Cu_{80}Zn_{20}$	$Cu_{58}Sn_{42}$	$Cu_{90}Sn_{10}$	$Cu_{50}Sn_{37}Zn_{13}$	$Cu_{66}Sn_{17}Zn_{17}$	$Sn_{12}Pb_{88}$			$Sb_{42}Pb_{58}$	$Sb_{10}Pb_{90}$					
Unalloyed	12						77					8	97	x	230 ppm Zn	Unalloyed Cu + SnPb + Sb
	12								68			8	88	x	656 ppm Sn + 230 ppm Zn	Unalloyed Cu + Pb + Sb
	12										76		88	x	656 ppm Sn + 230 ppm Zn	Unalloyed Cu + SbPb
	12								57	19			88	x	656 ppm Sn + 230 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{14}Pb_{86}$								
	12							66		19			97	x	230 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		15					77					8	100	✓		Brass + SnPb + Sb
		15							68			8	91	x	656 ppm Sn	Brass + Pb + Sb
		15									76		91	x	656 ppm Sn	Brass + SbPb
		15							57	19			91	x	656 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		15						66		19			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			21				77					8	106	x	230 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			21						68			8	97	x	230 ppm Zn	Bronze + Pb + Sb
			21								76		97	x	230 ppm Zn	Bronze + SbPb
			21						57	19			97	x	230 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{14}Pb_{86}$								
			21					66		19			106	x	230 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{10}Pb_{90}$								
				14				75				8	97	x	230 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{12}Pb_{88}$								
				14				65		19			97	x	230 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					24		77					8	109	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					24				68			8	100	✓		Gunmetal + Pb + Sb
					24						76		100	✓		Gunmetal + SbPb
					24				57	19			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_9Pb_{91}								
						19		63		19			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 84% Pb free (4191 ppm)
II costraint $Cu_{90}Sn_{10}$ → 85% Sn free (556 ppm)
III costraint : gunmetal with Sn=Zn → 65% Sn free (425 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com45 – Correlations Cu/Sb (0.94), strong SnPb, yellow group lead antimonates ($Sb_{39}Pb_{61}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2930	265	596	3113	4863	11767

									Pb							
				Sn												
			Cu							Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 128 ppm Zn content as "non natural")	
		$Cu_{92}Zn_8$	$Cu_{83}Sn_{17}$	$Cu_{90}Sn_{10}$	$Cu_{77}Sn_{16}Zn_7$	$Cu_{85}Sn_8Zn_8$	$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	$Sb_{39}Pb_{61}$					
Unalloyed	25						46					26	98	x	265 ppm Zn	Unalloyed Cu + SnPb + Sb
	25								41			26	93	x	596 ppm Sn + 265 ppm Zn	Unalloyed Cu + Pb + Sb
	25										68		93	x	596 ppm Sn + 265 ppm Zn	Unalloyed Cu + SbPb
	25								5	63			93	x	596 ppm Sn + 265 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{51}Pb_{49}$								
	25							10		63			98	x	265 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		27					46					26	100	✓		Brass + SnPb + Sb
		27							41			26	95	x	596 ppm Sn	Brass + Pb + Sb
		27									68		95	x	596 ppm Sn	Brass + SbPb
		27							5*	63			95	x	596 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		27						10		63			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			30				46					26	103	x	265 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			30						41			26	98	x	265 ppm Zn	Bronze + Pb + Sb
			30								68		98	x	265 ppm Zn	Bronze + SbPb
			30						5*	63			98	x	265 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{51}Pb_{49}$								
			30					10		63			103	x	265 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_5Pb_{95}								
				28				44				26	98	x	265 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{32}Pb_{68}$								
				28				7		63			98	x	265 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					32		46					26	105	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					32				41			26	100	✓		Gunmetal + Pb + Sb
					32						68		100	✓		Gunmetal + SbPb
					32				5*	63			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{37}Pb_{63}$								
						29		8		63			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 12% Pb free (564 ppm)
II costraint $Cu_{90}Sn_{10}$ → 45% Sn free (270 ppm)
III costraint : gunmetal with Sn=Zn → 55% Sn free (331 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com46 – Correlations Cu/Sb (0.94), strong SnPb, yellow group lead antimonates ($Sb_{39}Pb_{61}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2930	128	596	3113	4863	11630

				Cu	Sn				Pb		Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 128 ppm Zn content as "non natural")	
		$Cu_{96}Zn_4$	$Cu_{83}Sn_{17}$	$Cu_{90}Sn_{10}$	$Cu_{80}Sn_{16}Zn_4$	$Cu_{92}Sn_4Zn_4$	$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	$Sb_{39}Pb_{61}$					
Unalloyed	25						47					27	99	x	128 ppm Zn	Unalloyed Cu + SnPb + Sb
	25								42			27	94	x	596 ppm Sn + 128 ppm Zn	Unalloyed Cu + Pb + Sb
	25										69		94	x	596 ppm Sn + 128 ppm Zn	Unalloyed Cu + SbPb
	25								5	64			94	x	596 ppm Sn + 128 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{51}Pb_{49}$								
	25							10		64			99	x	128 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		26					47					27	100	✓		Brass + SnPb + Sb
		26							42			27	95	x	596 ppm Sn	Brass + Pb + Sb
		26									69		95	x	596 ppm Sn	Brass + SbPb
		26							5*	64			95	x	596 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		26						10		64			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			30				47					27	104	x	128 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			30						42			27	99	x	128 ppm Zn	Bronze + Pb + Sb
			30								69		99	x	128 ppm Zn	Bronze + SbPb
			30						5*	64			99	x	128 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{51}Pb_{49}$								
			30					10		64			104	x	128 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_5Pb_{95}								
				28				44				27	99	x	128 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{32}Pb_{68}$								
				28				7		64			99	x	128 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					31		47					27	105	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					31				42			27	100	✓		Gunmetal + Pb + Sb
					31						69		100	✓		Gunmetal + SbPb
					31				5*	64			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{45}Pb_{55}$								
						27		9		64			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 12% Pb free (564 ppm)
II costraint $Cu_{90}Sn_{10}$ → 45% Sn free (270 ppm)
III costraint : gunmetal with Sn=Zn → 78% Sn free (467 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com47 – Correlations Cu/Sb (0.97), SnPb, orange group lead antimonates ($Sb_{33}Pb_{67}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	1427	161	72	1473	2927	6060

									Pb							
				Sn												
			Cu								Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 161 ppm Zn content as "non natural")	
		$Cu_{90}Zn_{10}$	$Cu_{95}Sn_5$	$Cu_{90}Sn_{10}$	$Cu_{86}Sn_4Zn_{10}$	$Cu_{82}Sn_9Zn_9$	Sn_2Pb_{98}			$Sb_{42}Pb_{58}$	$Sb_{33}Pb_{67}$					
Unalloyed	24						49					24	97	x	161 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	24								48			24	96	x	72 ppm Sn + 161 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	24										73		96	x	72 ppm Sn + 161 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	24								15	58			96	x	72 ppm Sn + 161 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								Sn_7Pb_{93}								
Unalloyed	24							16		58			97	x	161 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		26					49					24	100	✓		Brass + SnPb + Sb
Brass		26							48			24	99	x	72 ppm Sn	Brass + Pb + Sb
Brass		26									73		99	x	72 ppm Sn	Brass + SbPb
Brass		26							15	58			99	x	72 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		26						16		58			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			25				49					24	99	x	161 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			25						48			24	97	x	161 ppm Zn	Bronze + Pb + Sb
Bronze			25								73		97	x	161 ppm Zn	Bronze + SbPb
Bronze			25						15	58			97	x	161 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_7Pb_{93}								
Bronze			25					16		58			99	x	161 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Low Sn								
Bronze				26				-				24	-	x	-	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Low Sn								
Bronze				26				-		58			-	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					27		49					24	101	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					27				48			24	100	✓		Gunmetal + Pb + Sb
Gunmetal					27						73		100	✓		Gunmetal + SbPb
Gunmetal					27				15	58			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Sn								
Gunmetal						29		-		58			-	x		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 31% Pb free (893 ppm)
II costraint $Cu_{90}Sn_{10}$ → 121% less Sn (87 ppm missing)
III costraint : gunmetal with Sn=Zn → 124% less Sn (89 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com48 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	7813	2455	6507	248	23647	40670

									Pb							
					Sn											
				Cu						Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 2455 ppm Zn content as “non natural”)	
		$Cu_{76}Zn_{24}$	$Cu_{55}Sn_{45}$	$Cu_{90}Sn_{10}$	$Cu_{47}Sn_{39}Zn_{15}$	$Cu_{61}Sn_{19}Zn_{19}$	$Sn_{22}Pb_{78}$			$Sb_{42}Pb_{58}$	Sb_1Pb_{99}					
Unalloyed	19						74					1	94	x	2455 ppm Zn	Unalloyed Cu + SnPb + Sb
	19								58			1	78	x	6507 ppm Sn + 2455 ppm Zn	Unalloyed Cu + Pb + Sb
	19										59		78	x	6507 ppm Sn + 2455 ppm Zn	Unalloyed Cu + SbPb
	19								57	1			78	x	6507 ppm Sn + 2455 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{22}Pb_{78}$								
	19							73		1			94	x	2455 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		25					74					1	100	✓		Brass + SnPb + Sb
		25							58			1	84	x	6507 ppm Sn	Brass + Pb + Sb
		25									59		84	x	6507 ppm Sn	Brass + SbPb
		25							57	1			84	x	6507 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		25						73		1			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			35				74					1	110	x	2455 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			35						58			1	94	x	2455 ppm Zn	Bronze + Pb + Sb
			35								59		94	x	2455 ppm Zn	Bronze + SbPb
			35						57	1			94	x	2455 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{22}Pb_{78}$								
			35					73		1			110	x	2455 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{19}Pb_{81}$								
				21				72				1	94	x	2455 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{19}Pb_{81}$								
				21				71		1			94	x	2455 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					41		74					1	116	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					41				58			1	100	✓		Gunmetal + Pb + Sb
					41						59		100	✓		Gunmetal + SbPb
					41				57	1			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{15}Pb_{85}$								
						31		67		1			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 99% Pb free (23304 ppm)
II costraint $Cu_{90}Sn_{10}$ → 87% Sn free (5639 ppm)
III costraint : gunmetal with Sn=Zn → 62% Sn free (4051 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com50 – Correlations Cu/Sb (0.93), strong SnPb, orange group lead antimonates ($Sb_{32}Pb_{68}$).

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	2175	182	691	2346	4972	10366

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 182 ppm Zn content as "non natural")	
		$Cu_{92}Zn_8$	$Cu_{76}Sn_{24}$	$Cu_{90}Sn_{10}$	$Cu_{71}Sn_{23}Zn_6$	$Cu_{86}Sn_7Zn_7$	$Sn_{12}Pb_{88}$			$Sb_{42}Pb_{58}$	$Sb_{32}Pb_{68}$					
Unalloyed	21						55					23	98	x	182 ppm Zn	Unalloyed Cu + SnPb + Sb
	21								48			23	92	x	691 ppm Sn + 182 ppm Zn	Unalloyed Cu + Pb + Sb
	21										71		92	x	691 ppm Sn + 182 ppm Zn	Unalloyed Cu + SbPb
	21								17	54			92	x	691 ppm Sn + 182 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{29}Pb_{71}$								
	21							23		54			98	x	182 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		23					55					23	100	✓		Brass + SnPb + Sb
		23							48			23	93	x	691 ppm Sn	Brass + Pb + Sb
		23									71		93	x	691 ppm Sn	Brass + SbPb
		23							17*	54			93	x	691 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		23						23		54			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			28				55					23	105	x	182 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			28						48			23	98	x	182 ppm Zn	Bronze + Pb + Sb
			28								71		98	x	182 ppm Zn	Bronze + SbPb
			28						17*	54			98	x	182 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{29}Pb_{71}$								
			28					23		54			105	x	182 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_8Pb_{92}								
				23				52				23	98	x	182 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{21}Pb_{79}$								
				23				21		54			98	x	182 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal	21				29		55					23	98	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
	21				29				48			23	92	✓		Gunmetal + Pb + Sb
	21				29						71		92	✓		Gunmetal + SbPb
	21				29				17*	54			92	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{29}Pb_{71}$								
	21					24		23		54			98	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 35% Pb free (564 ppm)
II costraint $Cu_{90}Sn_{10}$ → 65% Sn free (270 ppm)
III costraint : gunmetal with Sn=Zn → 74% Sn free (467 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com51 – Correlations Cu/Sb (0.86), SnPb, orange group lead antimonates ($Sb_{34}Pb_{66}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2160	285	446	2506	4787	10183

	Cu								Pb	Sb						
			Sn													
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 285 ppm Zn content as "non natural")	
		$Cu_{88}Zn_{12}$	$Cu_{83}Sn_{17}$	$Cu_{90}Sn_{10}$	$Cu_{75}Sn_{15}Zn_{10}$	$Cu_{79}Sn_{10}Zn_{10}$	Sn_9Pb_{91}			$Sb_{42}Pb_{58}$	$Sb_{34}Pb_{66}$					
Unalloyed	21						51					25	97	x	285 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	21								47			25	93	x	446 ppm Sn + 285 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	21										72		93	x	446 ppm Sn + 285 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	21								13	59			93	x	446 ppm Sn + 285 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{25}Pb_{75}$								
Unalloyed	21							17		59			97	x	285 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		24					51					25	100	✓		Brass + SnPb + Sb
Brass		24							47			25	96	x	446 ppm Sn	Brass + Pb + Sb
Brass		24									72		96	x	446 ppm Sn	Brass + SbPb
Brass		24							13	59			96	x	446 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		24						17		59			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				51					25	102	x	285 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			26						47			25	97	x	285 ppm Zn	Bronze + Pb + Sb
Bronze			26								72		97	x	285 ppm Zn	Bronze + SbPb
Bronze			26						13	59			97	x	285 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{25}Pb_{75}$								
Bronze			26					17		59			102	x	285 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_4Pb_{96}								
Bronze				24				49				25	97	x	285 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{13}Pb_{87}$								
Bronze				24				15		59			97	x	285 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					28		51					25	104	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					28				47			25	100	✓		Gunmetal + Pb + Sb
Gunmetal					28						72		100	✓		Gunmetal + SbPb
Gunmetal					28				13	59			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{11}Pb_{89}$								
Gunmetal						27		15		59			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 28% Pb free (1326 ppm)
II costraint $Cu_{90}Sn_{10}$ → 46% Sn free (206 ppm)
III costraint : gunmetal with Sn=Zn → 36% Sn free (160 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com52 – Correlations SnPb, red group lead antimonates ($Sb_{26}Pb_{74}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	3709	364	840	2775	7795	15484

								Pb								
			Sn													
	Cu										Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 364 ppm Zn content as “non natural”)	
		$Cu_{91}Zn_9$	$Cu_{82}Sn_{18}$	$Cu_{90}Sn_{10}$	$Cu_{75}Sn_{17}Zn_7$	$Cu_{84}Sn_8Zn_8$	$Sn_{10}Pb_{90}$			$Sb_{42}Pb_{58}$	$Sb_{26}Pb_{74}$					
Unalloyed	24						56					18	98	x	364 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	24								50			18	92	x	840 ppm Sn + 364 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	24										68		92	x	840 ppm Sn + 364 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	24								26	43			92	x	840 ppm Sn + 364 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	24							$Sn_{17}Pb_{83}$ 31		43			98	x	364 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		26					56					18	100	✓		Brass + SnPb + Sb
Brass		26							50			18	95	x	840 ppm Sn	Brass + Pb + Sb
Brass		26									68		95	x	840 ppm Sn	Brass + SbPb
Brass		26							26*	43			95	x	840 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		26						31		43			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			29				56					18	103	x	364 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			29						50			18	98	x	364 ppm Zn	Bronze + Pb + Sb
Bronze			29								68		98	x	364 ppm Zn	Bronze + SbPb
Bronze			29						26*	43			98	x	364 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			29					$Sn_{17}Pb_{83}$ 31		43			103	x	364 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				27				Sn_5Pb_{95} 53				18	98	x	364 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				27				$Sn_{10}Pb_{90}$ 28		43			98	x	364 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					32		56					18	105	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					32				50			18	100	✓		Gunmetal + Pb + Sb
Gunmetal					32						68		100	✓		Gunmetal + SbPb
Gunmetal					32				26*	43			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						29		$Sn_{11}Pb_{89}$ 29		43			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 51% Pb free (3963 ppm)
II costraint $Cu_{90}Sn_{10}$ → 51% Sn free (428 ppm)
III costraint : gunmetal with Sn=Zn → 57% Sn free (476 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com54 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	6950	161	158	2634	17452	27355

								Pb								
				Sn												
			Cu							Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 161 ppm Zn content as "non natural")	
		$Cu_{98}Zn_2$	$Cu_{98}Sn_2$	$Cu_{90}Sn_{10}$	$Cu_{96}Sn_2Zn_2$	$Cu_{96}Sn_2Zn_2$	Sn_1Pb_{99}			$Sb_{42}Pb_{58}$	$Sb_{13}Pb_{87}$					
Unalloyed	25						64					10	99	x	161 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	25								64			10	99	x	158 ppm Sn + 161 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	25										73		99	x	158 ppm Sn + 161 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	25								51	23			99	x	158 ppm Sn + 161 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	25							Sn_1Pb_{99} 51		23			99	x	161 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		26					64					10	100	✓		Brass + SnPb + Sb
Brass		26							64			10	99	x	158 ppm Sn	Brass + Pb + Sb
Brass		26									73		99	x	158 ppm Sn	Brass + SbPb
Brass		26							51*	23			99	x	158 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		26						51		23			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				64					10	100	x	161 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			26						64			10	99	x	161 ppm Zn	Bronze + Pb + Sb
Bronze			26								73		99	x	161 ppm Zn	Bronze + SbPb
Bronze			26						50*	23			99	x	161 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			26					Sn_1Pb_{99} 51		23			100	x	161 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				28				Low Sn -				10	-	x	-	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				28				Low Sn -		23			-	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					27		64					10	101	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					27				64			10	100	✓		Gunmetal + Pb + Sb
Gunmetal					27						73		100	✓		Gunmetal + SbPb
Gunmetal					27				50*	23			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						27		Low Sn -		23			-	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 79% Pb free (13814 ppm)
II costraint $Cu_{90}Sn_{10}$ → 8% less Sn (615 ppm missing)
III costraint : gunmetal with Sn=Zn → equal
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com55 – Correlations SnPb, yellow group lead antimonates ($Sb_{45}Pb_{55}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	216	206	106	788	979	2295

Pb

Sn

Cu

Sb

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 206 ppm Zn content as "non natural")	
		$Cu_{51}Zn_{49}$	$Cu_{67}Sn_{33}$	$Cu_{90}Sn_{10}$	$Cu_{41}Sn_{20}Zn_{39}$	$Cu_{34}Sn_{33}Zn_{33}$	$Sn_{10}Pb_{90}$			$Sb_{42}Pb_{58}$	$Sb_{45}Pb_{55}$					
Unalloyed	9						47					34	91	x	206 ppm Zn	Unalloyed Cu + SnPb + Sb
	9								43			34	86	x	106 ppm Sn + 206 ppm Zn	Unalloyed Cu + Pb + Sb
	9										77		86	x	106 ppm Sn + 206 ppm Zn	Unalloyed Cu + SbPb
	9								-	Low Pb			86	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								Low Sn								
	9							-		Low Pb			91	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		18					47					34	100	✓		Brass + SnPb + Sb
		18							43			34	95	x	106 ppm Sn	Brass + Pb + Sb
		18									77		95	x	106 ppm Sn	Brass + SbPb
		18							-	Low Pb			95	x	-	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		18						-		Low Pb			100	x	-	Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			14				47					34	96	x	206 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			14						43			34	91	x	206 ppm Zn	Bronze + Pb + Sb
			14								77		91	x	206 ppm Zn	Bronze + SbPb
			14						-	Low Pb			91	x	-	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Sn								
			14					-		Low Pb			96	x	-	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_8Pb_{92}								
				10				46				34	91	x	206 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Low Sn								
				10				-		Low Pb			91	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					23		47					34	105	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					23				43			34	100	✓		Gunmetal + Pb + Sb
					23						77		100	✓		Gunmetal + SbPb
					23				-	Low Pb			100	x	-	Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Sn								
						27		-		Low Pb			100	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 11% Pb less (109 ppm missing)
II costraint $Cu_{90}Sn_{10}$ → 77% Sn free (82 ppm)
III costraint : gunmetal with Sn=Zn → 94% Sn less (100 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com58 – Correlations SnPb, yellow group lead antimonates ($Sb_{45}Pb_{55}$).

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	256	153	354	590	805	2157

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 153 ppm Zn content as "non natural")	
		$Cu_{63}Zn_{37}$	$Cu_{42}Sn_{58}$	$Cu_{90}Sn_{10}$	$Cu_{34}Sn_{46}Zn_{20}$	$Cu_{46}Sn_{27}Zn_{27}$	$Sn_{31}Pb_{69}$			$Sb_{42}Pb_{58}$	$Sb_{42}Pb_{58}$					
Unalloyed	12						54					27	93	x	153 ppm Zn	Unalloyed Cu + SnPb + Sb
	12								37			27	76	x	354 ppm Sn + 153 ppm Zn	Unalloyed Cu + Pb + Sb
	12										65		76	x	354 ppm Sn + 153 ppm Zn	Unalloyed Cu + SbPb
	12								-	65			77	x	354 ppm Sn + 153 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								Low Pb								
	12							-		65			-	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		19					54					27	100	✓		Brass + SnPb + Sb
		19							37			27	84	x	354 ppm Sn	Brass + Pb + Sb
		19									65		84	x	354 ppm Sn	Brass + SbPb
		19							-	65			84	x	354 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		19						16		65			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			28				54					27	109	x	153 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			28						37			27	93	x	153 ppm Zn	Bronze + Pb + Sb
			28								65		93	x	153 ppm Zn	Bronze + SbPb
			28						-	65			93	x	153 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Pb								
			28					-		65			-	x	-	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{29}Pb_{71}$								
				13				52				27	93	x	153 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Low Pb					-			
				13				-		65			-	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					35		54					27	116	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					35				37			27	100	✓		Gunmetal + Pb + Sb
					35						65		100	✓		Gunmetal + SbPb
					35				-	65			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Pb								
						26		-		65			-	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 0% Pb free
II costraint $Cu_{90}Sn_{10}$ → 92% Sn free (326 ppm)
III costraint : gunmetal with Sn=Zn → 57% Sn free (202 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com61 – Correlations Cu/Sb (0.94), strong SnPb, red group lead antimonates ($Sb_{31}Pb_{69}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2003	104	630	2126	5508	10371

									Pb							
					Sn											
				Cu							Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 104 ppm Zn content as "non natural")	
		$Cu_{95}Zn_5$	$Cu_{76}Sn_{24}$	$Cu_{90}Sn_{10}$	$Cu_{73}Sn_{23}Zn_4$	$Cu_{91}Sn_5Zn_5$	$Sn_{10}Pb_{90}$			$Sb_{42}Pb_{58}$	$Sb_{28}Pb_{72}$					
Unalloyed	19						59					20	99	x	104 ppm Zn	Unalloyed Cu + SnPb + Sb
	19								53			20	93	x	630 ppm Sn + 104 ppm Zn	Unalloyed Cu + Pb + Sb
	19										74		93	x	630 ppm Sn + 104 ppm Zn	Unalloyed Cu + SbPb
	19								25	49			93	x	630 ppm Sn + 104 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{20}Pb_{80}$								
	19							31		49			99	x	104 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		20					59					20	100	✓		Brass + SnPb + Sb
		20							53			20	94	x	630 ppm Sn	Brass + Pb + Sb
		20									74		94	x	630 ppm Sn	Brass + SbPb
		20							25*	49			94	x	630 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		20						31		49			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			25				59					20	105	x	104 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			25						53			20	99	x	104 ppm Zn	Bronze + Pb + Sb
			25								74		99	x	104 ppm Zn	Bronze + SbPb
			25						25*	49			99	x	104 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{20}Pb_{80}$								
			25					31		49			105	x	104 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_7Pb_{93}								
				21				57				20	99	x	104 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{14}Pb_{86}$								
				21				29		49			99	x	104 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					26		59					20	106	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					26				53			20	100	✓		Gunmetal + Pb + Sb
					26						74		100	✓		Gunmetal + SbPb
					26				25*	49			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$								
						21		30		49			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 47% Pb free (2572 ppm)
II costraint $Cu_{90}Sn_{10}$ → 65% Sn free (408 ppm)
III costraint : gunmetal with Sn=Zn → 83% Sn free (526 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com64 – Correlations strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	203	198	152	106	834	1494

									Pb							
					Sn											
			Cu								Sb					
	Cu	Brass	Bronze	Gunmetal			SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 198 ppm Zn content as "non natural")	
		$Cu_{51}Zn_{49}$	$Cu_{57}Sn_{43}$	$Cu_{90}Sn_{10}$	$Cu_{37}Sn_{28}Zn_{36}$	$Cu_{34}Sn_{33}Zn_{33}$	$Sn_{15}Pb_{85}$			$Sb_{42}Pb_{58}$	$Sb_{11}Pb_{89}$					
Unalloyed copper	14						66					7	87	x	198 ppm Zn	Unalloyed Cu + SnPb + Sb
	14								56			7	77	x	152 ppm Sn + 198 ppm Zn	Unalloyed Cu + Pb + Sb
	14										63		77	x	152 ppm Sn + 198 ppm Zn	Unalloyed Cu + SbPb
	14								46	17			77	x	152 ppm Sn + 198 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{18}Pb_{82}$								
	14							56		17			87	x	198 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		27					66					7	100	✓		Brass + SnPb + Sb
		27							56			7	90	x	152 ppm Sn	Brass + Pb + Sb
		27									63		90	x	152 ppm Sn	Brass + SbPb
		27							46*	17			90	x	152 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		27						56		17			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			24				66					7	97	x	198 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			24						56			7	87	x	198 ppm Zn	Bronze + Pb + Sb
			24								63		87	x	198 ppm Zn	Bronze + SbPb
			24						46*	17			87	x	198 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{18}Pb_{82}$								
			24					56		17			97	x	198 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{13}Pb_{87}$								
				15				65				7	87	x	198 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{16}Pb_{84}$								
				15				55		17			87	x	198 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					37		66					7	110	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					37				56			7	100	✓		Gunmetal + Pb + Sb
					37						63		100	✓		Gunmetal + SbPb
					37				46*	17			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
						unreliable								x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 82% Pb free (687 ppm)
II costraint $Cu_{90}Sn_{10}$ → 85% Sn free (130 ppm)
III costraint : gunmetal with Sn=Zn → unreliable
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com65 – Correlations strong SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	189	364	193	86	1283	2116

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 364 ppm Zn content as “non natural”)	
		$Cu_{34}Zn_{66}$	$Cu_{49}Sn_{51}$	$Cu_{90}Sn_{10}$	$Cu_{25}Sn_{26}Zn_{49}$	$Cu_{21}Sn_{40}Zn_{40}$	$Sn_{13}Pb_{87}$			$Sb_{42}Pb_{58}$	Sb_6Pb_{94}					
Unalloyed	9						70					4	83	x	364 ppm Zn	Unalloyed Cu + SnPb + Sb
	9								61			4	74	x	193 ppm Sn + 364 ppm Zn	Unalloyed Cu + Pb + Sb
	9										65		74	x	193 ppm Sn + 364 ppm Zn	Unalloyed Cu + SbPb
	9								55	10			74	x	193 ppm Sn + 364 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
	9							$Sn_{14}Pb_{86}$ 64		10			83	x	364 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		26					70					4	100	✓		Brass + SnPb + Sb
		26							61			4	91	x	193 ppm Sn	Brass + Pb + Sb
		26									65		91	x	193 ppm Sn	Brass + SbPb
		26							55*	10			91	x	193 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		26						64		10			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			18				70					4	92	x	364 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			18						61			4	83	x	364 ppm Zn	Bronze + Pb + Sb
			18								65		83	x	364 ppm Zn	Bronze + SbPb
			18						55*	10			83	x	364 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
			18					$Sn_{14}Pb_{86}$ 64		10			92	x	364 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
				10				$Sn_{12}Pb_{88}$ 69				4	83	x	364 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
				10				$Sn_{13}Pb_{87}$ 63		10			83	x	364 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					35		70					4	109	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					35				61			4	100	✓		Gunmetal + Pb + Sb
					35						65		100	✓		Gunmetal + SbPb
					35				55*	10			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
						Unreliable								x		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 91% Pb free (1164 ppm)
II costraint $Cu_{90}Sn_{10}$ → 89% Sn free (172 ppm)
III costraint : gunmetal with Sn=Zn → unreliable, not calculated
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com66 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	2184	506	2833	1039	12755	19316

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 158 ppm Zn content as "non natural")	
		$Cu_{81}Zn_{19}$	$Cu_{44}Sn_{56}$	$Cu_{90}Sn_{10}$	$Cu_{40}Sn_{51}Zn_{9}$	$Cu_{68}Sn_{16}Zn_{16}$	$Sn_{18}Pb_{82}$			$Sb_{42}Pb_{58}$	$Sb_{8}Pb_{92}$					
Unalloyed	11						81					5	97	x	506 ppm Zn	Unalloyed Cu + SnPb + Sb
	11								66			5	83	x	2833 ppm Sn + 506 ppm Zn	Unalloyed Cu + Pb + Sb
	11										71		83	x	2833 ppm Sn + 506 ppm Zn	Unalloyed Cu + SbPb
	11								59	13			83	x	2833 ppm Sn + 506 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{20}Pb_{80}$								
	11							73		13			97	x	506 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		14					81					5	100	✓		Brass + SnPb + Sb
		14							66			5	85	x	2833 ppm Sn	Brass + Pb + Sb
		14									71		85	x	2833 ppm Sn	Brass + SbPb
		14							59*	13			85	x	2833 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		14						73		13			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				81					5	112	x	506 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			26						66			5	97	x	506 ppm Zn	Bronze + Pb + Sb
			26								71		97	x	506 ppm Zn	Bronze + SbPb
			26						59*	13			97	x	506 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{20}Pb_{80}$								
			26					73		13			112	x	506 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{17}Pb_{83}$								
				13				79				5	97	x	506 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{19}Pb_{81}$								
				13				72		13			97	x	506 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					29		81					5	115	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					29				66			5	100	✓		Gunmetal + Pb + Sb
					29						71		100	✓		Gunmetal + SbPb
					29				59*	13			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$								
						17		71		13			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 89% Pb free (11321 ppm)
II costraint $Cu_{90}Sn_{10}$ → 91% Sn free (2590 ppm)
III costraint : gunmetal with Sn=Zn → 82% Sn free (2327 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com71 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	1877	246	112	6927	1745	10907

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 246 ppm Zn content as "non natural")	
		$Cu_{88}Zn_{12}$	$Cu_{94}Sn_{6}$	$Cu_{90}Sn_{10}$	$Cu_{84}Sn_{5}Zn_{11}$	$Cu_{79}Sn_{10}Zn_{10}$	$Sn_{6}Pb_{94}$			$Sb_{42}Pb_{58}$	$Sb_{80}Pb_{20}$					
Unalloyed	17						17					64	98	x	246 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	17								16			64	97	x	112 ppm Sn + 246 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	17										80		97	x	112 ppm Sn + 246 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	17								16	Low Pb			-	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	17							Low Sn -		Low Pb			-	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		19					17					64	100	✓		Brass + SnPb + Sb
Brass		19							16			64	99	x	112 ppm Sn	Brass + Pb + Sb
Brass		19									80		99	x	112 ppm Sn	Brass + SbPb
Brass		19							16*	Low Pb			-	x	-	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		19						-		Low Pb			-	x	-	Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			18				17					64	99	x	246 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			18						16			64	98	x	246 ppm Zn	Bronze + Pb + Sb
Bronze			18								80		98	x	246 ppm Zn	Bronze + SbPb
Bronze			18						16*	Low Pb			-	x	-	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			18					Low Sn -		Low Pb			-	x	-	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				19				Low Sn -				64	-	x	-	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				19				Low Sn -		Low Pb			-	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					20		17					64	101	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					20				16			64	100	✓		Gunmetal + Pb + Sb
Gunmetal					20						80		100	✓		Gunmetal + SbPb
Gunmetal					20				16*	Low Pb			100	x		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						22		Sn -		Low Pb			-	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 448% less Pb (7820 ppm missing)
II costraint $Cu_{90}Sn_{10}$ → 87% less Sn (97 ppm missing)
III costraint : gunmetal with Sn=Zn → 120% less Sn (135 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com72 – Correlations Cu/Sb (1.05), strong SnPb, red group lead antimonates ($Sb_{31}Pb_{69}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2932	142	872	2795	6269	13010

Pb

Sn

	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 142 ppm Zn content as “non natural”)	
		$Cu_{95}Zn_5$	$Cu_{77}Sn_{23}$	$Cu_{90}Sn_{10}$	$Cu_{74}Sn_{22}Zn_4$	$Cu_{91}Sn_4Zn_4$	$Sn_{12}Pb_{88}$			$Sb_{42}Pb_{58}$	$Sb_{31}Pb_{69}$					
Unalloyed	23						55					21	99	x	142 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	23								48			21	92	x	872 ppm Sn + 142 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	23										70		92	x	872 ppm Sn + 142 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	23								19	51			92	x	872 ppm Sn + 142 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{27}Pb_{73}$								
Unalloyed	23							25		51			99	x	142 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		24					55					21	100	✓		Brass + SnPb + Sb
Brass		24							48			21	93	x	872 ppm Sn	Brass + Pb + Sb
Brass		24									70		93	x	872 ppm Sn	Brass + SbPb
Brass		24							19*	51			93	x	872 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		24						25		51			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			29				55					21	106	x	142 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			29						48			21	99	x	142 ppm Zn	Bronze + Pb + Sb
Bronze			29								70		99	x	142 ppm Zn	Bronze + SbPb
Bronze			29						19*	51			99	x	142 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{27}Pb_{73}$								
Bronze			29					25		51			106	x	142 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_8Pb_{92}								
Bronze				25				52				21	99	x	142 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{18}Pb_{82}$								
Bronze				25				23		51			99	x	142 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					30		55					21	107	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					30				48			21	100	✓		Gunmetal + Pb + Sb
Gunmetal					30						70		100	✓		Gunmetal + SbPb
Gunmetal					30				19*	51			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{23}Pb_{77}$								
Gunmetal						25		24		51			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 38% Pb free (2409 ppm)
II costraint $Cu_{90}Sn_{10}$ → 63% Sn free (546 ppm)
III costraint : gunmetal with Sn=Zn → 84% Sn free (730 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com73 – Correlations Cu/Sb (1.02), SnPb, orange group lead antimonates ($Sb_{36}Pb_{64}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2134	214	348	2083	3774	8554

									Pb							
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 214 ppm Zn content as "non natural")	
		$Cu_{91}Zn_9$	$Cu_{86}Sn_{14}$	$Cu_{90}Sn_{10}$	$Cu_{79}Sn_{13}Zn_8$	$Cu_{83}Sn_8Zn_8$	Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{36}Pb_{64}$					
Unalloyed	25						48					24	97	x	214 ppm Zn	Unalloyed Cu + SnPb + Sb
	25								44			24	93	x	348 ppm Sn + 214 ppm Zn	Unalloyed Cu + Pb + Sb
	25										68		93	x	348 ppm Sn + 214 ppm Zn	Unalloyed Cu + SbPb
	25								11	58			93	x	348 ppm Sn + 214 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{28}Pb_{72}$								
	25							15		58			97	x	214 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		27					48					24	100	✓		Brass + SnPb + Sb
		27							44			24	96	x	348 ppm Sn	Brass + Pb + Sb
		27									68		96	x	348 ppm Sn	Brass + SbPb
		27							11*	58			96	x	348 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		27						15		58			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			29				48					24	102	x	214 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			29						44			24	97	x	214 ppm Zn	Bronze + Pb + Sb
			29								68		97	x	214 ppm Zn	Bronze + SbPb
			29						10*	58			97	x	214 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{28}Pb_{72}$								
			29					15		58			102	x	214 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_3Pb_{97}								
				28				45				24	97	x	214 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{11}Pb_{89}$								
				28				12		58			97	x	214 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					32		48					24	104	✓	Sn counted twice	Gunmetal + SnPb + Sb
					32				44			24	100	✓		Gunmetal + Pb + Sb
					32						68		100	✓		Gunmetal + SbPb
					32				10*	58			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{13}Pb_{87}$								
						30		12		58			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 24% Pb free (897 ppm)
II costraint $Cu_{90}Sn_{10}$ → 32% Sn free (111 ppm)
III costraint : gunmetal with Sn=Zn → 39% Sn free (134 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com77 – Correlations Cu/Sb (0.88), SnPb, red group lead antimonates ($Sb_{28}Pb_{72}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	1677	252	359	1896	4902	9085

									Pb							
					Sn											
				Cu							Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 252 ppm Zn content as “non natural”)	
		$Cu_{87}Zn_{13}$	$Cu_{82}Sn_{18}$	$Cu_{90}Sn_{10}$	$Cu_{73}Sn_{16}Zn_{11}$	$Cu_{77}Sn_{12}Zn_{12}$	Sn_7Pb_{93}			$Sb_{42}Pb_{58}$	$Sb_{28}Pb_{72}$					
Unalloyed	18						58					21	97	x	252 ppm Zn	Unalloyed Cu + SnPb + Sb
	18								54			21	93	x	359 ppm Sn + 252 ppm Zn	Unalloyed Cu + Pb + Sb
	18										75		93	x	359 ppm Sn + 252 ppm Zn	Unalloyed Cu + SbPb
	18								25	50			93	x	359 ppm Sn + 252 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{14}Pb_{86}$								
	18							29		50			97	x	252 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		21					58					21	100	✓		Brass + SnPb + Sb
		21							54			21	96	x	359 ppm Sn	Brass + Pb + Sb
		21									75		96	x	359 ppm Sn	Brass + SbPb
		21							25*	50			96	x	359 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		21						29		50			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			22				58					21	101	x	252 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			22						54			21	97	x	252 ppm Zn	Bronze + Pb + Sb
			22								75		97	x	252 ppm Zn	Bronze + SbPb
			22						25*	50			97	x	252 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{14}Pb_{86}$								
			22					29		50			101	x	252 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_3Pb_{97}								
				21				56				21	97	x	252 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Sn_7Pb_{93}								
				21				27		50			97	x	252 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					25		58					21	104	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					25				54			21	100	✓		Gunmetal + Pb + Sb
					25						75		100	✓		Gunmetal + SbPb
					25				25*	50			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_4Pb_{96}								
						24		26		50			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 47% Pb free (2284 ppm)
II costraint $Cu_{90}Sn_{10}$ → 48% Sn free (172 ppm)
III costraint : gunmetal with Sn=Zn → 30% Sn free (107 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com78 – Correlations Cu/Sb (0.85), SnPb, orange correlation lead antimonates ($Sb_{38}Pb_{62}$).

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	2259	222	396	2666	4426	9969

								Pb								
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 222 ppm Zn content as "non natural")	
		$Cu_{91}Zn_9$	$Cu_{85}Sn_{15}$	$Cu_{90}Sn_{10}$	$Cu_{79}Sn_{14}Zn_8$	$Cu_{84}Sn_8Zn_8$	Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{38}Pb_{62}$					
Unalloyed	23						48					27	98	x	222 ppm Zn	Unalloyed Cu + SnPb + Sb
	23								44			27	94	x	396 ppm Sn + 222 ppm Zn	Unalloyed Cu + Pb + Sb
	23										71		94	x	396 ppm Sn + 222 ppm Zn	Unalloyed Cu + SbPb
	23								7	64			94	x	396 ppm Sn + 222 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{35}Pb_{65}$								
	23							11		64			98	x	222 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		25					48					27	100	✓		Brass + SnPb + Sb
		25							44			27	96	x	396 ppm Sn	Brass + Pb + Sb
		25									71		96	x	396 ppm Sn	Brass + SbPb
		25							7*	64			96	x	396 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		25						11		64			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			27				48					27	102	x	222 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			27						44			27	98	x	222 ppm Zn	Bronze + Pb + Sb
			27								71		98	x	222 ppm Zn	Bronze + SbPb
			27						7*	64			98	x	222 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{35}Pb_{65}$								
			27					11		64			102	x	222 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_3Pb_{97}								
				25				46				27	98	x	222 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{16}Pb_{84}$								
				25				9		64			98	x	222 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					29		48					27	104	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					29				44			27	100	✓		Gunmetal + Pb + Sb
					29						71		100	✓		Gunmetal + SbPb
					29				7*	64			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{19}Pb_{81}$								
						27		9		64			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 17% Pb free (744 ppm)
II costraint $Cu_{90}Sn_{10}$ → 37% Sn free (145 ppm)
III costraint : gunmetal with Sn=Zn → 44% Sn free (174 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com80 – Correlations Cu/Sb (0.80), SnPb, orange group lead antimonates ($Sb_{36}Pb_{64}$).

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	565	75	278	711	1245	2874

								Pb							
					Sn										
			Cu							Sb					
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 75 ppm Zn content as “natural”)	
			$Cu_{67}Sn_{33}$	$Cu_{90}Sn_{10}$		$Sn_{18}Pb_{82}$			$Sb_{42}Pb_{58}$	$Sb_{36}Pb_{64}$					
Unalloyed	20					54					25	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	20							44			25	90	x	278 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	20									70		90	x	278 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	20							9	60			90	x	278 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{51}Pb_{49}$								
Unalloyed	20						19		60			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			30			54					25	110	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			30					44			25	100	✓		Bronze + Pb + Sb
Bronze			30							70		100	✓		Bronze + SbPb
Bronze			30					9	60			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{51}Pb_{49}$								
Bronze			30				19		60			110	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							$Sn_{15}Pb_{85}$								
Bronze				22			52				25	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{45}Pb_{55}$								
Bronze				22			17		60			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 21% Pb free (263 ppm)
II costraint $Cu_{90}Sn_{10}$ → 77% Sn free (215 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com82 – Correlations Cu/Sb (1.20), SnPb, red group lead antimonates ($Sb_{23}Pb_{77}$).

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	730	220	183	609	2081	3824

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 220 ppm Zn content as “non natural”)	
		$Cu_{77}Zn_{23}$	$Cu_{80}Sn_{20}$	$Cu_{90}Sn_{10}$	$Cu_{64}Sn_{16}Zn_{19}$	$Cu_{62}Sn_{19}Zn_{19}$	Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{23}Pb_{77}$					
Unalloyed	19						59					16	94	x	220 ppm Zn	Unalloyed Cu + SnPb + Sb
	19								54			16	89	x	183 ppm Sn + 220 ppm Zn	Unalloyed Cu + Pb + Sb
	19										70		89	x	183 ppm Sn + 220 ppm Zn	Unalloyed Cu + SbPb
	19								32	38			89	x	183 ppm Sn + 220 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{13}Pb_{87}$								
	19							37		38			94	x	220 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		25					59					16	100	✓		Brass + SnPb + Sb
		25							54			16	95	x	183 ppm Sn	Brass + Pb + Sb
		25									70		95	x	183 ppm Sn	Brass + SbPb
		25							32	38			95	x	183 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		25						37		38			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			24				59					16	99	x	220 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			24						54			16	94	x	220 ppm Zn	Bronze + Pb + Sb
			24								70		94	x	220 ppm Zn	Bronze + SbPb
			24						32	38			94	x	220 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{13}Pb_{87}$								
			24					37		38			99	x	220 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_5Pb_{95}								
				21				57				16	94	x	220 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Sn_8Pb_{92}								
				21				35		38			94	x	220 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					30		59					16	105	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					30				54			16	100	✓		Gunmetal + Pb + Sb
					30						70		100	✓		Gunmetal + SbPb
					30				32	38			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Sn								
						31		-		38			-	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 60% Pb free (1240 ppm)
II costraint $Cu_{90}Sn_{10}$ → 56% Sn free (102 ppm)
III costraint : gunmetal with Sn=Zn → 20% Sn less (36 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com89 – Correlation SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	1679	1154	741	36	1646	5257

									Pb							
			Sn													
				Cu						Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 1154 ppm Zn content as "non natural")	
		$Cu_{59}Zn_{41}$	$Cu_{69}Sn_{31}$	$Cu_{90}Sn_{10}$	$Cu_{47}Sn_{21}Zn_{32}$	$Cu_{42}Sn_{29}Zn_{29}$	$Sn_{31}Pb_{69}$			$Sb_{42}Pb_{58}$	Sb_2Pb_{98}					
Unalloyed	32						45					1	78	x	1154 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	32								31			1	64	x	741 ppm Sn + 1154 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	32										32		64	x	741 ppm Sn + 1154 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	32								30	2			64	x	741 ppm Sn + 1154 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	32							$Sn_{32}Pb_{68}$ 44		2			78	x	1154 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		54					45					1	100	✓		Brass + SnPb + Sb
Brass		54							31			1	86	x	741 ppm Sn	Brass + Pb + Sb
Brass		54									32		86	x	741 ppm Sn	Brass + SbPb
Brass		54							30	2			86	x	741 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		54						44		2			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			46				45					1	92	x	1154 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			46						31			1	78	x	1154 ppm Zn	Bronze + Pb + Sb
Bronze			46								32		78	x	1154 ppm Zn	Bronze + SbPb
Bronze			46						30	2			78	x	1154 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			46					$Sn_{32}Pb_{68}$ 44		2			92	x	1154 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				35				$Sn_{25}Pb_{75}$ 42				1	78	x	1154 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				35				$Sn_{26}Pb_{74}$ 41		2			78	x	1154 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					68		45					1	114	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					68				31			1	100	✓		Gunmetal + Pb + Sb
Gunmetal					68						32		100	✓		Gunmetal + SbPb
Gunmetal					68				30	2			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						76		Low Sn -		2			-	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 97% Pb free (1596 ppm)
II costraint $Cu_{90}Sn_{10}$ → 75% Sn free (555 ppm)
III costraint : gunmetal with Sn=Zn → 56% Sn less (413 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com90 – Correlations SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue dark	2562	150	208	6563	2480	11963

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 150 ppm Zn content as "non natural")	
		$Cu_{94}Zn_{6}$	$Cu_{92}Sn_{8}$	$Cu_{90}Sn_{10}$	$Cu_{88}Sn_{7}Zn_{5}$	$Cu_{90}Sn_{5}Zn_{5}$	$Sn_{8}Pb_{92}$			$Sb_{42}Pb_{58}$	$Sb_{73}Pb_{27}$					
Unalloyed	21						22					55	99	x	150 ppm Zn	Unalloyed Cu + SnPb + Sb
	21								21			55	97	x	208 ppm Sn + 150 ppm Zn	Unalloyed Cu + Pb + Sb
	21										76		97	x	208 ppm Sn + 150 ppm Zn	Unalloyed Cu + SbPb
	21								-	Low Pb			97	x	208 ppm Sn + 150 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								Low Sn								
	21							-		Low Pb			99	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		23					22					55	100	✓		Brass + SnPb + Sb
		23							21			55	98	x	208 ppm Sn	Brass + Pb + Sb
		23									76		98	x	208 ppm Sn	Brass + SbPb
		23							-	Low Pb			98	x	-	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		23						-		Low Pb			100	x	-	Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			23				22					55	100	x	150 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			23						21			55	99	x	150 ppm Zn	Bronze + Pb + Sb
			23								76		99	x	150 ppm Zn	Bronze + SbPb
			23						-	Low Pb			99	x	150 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								Low Sn								
			23					-		Low Pb			100	x	-	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Low Sn								
				24				-				55	99	x	-	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
				24				-		Low Pb			99	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					24		22					55	102	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					24				21			55	100	✓		Gunmetal + Pb + Sb
					24						76		100	✓		Gunmetal + SbPb
					24				-	Low Pb			100	x	-	Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
						24		-		Low Pb			100	x	-	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 265% Pb less (6584 ppm missing)
II costraint $Cu_{90}Sn_{10}$ → 37% Sn less (77 ppm missing)
III costraint : gunmetal with Sn=Zn → 28% Sn free (58 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com94 – Correlation strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green olive	4474	905	5883	825	30604	42690

									Pb							
						Sn										
				Cu							Sb					
	Cu	Brass	Bronze			Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 905 ppm Zn content as “non natural”)	
		$Cu_{83}Zn_{17}$	$Cu_{43}Sn_{57}$	$Cu_{90}Sn_{10}$	$Cu_{40}Sn_{52}Zn_{8}$	$Cu_{71}Sn_{14}Zn_{14}$	$Sn_{16}Pb_{84}$			$Sb_{42}Pb_{58}$	$Sb_{3}Pb_{97}$					
Unalloyed	10						85					2	98	x	905 ppm Zn	Unalloyed Cu + SnPb + Sb
	10								72			2	84	x	5883 ppm Sn + 905 ppm Zn	Unalloyed Cu + Pb + Sb
	10										74		84	x	5883 ppm Sn + 905 ppm Zn	Unalloyed Cu + SbPb
	10								69	5			84	x	5883 ppm Sn + 905 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{17}Pb_{83}$								
	10							83		5			98	x	905 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		13					85					2	100	✓		Brass + SnPb + Sb
		13							72			2	86	x	5883 ppm Sn	Brass + Pb + Sb
		13									74		86	x	5883 ppm Sn	Brass + SbPb
		13							69*	5			86	x	5883 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		13						83		5			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			24				85					2	112	x	905 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			24						72			2	98	x	905 ppm Zn	Bronze + Pb + Sb
			24								74		98	x	905 ppm Zn	Bronze + SbPb
			24						69*	5			98	x	905 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$								
			24					83		5			112	x	905 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{15}Pb_{85}$								
				12				84				2	98	x	905 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{15}Pb_{85}$								
				12				82		5			98	x	905 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					26		85					2	114	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					26				72			2	100	✓		Gunmetal + Pb + Sb
					26						74		100	✓		Gunmetal + SbPb
					26				69*	5			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{14}Pb_{86}$								
						15		81		5			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 96% Pb free (29464 ppm)
II costraint $Cu_{90}Sn_{10}$ → 92% Sn free (5386 ppm)
III costraint : gunmetal with Sn=Zn → 85% Sn free (4978 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com95 – Correlations SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	11823	723	4052	2448	42290	61336

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 723 ppm Zn content as "non natural")	
		$Cu_{94}Zn_6$	$Cu_{74}Sn_{26}$	$Cu_{90}Sn_{10}$	$Cu_{71}Sn_{24}Zn_4$	$Cu_{89}Sn_5Zn_5$	Sn_9Pb_{91}			$Sb_{42}Pb_{58}$	Sb_5Pb_{95}					
Unalloyed	19						76					4	99	x	723 ppm Zn	Unalloyed Cu + SnPb + Sb
	19								69			4	92	x	4052 ppm Sn + 723 ppm Zn	Unalloyed Cu + Pb + Sb
	19										73		92	x	4052 ppm Sn + 723 ppm Zn	Unalloyed Cu + SbPb
	19								63	10			92	x	4052 ppm Sn + 723 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								Sn_9Pb_{91}								
	19							70		10			99	x	723 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		20					76					4	100	✓		Brass + SnPb + Sb
		20							69			4	93	x	4052 ppm Sn	Brass + Pb + Sb
		20									73		93	x	4052 ppm Sn	Brass + SbPb
		20							63*	10			93	x	4052 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		20						70		10			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				76					4	105	x	723 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			26						69			4	99	x	723 ppm Zn	Bronze + Pb + Sb
			26								73		99	x	723 ppm Zn	Bronze + SbPb
			26						63*	10			99	x	723 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_9Pb_{91}								
			26					70		10			105	x	723 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_6Pb_{94}								
				21				73				4	99	x	723 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Sn_7Pb_{93}								
				21				68		10			99	x	723 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					27		76					4	107	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					27				69			4	100	✓		Gunmetal + Pb + Sb
					27						73		100	✓		Gunmetal + SbPb
					27				63*	10			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								Sn_8Pb_{92}								
						22		69		10			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 92% Pb free (38909 ppm)
II costraint $Cu_{90}Sn_{10}$ → 68% Sn free (2738 ppm)
III costraint : gunmetal with Sn=Zn → 82% Sn free (3329 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com96a – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue-green	1278	316	842	519	4883	7838

							Pb								
			Sn												
	Cu									Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 316 ppm Zn content as "non natural")	
		$Cu_{80}Zn_{20}$	$Cu_{60}Sn_{40}$	$Cu_{90}Sn_{10}$	$Cu_{52}Sn_{35}Zn_{13}$	$Cu_{67}Sn_{17}Zn_{17}$	$Sn_{15}Pb_{85}$			$Sb_{42}Pb_{58}$	$Sb_{10}Pb_{90}$				
Unalloyed copper	16						73					7	96	x 316 ppm Zn	Unalloyed Cu + SnPb + Sb
	16								62			7	85	x 842 ppm Sn + 316 ppm Zn	Unalloyed Cu + Pb + Sb
	16										69		85	x 842 ppm Sn + 316 ppm Zn	Unalloyed Cu + SbPb
	16								53	16			85	x 842 ppm Sn + 316 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{17}Pb_{83}$							
	16							64		16			96	x 316 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		20					73					7	100	✓	Brass + SnPb + Sb
		20							62			7	89	x 842 ppm Sn	Brass + Pb + Sb
		20									69		89	x 842 ppm Sn	Brass + SbPb
		20							53*	16			89	x 842 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		20						64		16			100	✓	Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			27				73					7	107	x 316 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			27						62			7	96	x 316 ppm Zn	Bronze + Pb + Sb
			27								69		96	x 316 ppm Zn	Bronze + SbPb
			27						53*	16			96	x 316 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$							
			27					64		16			107	x 316 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{13}Pb_{87}$							
				18				71				7	96	x 316 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{14}Pb_{86}$							
				18				62		16			96	x 316 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					31		73					7	111	✓ [Sn counted twice]	Gunmetal + SnPb + Sb
					31				62			7	100	✓	Gunmetal + Pb + Sb
					31						69		100	✓	Gunmetal + SbPb
					31				53*	16			100	✓	Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{11}Pb_{89}$							
						24		60		16			100	✓	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 85% Pb free (4617 ppm)
II costraint $Cu_{90}Sn_{10}$ → 83% Sn free (700 ppm)
III costraint : gunmetal with Sn=Zn → 62% Sn free (526 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com97 – Correlations Cu/Sb (1.02), SnPb, orange group lead antimonates ($Sb_{35}Pb_{65}$).

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green	1908	166	670	1906	5311	9962

									Pb							
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 166 ppm Zn content as “non natural”)	
		$Cu_{93}Zn_7$	$Cu_{88}Sn_{12}$	$Cu_{90}Sn_{10}$	$Cu_{83}Sn_{11}Zn_6$	$Cu_{88}Sn_6Zn_6$	Sn_7Pb_{93}			$Sb_{42}Pb_{58}$	$Sb_{35}Pb_{65}$					
Unalloyed	25						49					24	98	x	131 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	25								46			24	95	x	244 ppm Sn + 131 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	25										70		95	x	244 ppm Sn + 131 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	25								12	58			95	x	244 ppm Sn + 131 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{21}Pb_{79}$								
Unalloyed	25							16		58			98	x	131 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		26					49					24	100	✓		Brass + SnPb + Sb
Brass		26							46			24	97	x	244 ppm Sn	Brass + Pb + Sb
Brass		26									70		97	x	244 ppm Sn	Brass + SbPb
Brass		26							12*	58			97	x	244 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		26						16		58			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			28				49					24	101	x	131 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			28						46			24	98	x	131 ppm Zn	Bronze + Pb + Sb
Bronze			28								70		98	x	131 ppm Zn	Bronze + SbPb
Bronze			28						12*	58			98	x	131 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{21}Pb_{79}$								
Bronze			28					16		58			101	x	131 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_1Pb_{99}								
Bronze				27				46				24	98	x	131 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								Sn_4Pb_{96}								
Bronze				27				13		58			98	x	131 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					30		49					24	103	✓	Sn counted twice	Gunmetal + SnPb + Sb
Gunmetal					30				46			24	100	✓		Gunmetal + Pb + Sb
Gunmetal					30						70		100	✓		Gunmetal + SbPb
Gunmetal					30				12*	58			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{11}Pb_{89}$								
Gunmetal						28		14		58			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 27% Pb free (939 ppm)
II costraint $Cu_{90}Sn_{10}$ → 15% Sn free (36 ppm)
III costraint : gunmetal with Sn=Zn → 46% Sn free (113 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

Com98 – Correlation strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue-green	2574	482	2599	1468	14780	21903

							Pb	Pb	Pb	Pb	Pb					
			Sn	Sn	Sn	Sn	Sn	Sn								
	Cu	Cu	Cu	Cu	Cu	Cu				Sb	Sb	Sb				
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 482 ppm Zn content as "non natural")	
		$Cu_{84}Zn_{16}$	$Cu_{50}Sn_{50}$	$Cu_{90}Sn_{10}$	$Cu_{46}Sn_{46}Zn_{9}$	$Cu_{73}Sn_{14}Zn_{14}$	$Sn_{15}Pb_{85}$			$Sb_{42}Pb_{58}$	$Sb_{9}Pb_{91}$					
Unalloyed	12						79					7	98	x	482 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	12								67			7	86	x	2599 ppm Sn + 482 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	12										74		86	x	2599 ppm Sn + 482 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	12								58	16			86	x	2599 ppm Sn + 482 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{17}Pb_{83}$								
Unalloyed	12							70		16			98	x	482 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		14					79					7	100	✓		Brass + SnPb + Sb
Brass		14							67			7	88	x	2599 ppm Sn	Brass + Pb + Sb
Brass		14									74		88	x	2599 ppm Sn	Brass + SbPb
Brass		14							58*	16			88	x	2599 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		14						70		16			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			24				79					7	110	x	482 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			24						67			7	98	x	482 ppm Zn	Bronze + Pb + Sb
Bronze			24								74		98	x	482 ppm Zn	Bronze + SbPb
Bronze			24						58*	16			98	x	482 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$								
Bronze			24					70		16			110	x	482 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{14}Pb_{86}$								
Bronze				13				78				7	98	x	482 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{15}Pb_{85}$								
Bronze				13				69		16			98	x	482 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					26		79					7	112	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					26				67			7	100	✓		Gunmetal + Pb + Sb
Gunmetal					26						74		100	✓		Gunmetal + SbPb
Gunmetal					26				58*	16			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{14}Pb_{86}$								
Gunmetal						16		68		16			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 86% Pb free (12753 ppm)
II costraint $Cu_{90}Sn_{10}$ → 89% Sn free (2313 ppm)
III costraint : gunmetal with Sn=Zn → 81% Sn free (2117 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO23A – Correlations Cu/Sb (0.96), strong SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green	885	102	521	924	4076	6507

	Cu	Brass	Bronze	Bronze	Gunmetal	Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 102 ppm Zn content as "non natural")	
	Cu	Cu	Cu / Sn	Cu / Sn	Cu / Sn	Cu / Sn	Sn / Pb	Sn / Pb	Pb	Pb / Sb	Pb / Sb	Sb				
		$Cu_{90}Zn_{10}$	$Cu_{63}Sn_{37}$	$Cu_{90}Sn_{10}$	$Cu_{59}Sn_{35}Zn_7$	$Cu_{81}Sn_9Zn_9$	$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	$Sb_{18}Pb_{82}$					
Unalloyed	14						71					14	98	x	102 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	14								63			14	90	x	521 ppm Sn + 102 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	14										77		90	x	521 ppm Sn + 102 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	14								43	34			90	x	521 ppm Sn + 102 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	14							$Sn_{16}Pb_{84}$ 51		34			98	x	102 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		15					71					14	100	✓		Brass + SnPb + Sb
Brass		15							63			14	92	x	521 ppm Sn	Brass + Pb + Sb
Brass		15									77		92	x	521 ppm Sn	Brass + SbPb
Brass		15							43*	34			92	x	521 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		15						51		34			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			22				71					14	106	x	102 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			22						63			14	98	x	102 ppm Zn	Bronze + Pb + Sb
Bronze			22								77		98	x	102 ppm Zn	Bronze + SbPb
Bronze			22						43*	34			98	x	102 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			22					$Sn_{16}Pb_{84}$ 51		34			106	x	102 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				15				Sn_9Pb_{91} 69				14	98	x	102 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				15				$Sn_{13}Pb_{87}$ 50		34			98	x	102 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					23		71					14	108	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					23				63			14	100	✓		Gunmetal + Pb + Sb
Gunmetal					23						77		100	✓		Gunmetal + SbPb
Gunmetal					23				43*	34			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						17		$Sn_{13}Pb_{87}$ 49		34			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 69% Pb free (2800 ppm)
II costraint $Cu_{90}Sn_{10}$ → 81% Sn free (422 ppm)
III costraint : gunmetal with Sn=Zn → 80% Sn free (419 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO24 – Correlations Cu/Sb (0.30), SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Blue	2133	59	178	6991	3381	12742

						Pb									
			Sn												
	Cu								Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 59 ppm Zn content as "natural")	
			$Cu_{92}Sn_8$	$Cu_{90}Sn_{10}$		Sn_5Pb_{95}			$Sb_{42}Pb_{58}$	$Sb_{67}Pb_{33}$					
Unalloyed	17					28					55	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	17							27			55	99	x	178 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	17									82		99	x	178 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	17							-	Low Pb			-	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	17						Low Sn -		Low Pb			-	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			18			28					55	101	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			18					27			55	100	✓		Bronze + Pb + Sb
Bronze			18							82		100	✓		Bronze + SbPb
Bronze			18					-	Low Pb			-	x	-	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			18				Low Sn -		Low Pb			-	x	-	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				19			Low Sn -				55	-	x	-	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				19			-		Low Pb			-	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 186% Pb less (6273 ppm missing)
II costraint $Cu_{90}Sn_{10}$ → 33% Sn less (59 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO58A – Correlations Cu/Sb (1.0), strong SnPb, red group lead antimonates.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green	797	65	343	797	1866	3869

								Pb						
			Sn											
	Cu								Sb					
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 65 ppm Zn content as "natural")	
			$Cu_{70}Sn_{30}$	$Cu_{90}Sn_{10}$		$Sn_{16}Pb_{84}$			$Sb_{42}Pb_{58}$	$Sb_{30}Pb_{70}$				
Unalloyed	21					58					21	100	✓	Unalloyed Cu + SnPb + Sb
Unalloyed	21							49			21	91	x 343 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	21									69		91	x 343 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	21							20	50			91	x 343 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{31}Pb_{69}$							
Unalloyed	21						29		50			100	✓	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			30			58					21	109	✓ [Sn counted twice]	Bronze + SnPb + Sb
Bronze			30					49			21	100	✓	Bronze + Pb + Sb
Bronze			30							70		100	✓	Bronze + SbPb
Bronze			30					20*	50			100	✓	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{31}Pb_{69}$							
Bronze			30				29		50			109	✓ [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							$Sn_{12}Pb_{88}$							
Bronze				23			56				21	100	✓	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{25}Pb_{75}$							
Bronze				23			27		50			100	✓	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 41% Pb free (766 ppm)
II costraint $Cu_{90}Sn_{10}$ → 74% Sn free (254 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO58B – Correlations SnPb, red group lead antimonates.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green	1124	142	668	2645	6528	11107

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 364 ppm Zn content as "non natural")	
		$Cu_{89}Zn_{11}$	$Cu_{63}Sn_{37}$	$Cu_{90}Sn_{10}$	$Cu_{58}Sn_{35}Zn_{7}$	$Cu_{80}Sn_{10}Zn_{10}$	$Sn_{9}Pb_{91}$			$Sb_{42}Pb_{58}$	$Sb_{29}Pb_{71}$					
Unalloyed	10						65					24	99	x	142 ppm Zn	Unalloyed Cu + SnPb + Sb
	10								59			24	93	x	668 ppm Sn + 142 ppm Zn	Unalloyed Cu + Pb + Sb
	10										83		93	x	668 ppm Sn + 142 ppm Zn	Unalloyed Cu + SbPb
	10								26	57			93	x	668 ppm Sn + 142 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{19}Pb_{81}$								
	10							32		57			99	x	142 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		11					65					24	100	✓		Brass + SnPb + Sb
		11							59			24	94	x	668 ppm Sn	Brass + Pb + Sb
		11									83		94	x	668 ppm Sn	Brass + SbPb
		11							26	57			94	x	668 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		11						32		57			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			16				65					24	105	x	142 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			16						59			24	99	x	142 ppm Zn	Bronze + Pb + Sb
			16								83		99	x	142 ppm Zn	Bronze + SbPb
			16						26	57			99	x	142 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{19}Pb_{81}$								
			16					32		57			105	x	142 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{8}Pb_{92}$								
				11				64				24	99	x	142 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{16}Pb_{84}$								
				11				31		57			99	x	142 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					17		65					24	106	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					17				59			24	100	✓		Gunmetal + Pb + Sb
					17						83		100	✓		Gunmetal + SbPb
					17				26	57			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{15}Pb_{85}$								
						13		31		57			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 44% Pb free (2875 ppm)
II costraint $Cu_{90}Sn_{10}$ → 81% Sn free (543 ppm)
III costraint : gunmetal with Sn=Zn → 79% Sn free (526 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO58C – Correlations SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green	105	37	183	42	295	662

								Pb							
					Sn										
				Cu						Sb					
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 37 ppm Zn content as "natural")		
			$Cu_{37}Sn_{63}$	$Cu_{90}Sn_{10}$		$Sn_{38}Pb_{62}$			$Sb_{42}Pb_{58}$	$Sb_{12}Pb_{88}$					
Unalloyed	17					76					7	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	17							47			7	71	x	183 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	17									54		71	x	183 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	17							38	16			71	x	183 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{44}Pb_{56}$								
Unalloyed	17						67		16			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			46			76					7	129	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			46					47			7	100	✓		Bronze + Pb + Sb
Bronze			46							54		100	✓		Bronze + SbPb
Bronze			46					38	16			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{44}Pb_{56}$								
Bronze			46				67		16			129	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							$Sn_{37}Pb_{63}$								
Bronze				19			75				7	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{42}Pb_{58}$								
Bronze				19			65		16			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 80% Pb free (237 ppm)
II costraint $Cu_{90}Sn_{10}$ → 94% Sn free (171 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO88 – Correlations Cu/Sb (0.97), strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green light	1561	186	2201	1608	14546	20100

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 186 ppm Zn content as "non natural")	
		$Cu_{89}Zn_{11}$	$Cu_{41}Sn_{59}$	$Cu_{90}Sn_{10}$	$Cu_{40}Sn_{56}Zn_{5}$	$Cu_{81}Sn_{10}Zn_{10}$	$Sn_{13}Pb_{87}$			$Sb_{42}Pb_{58}$	$Sb_{10}Pb_{90}$					
Unalloyed	8						83					8	99	x	186 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	8								72			8	88	x	2201 ppm Sn + 186 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	8										80		88	x	2201 ppm Sn + 186 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	8								61	19			88	x	2201 ppm Sn + 186 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{15}Pb_{85}$								
	8							72		19			99	x	186 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		9					83					8	100	✓		Brass + SnPb + Sb
Brass		9							72			8	89	x	2201 ppm Sn	Brass + Pb + Sb
Brass		9									80		89	x	2201 ppm Sn	Brass + SbPb
Brass		9							61*	19			89	x	2201 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		9						72		19			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			19				83					8	110	x	186 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			19						72			8	99	x	186 ppm Zn	Bronze + Pb + Sb
Bronze			19								80		99	x	186 ppm Zn	Bronze + SbPb
Bronze			19						61*	19			99	x	186 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{15}Pb_{85}$								
Bronze			19					72		19			110	x	186 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{12}Pb_{88}$								
Bronze				9				82				8	99	x	186 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{14}Pb_{86}$								
Bronze				9				71		19			99	x	186 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					20		83					8	111	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					20				72			8	100	✓		Gunmetal + Pb + Sb
Gunmetal					20						80		100	✓		Gunmetal + SbPb
Gunmetal					20				61*	19			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{14}Pb_{86}$								
Gunmetal						10		71		19			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 85% Pb free (12325 ppm)
II costraint $Cu_{90}Sn_{10}$ → 92% Sn free (2027 ppm)
III costraint : gunmetal with Sn=Zn → 92% Sn free (2015 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO92 – Correlations Cu/Sb (0.94), strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green light	3180	589	2875	3402	17683	27729

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 589 ppm Zn content as "non natural")	
		$Cu_{84}Zn_{16}$	$Cu_{53}Sn_{47}$	$Cu_{90}Sn_{10}$	$Cu_{48}Sn_{43}Zn_{9}$	$Cu_{73}Sn_{14}Zn_{14}$	$Sn_{14}Pb_{86}$			$Sb_{42}Pb_{58}$	$Sb_{16}Pb_{84}$					
Unalloyed	11						74					12	98	x	589 ppm Zn	Unalloyed Cu + SnPb + Sb
	11								64			12	88	x	2875 ppm Sn + 589 ppm Zn	Unalloyed Cu + Pb + Sb
	11										76		88	x	2875 ppm Sn + 589 ppm Zn	Unalloyed Cu + SbPb
	11								47	29			88	x	2875 ppm Sn + 589 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{18}Pb_{82}$								
	11							57		29			98	x	589 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		14					74					12	100	✓		Brass + SnPb + Sb
		14							64			12	90	x	2875 ppm Sn	Brass + Pb + Sb
		14									76		90	x	2875 ppm Sn	Brass + SbPb
		14							47*	29			90	x	2875 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		14						57		29			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			22				74					12	108	x	589 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			22						64			12	98	x	589 ppm Zn	Bronze + Pb + Sb
			22								76		98	x	589 ppm Zn	Bronze + SbPb
			22						47*	29			98	x	589 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{18}Pb_{82}$								
			22					57		29			108	x	589 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{12}Pb_{88}$								
				13				73				12	98	x	589 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{16}Pb_{84}$								
				13				56		29			98	x	589 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					24		74					12	110	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					24				64			12	100	✓		Gunmetal + Pb + Sb
					24						76		100	✓		Gunmetal + SbPb
					24				47*	29			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{15}Pb_{85}$								
						16		55		29			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 73% Pb free (12985 ppm)
II costraint $Cu_{90}Sn_{10}$ → 88% Sn free (2027 ppm)
III costraint : gunmetal with Sn=Zn → 80% Sn free (2286 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO93 – Correlations Cu/Sb (0.97), strong SnPb, red group lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green	1742	78	706	1788	4578	8893

									Pb							
					Sn											
				Cu							Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 78 ppm Zn content as "natural")	
			$Cu_{71}Sn_{29}$	$Cu_{90}Sn_{10}$	$Cu_{69}Sn_{28}Zn_3$	$Cu_{92}Sn_4Zn_4$	$Sn_{13}Pb_{87}$			$Sb_{42}Pb_{58}$	$Sb_{28}Pb_{72}$					
Unalloyed	20						60					20	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	20								52			20	92	x	706 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	20										72		92	x	706 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	20								24	48			92	x	706 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{25}Pb_{75}$								
Unalloyed	20							32		48			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			28				60					20	108	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			28						52			20	100	✓		Bronze + Pb + Sb
Bronze			28								72		100	✓		Bronze + SbPb
Bronze			28						24*	48			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{25}Pb_{75}$								
Bronze			28					32		48			108	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{10}Pb_{90}$								
Bronze				22				58				20	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{20}Pb_{80}$								
Bronze				22				30		48			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 46% Pb free (2109 ppm)
II costraint $Cu_{90}Sn_{10}$ → 73% Sn free (513 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO95 – Correlations Cu/Sb (1.03), SnPb, red correlation lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green	1805	73	381	1745	4603	8606

								Pb							
				Sn											
			Cu							Sb					
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 73 ppm Zn content as "natural")	
			$Cu_{83}Sn_{17}$	$Cu_{90}Sn_{10}$		Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{27}Pb_{73}$					
Unalloyed	21					58					20	100	✓		Unalloyed Cu + SnPb + Sb
	21							54			20	96	x	381 ppm Sn	Unalloyed Cu + Pb + Sb
	21									74		96	x	381 ppm Sn	Unalloyed Cu + SbPb
	21							26	49			96	x	381 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{15}Pb_{85}$								
	21						30		49			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26			58					20	104	✓	[Sn counted twice]	Bronze + SnPb + Sb
			26					54			20	100	✓		Bronze + Pb + Sb
			26							74		100	✓		Bronze + SbPb
			26					26	48			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{15}Pb_{85}$								
			26				30		48			104	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							Sn_4Pb_{96}								
				23			56				20	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							Sn_8Pb_{92}								
				23			28		49			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 48% Pb free (2194 ppm)
II costraint $Cu_{90}Sn_{10}$ → 47% Sn free (180 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO96 – Correlation strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green light	2579	187	896	1263	5929	10852

							Pb									
			Sn													
	Cu								Sb							
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 187 ppm Zn content as "non natural")	
		$Cu_{93}Zn_7$	$Cu_{74}Sn_{26}$	$Cu_{90}Sn_{10}$	$Cu_{70}Sn_{24}Zn_5$	$Cu_{87}Sn_6Zn_6$	$Sn_{13}Pb_{87}$			$Sb_{42}Pb_{58}$	$Sb_{18}Pb_{82}$					
Unalloyed	24						63					12	98	x	187 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	24								55			12	90	x	896 ppm Sn + 187 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	24										66		90	x	896 ppm Sn + 187 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	24								39	28			90	x	896 ppm Sn + 187 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	24							$Sn_{18}Pb_{82}$ 47		28			98	x	187 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		25					63					12	100	✓		Brass + SnPb + Sb
Brass		25							55			12	92	x	896 ppm Sn	Brass + Pb + Sb
Brass		25									66		92	x	896 ppm Sn	Brass + SbPb
Brass		25							39*	28			92	x	896 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		25						47		28			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			32				63					12	107	x	187 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			32						55			12	98	x	187 ppm Zn	Bronze + Pb + Sb
Bronze			32								66		98	x	187 ppm Zn	Bronze + SbPb
Bronze			32						39*	28			98	x	187 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			32					$Sn_{18}Pb_{82}$ 47		28			107	x	187 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				26				Sn_9Pb_{91} 60				12	98	x	187 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				26				$Sn_{13}Pb_{87}$ 44		28			98	x	187 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					34		63					12	108	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					34				55			12	100	✓		Gunmetal + Pb + Sb
Gunmetal					34						66		100	✓		Gunmetal + SbPb
Gunmetal					34				39*	28			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						27		$Sn_{14}Pb_{86}$ 45		28			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 71% Pb free (4185 ppm)
II costraint $Cu_{90}Sn_{10}$ → 68% Sn free (609 ppm)
III costraint : gunmetal with Sn=Zn → 79% Sn free (709 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO100A – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green-red	2290	255	1801	1100	7719	13164

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 255 ppm Zn content as "non natural")	
		$Cu_{90}Zn_{10}$	$Cu_{56}Sn_{44}$	$Cu_{90}Sn_{10}$	$Cu_{53}Sn_{41}Zn_{6}$	$Cu_{82}Sn_{9}Zn_{9}$	$Sn_{19}Pb_{81}$			$Sb_{42}Pb_{58}$	$Sb_{12}Pb_{88}$					
Unalloyed	17						72					8	98	x	255 ppm Zn	Unalloyed Cu + SnPb + Sb
	17								59			8	84	x	1801 ppm Sn + 255 ppm Zn	Unalloyed Cu + Pb + Sb
	17										67		84	x	1801 ppm Sn + 255 ppm Zn	Unalloyed Cu + SbPb
	17								47	20			84	x	1801 ppm Sn + 255 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
	17							$Sn_{23}Pb_{77}$ 61		20			98	x	255 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		19					72					8	100	✓		Brass + SnPb + Sb
		19							59			8	86	x	1801 ppm Sn	Brass + Pb + Sb
		19									67		86	x	1801 ppm Sn	Brass + SbPb
		19							47	20			86	x	1801 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		19						61		20			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			31				72					8	112	x	255 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			31						59			8	98	x	255 ppm Zn	Bronze + Pb + Sb
			31								67		98	x	255 ppm Zn	Bronze + SbPb
			31						47	20			98	x	255 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
			31					$Sn_{23}Pb_{77}$ 61		20			112	x	255 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
				19				$Sn_{17}Pb_{83}$ 70				8	98	x	255 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
				19				$Sn_{20}Pb_{80}$ 59		20			98	x	255 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					33		72					8	114	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					33				59			8	100	✓		Gunmetal + Pb + Sb
					33						67		100	✓		Gunmetal + SbPb
					33				47	20			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
						21		$Sn_{20}Pb_{80}$ 59		20			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 80% Pb free (6200 ppm)
II costraint $Cu_{90}Sn_{10}$ → 86% Sn free (1546 ppm)
III costraint : gunmetal with Sn=Zn → 86% Sn free (1545 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO100B– Correlations Cu/Sb (1.10), SnPb, orange group lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green	1548	33	192	1404	2700	5876

								Pb							
			Sn												
	Cu								Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 33 ppm Zn content as “natural”)		
			$Cu_{89}Sn_{11}$	$Cu_{90}Sn_{10}$		Sn_7Pb_{93}			$Sb_{42}Pb_{58}$	$Sb_{34}Pb_{66}$					
Unalloyed	26					49					24	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	26							46			24	97	x	192 ppm Sn + 33 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	26									70		97	x	192 ppm Sn + 33 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	26							13	57			97	x	192 ppm Sn + 33 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{20}Pb_{80}$								
Unalloyed	26						16		57			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			30			49					24	103	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			30					46			24	100	✓		Bronze + Pb + Sb
Bronze			30							70		100	✓		Bronze + SbPb
Bronze			30					13*	57			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{20}Pb_{80}$								
Bronze			30				16		57			103	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							Sn_1Pb_{99}								
Bronze				29			47				24	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							Sn_3Pb_{97}								
Bronze				29			13		57			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 28% Pb free (761 ppm)
II costraint $Cu_{90}Sn_{10}$ → 10% Sn free (20 ppm)
III costraint : gunmetal with Sn=Zn → 83% Sn free (159 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO121A – Correlations Cu/Sb (1.04), strong SnPb, red group lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green light	1233	72	575	1189	3344	6413

							Pb								
			Sn												
	Cu								Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 72 ppm Zn content as "natural")		
			$Cu_{68}Sn_{32}$	$Cu_{90}Sn_{10}$		$Sn_{15}Pb_{85}$			$Sb_{42}Pb_{58}$	$Sb_{26}Pb_{74}$					
Unalloyed	19					62					19	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	19							53			19	91	x	575 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	19									71		91	x	575 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	19							27	45			91	x	575 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{25}Pb_{75}$								
Unalloyed	19						36		45			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			29			62					19	109	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			29					53			19	100	✓		Bronze + Pb + Sb
Bronze			29							71		100	✓		Bronze + SbPb
Bronze			29					27*	45			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{25}Pb_{75}$								
Bronze			29				36		45			109	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							$Sn_{12}Pb_{88}$								
Bronze				22			60				19	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{20}Pb_{80}$								
Bronze				22			34		45			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 51% Pb free (1702 ppm)
II costraint $Cu_{90}Sn_{10}$ → 76% Sn free (438 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO121B – Correlation SnPb, red group lead antimonates.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green light	1882	81	444	1389	4083	7879

							Pb								
			Sn												
	Cu								Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 81 ppm Zn content as "natural")		
			$Cu_{81}Sn_{19}$	$Cu_{90}Sn_{10}$		$Sn_{10}Pb_{90}$			$Sb_{42}Pb_{58}$	$Sb_{25}Pb_{75}$					
Unalloyed	24					58					18	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	24							52			18	94	x	444 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	24									70		94	x	444 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	24							28	42			94	x	444 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{17}Pb_{83}$								
Unalloyed	24						33		42			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			30			58					18	106	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			30					52			18	100	✓		Bronze + Pb + Sb
Bronze			30							70		100	✓		Bronze + SbPb
Bronze			30					28	42			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{17}Pb_{83}$								
Bronze			30				33		42			106	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							Sn_5Pb_{95}								
Bronze				27			55				18	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{10}Pb_{90}$								
Bronze				27			31		42			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 53% Pb free (2166 ppm)
II costraint $Cu_{90}Sn_{10}$ → 53% Sn free (235 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO121C – Correlations Cu/Sb (0.98), strong SnPb, red group lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green light	1491	57	305	1516	3395	6765

	Cu													
			Sn				Pb							
	Cu									Sb				
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 57 ppm Zn content as "natural")	
			$Cu_{83}Sn_{17}$	$Cu_{90}Sn_{10}$		Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{31}Pb_{69}$				
Unalloyed	22					55					23	100	✓	Unalloyed Cu + SnPb + Sb
	22							51			23	95	x 305 ppm Sn	Unalloyed Cu + Pb + Sb
	22									73		95	x 305 ppm Sn	Unalloyed Cu + SbPb
	22							19	54			95	x 305 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{19}Pb_{81}$							
	22						24		54			100	✓	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			27			55					23	105	✓ [Sn counted twice]	Bronze + SnPb + Sb
			27					51			23	100	✓	Bronze + Pb + Sb
			27							73		100	✓	Bronze + SbPb
			27					19	54			100	✓	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{19}Pb_{81}$							
			27				24		54			105	✓ [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							Sn_4Pb_{96}							
				25			53				23	100	✓	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{10}Pb_{90}$							
				25			21		54			100	✓	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 38% Pb free (1301 ppm)
II costraint $Cu_{90}Sn_{10}$ → 46% Sn free (139 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO121D – Correlations Cu/Sb (0.91), SnPb, orange correlation lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green light	2550	92	417	2819	4635	10513

								Pb						
				Sn										
			Cu						Sb					
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 92 ppm Zn content as "natural")	
			$Cu_{86}Sn_{14}$	$Cu_{90}Sn_{10}$		Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{38}Pb_{62}$				
Unalloyed	24					48					27	100	✓	Unalloyed Cu + SnPb + Sb
Unalloyed	24							44			27	96	x 417 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	24									72		96	x 417 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	24							7	64			96	x 417 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{36}Pb_{64}$							
Unalloyed	24						11		64			100	✓	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			28			48					27	104	✓ [Sn counted twice]	Bronze + SnPb + Sb
Bronze			28					44			27	100	✓	Bronze + Pb + Sb
Bronze			28							72		100	✓	Bronze + SbPb
Bronze			28					7	64			100	✓	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{36}Pb_{64}$							
Bronze			28				11		64			104	✓ [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							Sn_3Pb_{97}							
Bronze				27			45				27	100	✓	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{15}Pb_{85}$							
Bronze				27			8		64			100	✓	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 16% Pb free (743 ppm)
II costraint $Cu_{90}Sn_{10}$ → 32% Sn free (134 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO122 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue	2482	71	182	6345	2435	11515

						Pb	Pb	Pb	Pb	Pb					
			Sn	Sn	Sn	Sn									
	Cu	Cu	Cu	Cu	Cu				Sb	Sb	Sb				
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 71 ppm Zn content as "natural")	
			$Cu_{93}Sn_7$	$Cu_{90}Sn_{10}$		Sn_7Pb_{93}			$Sb_{42}Pb_{58}$	$Sb_{72}Pb_{28}$					
Unalloyed	22					23					55	99	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	22							21			55	98	x	182 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	22									76		98	x	182 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	22							-	Low Pb			98	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	22						Low Sn -		Low Pb			-	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			23			23					55	101	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			23					21			55	99	✓		Bronze + Pb + Sb
Bronze			23							77		99	✓		Bronze + SbPb
Bronze			23					-	Low Pb			99	x	-	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			23				Low Sn -		Low Pb			101	x	-	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				24			Low Sn -				55	99	x	-	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				24			-		Low Pb			99	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 260% Pb less (6327 ppm missing)
II costraint $Cu_{90}Sn_{10}$ → 94% Sn less (94 ppm missing)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO184A – Correlations Cu/Sb (1.0), strong SnPb, red correlation lead antimonates.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green	1908	166	670	1906	5311	9962

									Pb							
					Sn											
			Cu								Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 166 ppm Zn content as "non natural")		
		$Cu_{92}Zn_8$	$Cu_{74}Sn_{26}$	$Cu_{90}Sn_{10}$	$Cu_{70}Sn_{24}Zn_6$	$Cu_{85}Sn_7Zn_7$	$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	$Sb_{26}Pb_{74}$					
Unalloyed	19						60					19	98	x	166 ppm Zn	Unalloyed Cu + SnPb + Sb
	19								53			19	92	x	670 ppm Sn + 166 ppm Zn	Unalloyed Cu + Pb + Sb
	19										72		92	x	670 ppm Sn + 166 ppm Zn	Unalloyed Cu + SbPb
	19								27	46			92	x	670 ppm Sn + 166 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
	19							$Sn_{20}Pb_{80}$ 34		46			98	x	166 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		21					60					19	100	✓		Brass + SnPb + Sb
		21							53			19	93	x	670 ppm Sn	Brass + Pb + Sb
		21									72		93	x	670 ppm Sn	Brass + SbPb
		21							27*	46			93	x	670 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		21						34		46			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				60					19	105	x	166 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			26						53			19	98	x	166 ppm Zn	Bronze + Pb + Sb
			26								72		98	x	166 ppm Zn	Bronze + SbPb
			26						27*	46			98	x	166 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
			26					$Sn_{20}Pb_{80}$ 34		46			105	x	166 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
				21				Sn_8Pb_{92} 58				19	98	x	166 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
				21				$Sn_{15}Pb_{85}$ 32		46			98	x	166 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					28		60					19	107	✓	Sn counted twice	Gunmetal + SnPb + Sb
					28				53			19	100	✓		Gunmetal + Pb + Sb
					28						72		100	✓		Gunmetal + SbPb
					28				27*	46			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
						22		$Sn_{16}Pb_{84}$ 32		46			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 50% Pb free (2680 ppm)
II costraint $Cu_{90}Sn_{10}$ → 68% Sn free (458 ppm)
III costraint : gunmetal with Sn=Zn → 75% Sn free (504 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO184B – Correlations Cu/Sb (0.96), SnPb, orange group lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green	2098	58	261	2196	4389	9001

								Pb						
			Sn											
	Cu								Sb					
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 58 ppm Zn content as "natural")	
			$Cu_{89}Sn_{11}$	$Cu_{90}Sn_{10}$		Sn_6Pb_{94}			$Sb_{42}Pb_{58}$	$Sb_{33}Pb_{67}$				
Unalloyed	23					52					25	100	✓	Unalloyed Cu + SnPb + Sb
	23							49			25	97	x 261 ppm Sn	Unalloyed Cu + Pb + Sb
	23									74		97	x 261 ppm Sn	Unalloyed Cu + SbPb
	23							15	58			97	x 261 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{16}Pb_{84}$							
	23						18		58			100	✓	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26			52					25	103	✓ [Sn counted twice]	Bronze + SnPb + Sb
			26					49			25	100	✓	Bronze + Pb + Sb
			26							74		100	✓	Bronze + SbPb
			26					15	58			100	✓	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{16}Pb_{84}$							
			26				18		58			103	✓ [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							Sn_1Pb_{99}							
				26			49				25	100	✓	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							Sn_2Pb_{98}							
				26			15		58			100	✓	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 31% Pb free (1356 ppm)
II costraint $Cu_{90}Sn_{10}$ → 11% Sn free (28 ppm)
III costraint : gunmetal with Sn=Zn → 78% Sn free (203 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO184C – Correlations Cu/Sb (0.88), SnPb, orange group lead antimonates.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green	2057	114	421	2343	4725	9660

							Pb									
			Sn													
	Cu									Sb						
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 114 ppm Zn content as "non natural")	
		$Cu_{95}Zn_5$	$Cu_{83}Sn_{17}$	$Cu_{90}Sn_{10}$	$Cu_{79}Sn_{16}Zn_4$	$Cu_{90}Sn_5Zn_5$	Sn_8Pb_{92}			$Sb_{42}Pb_{58}$	$Sb_{33}Pb_{67}$					
Unalloyed	21						53					24	99	x	114 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	21								49			24	94	x	421 ppm Sn + 114 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	21										73		94	x	421 ppm Sn + 114 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	21								15	58			94	x	421 ppm Sn + 114 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{22}Pb_{78}$								
Unalloyed	21							20		58			99	x	114 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		22					53					24	100	✓		Brass + SnPb + Sb
Brass		22							49			24	96	x	421 ppm Sn	Brass + Pb + Sb
Brass		22									73		96	x	421 ppm Sn	Brass + SbPb
Brass		22							15*	58			96	x	421 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		22						20		58			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26				53					24	103	x	114 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			26						49			24	99	x	114 ppm Zn	Bronze + Pb + Sb
Bronze			26								73		99	x	114 ppm Zn	Bronze + SbPb
Bronze			26						15*	58			99	x	114 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{22}Pb_{78}$								
Bronze			26					20		58			103	x	114 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								Sn_4Pb_{96}								
Bronze				24				51				24	99	x	114 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{11}Pb_{89}$								
Bronze				24				17		58			99	x	114 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					27		53					24	104	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					27				49			24	100	✓		Gunmetal + Pb + Sb
Gunmetal					27						73		100	✓		Gunmetal + SbPb
Gunmetal					27				15*	58			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$								
Gunmetal						24		19		58			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 32% Pb free (1490 ppm)
II costraint $Cu_{90}Sn_{10}$ → 46% Sn free (193 ppm)
III costraint : gunmetal with Sn=Zn → 73% Sn free (308 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO230 – Correlation SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green	607	194	874	209	3504	5389

	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 194 ppm Zn content as “non natural”)	
		$Cu_{76}Zn_{24}$	$Cu_{41}Sn_{59}$	$Cu_{90}Sn_{10}$	$Cu_{36}Sn_{52}Zn_{12}$	$Cu_{61}Sn_{20}Zn_{20}$	$Sn_{20}Pb_{80}$			$Sb_{42}Pb_{58}$	$Sb_{6}Pb_{94}$					
Unalloyed	11						81					4	96	x	194 ppm Zn	Unalloyed Cu + SnPb + Sb
	11								65			4	80	x	874 ppm Sn + 194 ppm Zn	Unalloyed Cu + Pb + Sb
	11										69		80	x	874 ppm Sn + 194 ppm Zn	Unalloyed Cu + SbPb
	11								60	9			80	x	874 ppm Sn + 194 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{21}Pb_{79}$								
	11							76		9			96	x	194 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		15					81					4	100	✓		Brass + SnPb + Sb
		15							65			4	84	x	874 ppm Sn	Brass + Pb + Sb
		15									69		84	x	874 ppm Sn	Brass + SbPb
		15							60*	9			84	x	874 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		15						76		9			100	✓		Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			27				81					4	113	x	194 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			27						65			4	96	x	194 ppm Zn	Bronze + Pb + Sb
			27								69		96	x	194 ppm Zn	Bronze + SbPb
			27						60	9			96	x	194 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{21}Pb_{79}$								
			27					76		9			113	x	194 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{19}Pb_{81}$								
				13				80				4	96	x	194 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{20}Pb_{80}$								
				13				75		9			96	x	194 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					31		81					4	116	✓	[Sn counted twice]	Gunmetal + SnPb + Sb
					31				65			4	100	✓		Gunmetal + Pb + Sb
					31						69		100	✓		Gunmetal + SbPb
					31				60	9			100	✓		Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{17}Pb_{83}$								
						18		72		9			100	✓		Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 92% Pb free (3216 ppm)
II costraint $Cu_{90}Sn_{10}$ → 92% Sn free (806 ppm)
III costraint : gunmetal with Sn=Zn → 78% Sn free (679 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO233C – Correlation strong SnPb, yellow correlation lead antimonates.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Blue	2099	87	523	3349	4264	10320

							Pb								
			Sn												
	Cu								Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot		Unexplained (considering 87 ppm Zn content as "natural")	
			$Cu_{80}Sn_{20}$	$Cu_{90}Sn_{10}$		$Sn_{11}Pb_{89}$			$Sb_{42}Pb_{58}$	$Sb_{44}Pb_{56}$					
Unalloyed	21					47					33	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	21							42			33	95	x	523 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	21									74		95	x	523 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	21							-	Low Pb			-	x	-	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							Low Pb								
Unalloyed	21						-		Low Pb			-	x		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			26			47					33	105	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			26					42			33	100	✓		Bronze + Pb + Sb
Bronze			26							74		100	✓		Bronze + SbPb
Bronze			26					-	Low Pb			-	x	-	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							Low Pb								
Bronze			26				2		Low Pb			-	x	-	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							Sn_6Pb_{94}								
Bronze				23			44				33	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							Low Sn								
Bronze				23			-		Low Pb			-	x	-	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 8% less Pb (361 ppm missing)
II costraint $Cu_{90}Sn_{10}$ → 55% Sn free (289 ppm)
III costraint : gunmetal with Sn=Zn → 83% Sn free (436 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO325 – Correlation strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green	1986	267	1203	718	9245	13419

	Cu	Cu	Cu	Cu	Cu / Sn	Cu / Sn	Sn / Pb	Sn / Pb	Pb	Pb / Sb	Sb	Sb		
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 267 ppm Zn content as "non natural")	
		$Cu_{88}Zn_{12}$	$Cu_{62}Sn_{38}$	$Cu_{90}Sn_{10}$	$Cu_{57}Sn_{35}Zn_{8}$	$Cu_{79}Sn_{11}Zn_{11}$	$Sn_{12}Pb_{88}$			$Sb_{42}Pb_{58}$	$Sb_{7}Pb_{93}$				
Unalloyed	15						78					5	98	x 267 ppm Zn	Unalloyed Cu + SnPb + Sb
Unalloyed	15								69			5	89	x 1203 ppm Sn + 267 ppm Zn	Unalloyed Cu + Pb + Sb
Unalloyed	15										74		89	x 1203 ppm Sn + 267 ppm Zn	Unalloyed Cu + SbPb
Unalloyed	15								62	13			89	x 1203 ppm Sn + 267 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
Unalloyed	15							$Sn_{13}Pb_{87}$ 70		13			98	x 267 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		17					78					5	100	✓	Brass + SnPb + Sb
Brass		17							69			5	91	x 1203 ppm Sn	Brass + Pb + Sb
Brass		17									74		91	x 1203 ppm Sn	Brass + SbPb
Brass		17							62*	13			91	x 1203 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
Brass		17						70		13			100	✓	Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			24				78					5	107	x 267 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
Bronze			24						69			5	98	x 267 ppm Zn	Bronze + Pb + Sb
Bronze			24								74		98	x 267 ppm Zn	Bronze + SbPb
Bronze			24						62*	13			98	x 267 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
Bronze			24					$Sn_{13}Pb_{87}$ 70		13			107	x 267 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze				16				$Sn_{10}Pb_{90}$ 76				5	98	x 267 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
Bronze				16				$Sn_{11}Pb_{89}$ 69		13			98	x 267 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					26		78					5	109	✓ [Sn counted twice]	Gunmetal + SnPb + Sb
Gunmetal					26				69			5	100	✓	Gunmetal + Pb + Sb
Gunmetal					26						74		100	✓	Gunmetal + SbPb
Gunmetal					26				62*	13			100	✓	Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
Gunmetal						19		$Sn_{10}Pb_{90}$ 68		13			100	✓	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 89% Pb free (8254 ppm)
II costraint $Cu_{90}Sn_{10}$ → 82% Sn free (982 ppm)
III costraint : gunmetal with Sn=Zn → 78% Sn free (936 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO365 – Correlation strong SnPb.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green	205	19	137	73	650	1084

						Pb									
			Sn												
	Cu								Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 19 ppm Zn content as “natural”)		
			$Cu_{60}Sn_{40}$	$Cu_{90}Sn_{10}$		$Sn_{17}Pb_{83}$			$Sb_{42}Pb_{58}$	$Sb_{10}Pb_{90}$					
Unalloyed	19					74					7	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	19							61			7	87	x	137 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	19									68		87	x	137 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	19							52	16			87	x	137 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{20}Pb_{80}$								
Unalloyed	19						64		16			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			32			74					7	113	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			32					61			7	100	✓		Bronze + Pb + Sb
Bronze			32							68		100	✓		Bronze + SbPb
Bronze			32					52*	16			100	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{20}Pb_{80}$								
Bronze			32				64		16			113	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							$Sn_{15}Pb_{85}$								
Bronze				21			72				7	100	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{17}Pb_{83}$								
Bronze				21			62		16			100	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 85% Pb free (550 ppm)
II costraint $Cu_{90}Sn_{10}$ → 83% Sn free (114 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO366 – Correlations Cu/Sb (1.27), strong SnPb, red group lead antimonates.

Colour	**Cu**	**Zn**	**Sn**	**Sb**	**Pb**	**Total**
Green-blue	348	43	196	273	893	1753

	Cu							Pb							
			Sn						Sb						
	Cu	Brass	Bronze		Gunmetal	SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 43 ppm Zn content as "natural")		
			$Cu_{64}Sn_{36}$	$Cu_{90}Sn_{10}$		$Sn_{18}Pb_{82}$			$Sb_{42}Pb_{58}$	$Sb_{23}Pb_{77}$					
Unalloyed	20					64					16	100	✓		Unalloyed Cu + SnPb + Sb
Unalloyed	20							52			16	89	x	196 ppm Sn	Unalloyed Cu + Pb + Sb
Unalloyed	20									68		89	x	196 ppm Sn	Unalloyed Cu + SbPb
Unalloyed	20							30	38			89	x	196 ppm Sn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
							$Sn_{28}Pb_{72}$								
Unalloyed	20						42		38			100	✓		Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			32			64					16	109	✓	[Sn counted twice]	Bronze + SnPb + Sb
Bronze			32					52			16	98	✓		Bronze + Pb + Sb
Bronze			32							68		98	✓		Bronze + SbPb
Bronze			32					30*	38			98	✓		Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
							$Sn_{28}Pb_{72}$								
Bronze			32				42		38			109	✓	[Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
							$Sn_{15}Pb_{85}$								
Bronze				23			61				16	98	✓		Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
							$Sn_{23}Pb_{77}$								
Bronze				23			39		38			98	✓		Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ → 58% Pb free (515 ppm)
II costraint $Cu_{90}Sn_{10}$ → 80% Sn free (158 ppm)
* If contained in the copper alloy → leaded brass, leaded bronze, leaded gunmetal.

CO530 – Correlation SnPb.

Colour	Cu	Zn	Sn	Sb	Pb	Total
Green-red	7270	2442	5277	301	23672	38963

	Cu								Pb						
			Sn							Sb					
	Cu	Brass	Bronze		Gunmetal		SnPb	SnPb free	Pb	$Sb_{42}Pb_{58}$	SbPb	Sb	Tot	Unexplained (considering 2442 ppm Zn content as “non natural”)	
		$Cu_{75}Zn_{25}$	$Cu_{58}Sn_{42}$	$Cu_{90}Sn_{10}$	$Cu_{48}Sn_{35}Zn_{16}$	$Cu_{60}Sn_{20}Zn_{20}$	$Sn_{18}Pb_{82}$			$Sb_{42}Pb_{58}$	$Sb_{1}Pb_{99}$				
Unalloyed	19						74					1	94	x 2442 ppm Zn	Unalloyed Cu + SnPb + Sb
	19								61			1	80	x 5277 ppm Sn + 2442 ppm Zn	Unalloyed Cu + Pb + Sb
	19										62		80	x 5277 ppm Sn + 2442 ppm Zn	Unalloyed Cu + SbPb
	19								60	2			80	x 5277 ppm Sn + 2442 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + Pb (free)
								$Sn_{18}Pb_{82}$							
	19							73		2			94	x 2442 ppm Zn	Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)
Brass		25					74					1	100	✓	Brass + SnPb + Sb
		25							61			1	86	x 5277 ppm Sn	Brass + Pb + Sb
		25									62		86	x 5277 ppm Sn	Brass + SbPb
		25							60	2			86	x 5277 ppm Sn	Brass + $Sb_{42}Pb_{58}$ + *Pb (free)
		25						73		2			100	✓	Brass + $Sb_{42}Pb_{58}$ + SnPb (free)
Bronze			32				74					1	107	x 2442 ppm Zn [Sn counted twice]	Bronze + SnPb + Sb
			32						61			1	94	x 2442 ppm Zn	Bronze + Pb + Sb
			32								62		94	x 2442 ppm Zn	Bronze + SbPb
			32						60	2			94	x 2442 ppm Zn	Bronze + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{18}Pb_{82}$							
			32					73		2			107	x 2442 ppm Zn [Sn counted twice]	Bronze + $Sb_{42}Pb_{58}$ + SnPb (free)
								$Sn_{16}Pb_{84}$							
				21				72				1	94	x 2442 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb
								$Sn_{16}Pb_{84}$							
				21				71		2			94	x 2442 ppm Zn	Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)
Gunmetal					38		74					1	114	✓ [Sn counted twice]	Gunmetal + SnPb + Sb
					38				61			1	100	✓	Gunmetal + Pb + Sb
					38						62		100	✓	Gunmetal + SbPb
					38				60	2			100	✓	Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)
								$Sn_{11}Pb_{89}$							
						31		67		2			100	✓	Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)

I costraint $Sb_{42}Pb_{58}$ $\rightarrow$ 98% Pb free (23256 ppm)
II costraint $Cu_{90}Sn_{10}$ $\rightarrow$ 85% Sn free (4470 ppm)
III costraint : gunmetal with Sn=Zn $\rightarrow$ 54% Sn free (2835 ppm)
* If contained in the copper alloy $\rightarrow$ leaded brass, leaded bronze, leaded gunmetal.

SUMMARY

1) Samples with Zn < 100, showing Cu/Sb correlation.

	Unalloyed Cu + SnPb + Sb						Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)						Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb						Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)						
Sample ID	Cu	SnPb	Sb	Cu	Sb	SnPb	Cu	$Sb_{42}Pb_{58}$	SnPb	Cu	$Sb_{42}Pb_{58}$	SnPb	$Cu_{90}Sn_{10}$	SnPb	Sb	Cu	Sb	SnPb	$Cu_{90}Sn_{10}$	SnPb	$Sb_{42}Pb_{58}$	Cu	$Sb_{42}Pb_{58}$	SnPb	
CO366	20	64 $Sn_{18}Pb_{82}$	16	1	1	3	20	38	42 $Sn_{28}Pb_{72}$	1	2	2	23	61 $Sn_{15}Pb_{85}$	16	1	1	3	23	39 $Sn_{23}Pb_{77}$	38	1	2	2	SnPb
CO121A	19	62 $Sn_{15}Pb_{85}$	19	1	1	3	19	45	36 $Sn_{25}Pb_{75}$	1	2	2	22	60 $Sn_{12}Pb_{88}$	19	1	1	3	22	34 $Sn_{20}Pb_{80}$	45	1	2	2	SnPb
CO93	20	60 $Sn_{13}Pb_{87}$	20	1	1	3	20	48	32 $Sn_{25}Pb_{75}$	1	2	2	22	58 $Sn_{10}Pb_{90}$	20	1	1	3	22	30 $Sn_{20}Pb_{80}$	48	1	2	1	SnPb
CO95	21	58 $Sn_{8}Pb_{92}$	20	1	1	3	21	49	30 $Sn_{15}Pb_{85}$	1	2	1	23	56 $Sn_{4}Pb_{96}$	20	1	1	2	23	28 $Sn_{8}Pb_{92}$	49	1	2	1	
CO58A	21	57 $Sn_{16}Pb_{84}$	21	1	1	3	21	49	29 $\boxed{Sn_{31}Pb_{69}}$	1	2	1	23	55 $Sn_{12}Pb_{88}$	21	1	1	2	23	26 $Sn_{25}Pb_{75}$	49	1	2	1	SnPb
Com01	23	55 $Sn_{10}Pb_{90}$	21	1	1	2	23	51	26 $Sn_{21}Pb_{79}$	1	2	1	26	43 $Sn_{5}Pb_{95}$	21	1	1	2	26	23 $Sn_{12}Pb_{88}$	51	1	2	1	
CO121C	22	55 $Sn_{8}Pb_{92}$	23	1	1	3	22	54	24 $Sn_{19}Pb_{81}$	1	2	1	25	53 $Sn_{4}Pb_{96}$	23	1	1	2	25	21 $Sn_{10}Pb_{90}$	54	1	2	1	
CO100B	26	49 $Sn_{7}Pb_{93}$	24	1	1	2	26	57	16 $Sn_{20}Pb_{80}$	1	2	1	-	- -	-	-	-	-	29	13 $Sn_{3}Pb_{97}$	57	1	2	0	
CO184B	23	52 $Sn_{6}Pb_{94}$	25	1	1	2	23	58	18 $Sn_{16}Pb_{84}$	1	3	1	-	- -	-	-	-	-	26	15 $Sn_{2}Pb_{98}$	58	1	2	1	
Com80	20	54 $Sn_{18}Pb_{82}$	25	1	1	3	20	60	19 $Sn_{51}Pb_{49}$	1	3	1	22	52 $Sn_{15}Pb_{85}$	25	1	1	2	22	17 $Sn_{45}Pb_{55}$	60	1	3	1	SnPb
CO121D	24	48 $Sn_{8}Pb_{92}$	27	1	1	2	24	64	11 $\boxed{Sn_{36}Pb_{64}}$	1	3	0	27	45 $Sn_{3}Pb_{97}$	27	1	1	2	27	8 $Sn_{15}Pb_{85}$	64	1	2	0	

2) Samples with Zn > 100, showing Cu/Sb correlation.

	Brass + SnPb + Sb							Brass + $Sb_{42}Pb_{58}$ + SnPb (free)							Gunmetal + SnPb + Sb						
		Brass	SnPb	Sb	Cu	Sb	SnPb		Brass	$Sb_{42}Pb_{58}$	SnPb	Cu	$Sb_{42}Pb_{58}$	SnPb	Gunmetal	SnPb	Sb	G.	SnPb	Sb	
Com24	20	$Cu_{95}Zn_{5}$	59 $Sn_{10}Pb_{90}$	20	1	1	3	20	$Cu_{95}Zn_{5}$	49	31 $Sn_{20}Pb_{80}$	1	2	2	- -	- -	-	-	-	-	SnPb
Com61	25	$Cu_{77}Zn_{23}$	59 $Sn_{8}Pb_{92}$	16	1	1	2	25	$Cu_{77}Zn_{23}$	38	37 $Sn_{13}Pb_{87}$	1	2	1	- -	- -	-	-	-	-	SnPb
Com82	21	$Cu_{92}Zn_{8}$	53 $Sn_{13}Pb_{87}$	27	1	1	3	21	$Cu_{92}Zn_{8}$	64	16 $Sn_{45}Pb_{55}$	1	3	1	- -	- -	-	-	-	-	
Com25	15	$Cu_{90}Zn_{10}$	71 $Sn_{11}Pb_{89}$	14	1	1	5	15	$Cu_{90}Zn_{10}$	34	51 $Sn_{16}Pb_{84}$	1	2	3	- -	- -	-	-	-	-	SnPb
CO23A	22	$Cu_{95}Zn_{5}$	53 $Sn_{8}Pb_{92}$	24	1	1	2	22	$Cu_{95}Zn_{5}$	58	20 $Sn_{22}Pb_{78}$	1	3	1	- -	- -	-	-	-	-	SnPb
CO184C	26	$Cu_{96}Zn_{4}$	47 $Sn_{11}Pb_{89}$	27	1	1	2	26	$Cu_{96}Zn_{4}$	64	10 $Sn_{51}Pb_{49}$	1	2	0	- -	- -	-	-	-	-	
Com46	26	$Cu_{93}Zn_{7}$	49 $Sn_{7}Pb_{93}$	24	1	1	2	26	$Cu_{93}Zn_{7}$	58	16 $Sn_{21}Pb_{79}$	1	2	1	- -	- -	-	-	-	-	SnPb
Com97	24	$Cu_{95}Zn_{5}$	55 $Sn_{12}Pb_{88}$	21	1	1	2	24	$Cu_{95}Zn_{5}$	51	25 $Sn_{27}Pb_{73}$	1	2	1	- -	- -	-	-	-	-	
Com72	21	$Cu_{75}Zn_{25}$	64 $Sn_{11}Pb_{89}$	15	1	1	3	21	$Cu_{75}Zn_{25}$	36	43 $Sn_{17}Pb_{83}$	1	2	2	- -	- -	-	-	-	-	SnPb
Com36	26	$Cu_{90}Zn_{10}$	79 $Sn_{2}Pb_{98}$	24	1	1	3	26	$Cu_{90}Zn_{10}$	58	16 $Sn_{7}Pb_{93}$	1	2	1	- -	- -	-	-	-	-	SnPb
Com47	21	$Cu_{92}Zn_{8}$	60 $Sn_{11}Pb_{89}$	19	1	1	3	21	$Cu_{92}Zn_{8}$	46	34 $Sn_{20}Pb_{80}$	1	2	2	27 $Cu_{86}Sn_{4}Zn_{10}$	49 $Sn_{2}Pb_{98}$	24	1	1	2	
CO184A	23	$Cu_{92}Zn_{8}$	55 $Sn_{12}Pb_{88}$	23	1	1	2	23	$Cu_{92}Zn_{8}$	54	23 $Sn_{29}Pb_{71}$	1	2	1	- -	- -	-	-	-	-	SnPb
Com50	9	$Cu_{89}Zn_{11}$	83 $Sn_{13}Pb_{87}$	8	1	1	9	9	$Cu_{89}Zn_{11}$	19	72 $Sn_{15}Pb_{85}$	1	2	8	- -	- -	-	-	-	-	SnPb
CO88	27	$Cu_{91}Zn_{9}$	48 $Sn_{8}Pb_{92}$	24	1	1	2	27	$Cu_{91}Zn_{9}$	58	15 $Sn_{28}Pb_{72}$	1	2	1	- -	- -	-	-	-	-	SnPb
Com73	25	$Cu_{91}Zn_{9}$	48 $Sn_{8}Pb_{92}$	27	1	1	2	25	$Cu_{91}Zn_{9}$	64	11 $Sn_{35}Pb_{65}$	1	3	0	- -	- -	-	-	-	-	
Com78	21	$Cu_{88}Zn_{12}$	62 $Sn_{5}Pb_{95}$	16	1	1	3	21	$Cu_{88}Zn_{12}$	39	40 $Sn_{8}Pb_{92}$	1	2	2	- -	- -	-	-	-	-	
Com11	21	$Cu_{87}Zn_{13}$	58 $Sn_{7}Pb_{93}$	21	1	1	3	21	$Cu_{87}Zn_{13}$	50	29 $Sn_{14}Pb_{86}$	1	2	1	25 $Cu_{77}Sn_{13}Zn_{10}$	62 $Sn_{5}Pb_{95}$	16	1	1	2	
Com77	27	$Cu_{92}Zn_{8}$	46 $Sn_{11}Pb_{89}$	26	1	1	2	27	$Cu_{92}Zn_{8}$	63	10 $Sn_{51}Pb_{49}$	1	2	0	- -	- -	-	-	-	-	
Com45	28	$Cu_{89}Zn_{11}$	48 $Sn_{3}Pb_{97}$	23	1	1	2	28	$Cu_{89}Zn_{11}$	56	16 $Sn_{9}Pb_{91}$	1	2	1	- -	- -	-	-	-	-	SnPb
Com10	24	$Cu_{88}Zn_{12}$	51 $Sn_{9}Pb_{91}$	25	1	1	2	24	$Cu_{88}Zn_{12}$	59	17 $Sn_{25}Pb_{75}$	1	2	1	30 $Cu_{84}Sn_{5}Zn_{11}$	48 $Sn_{3}Pb_{97}$	23	1	1	2	
Com51	14	$Cu_{84}Zn_{16}$	74 $Sn_{14}Pb_{86}$	12	1	1	5	14	$Cu_{84}Zn_{16}$	29	57 $Sn_{18}Pb_{82}$	1	2	4	- -	- -	-	-	-	-	
CO92	20	$Cu_{95}Zn_{5}$	59 $Sn_{10}Pb_{90}$	20	1	1	3	20	$Cu_{95}Zn_{5}$	49	31 $Sn_{20}Pb_{80}$	1	2	2	- -	- -	-	-	-	-	SnPb

	Gunmetal + Pb + Sb							Gunmetal + SbPb						Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)							Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)								
	Gunmetal		Pb	Sb	Cu	Sb	SnPb	Gunmetal		SbPb		G	Sb	Gunmetal		$Sb_{42}Pb_{58}$	Pb	G	$Sb_{42}Pb_{58}$	Pb	Gunmetal		$Sb_{42}Pb_{58}$	SnPb		G	$Sb_{42}Pb_{58}$	SnPn	
Com24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	SnPb
Com61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	$Cu_{91}Sn_5Zn_5$	49	30	$Sn_{17}Pb_{83}$	1	2	1	SnPb
Com82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Com25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	$Cu_{86}Sn_7Zn_7$	64	14	$Sn_{38}Pb_{62}$	1	3	1	SnPb
CO23A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	$Cu_{81}Sn_9Zn_9$	34	49	$Sn_{13}Pb_{87}$	1	2	3	SnPb
CO184C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	$Cu_{90}Sn_5Zn_5$	58	19	$Sn_{17}Pb_{83}$	1	2	1	
Com46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	$Cu_{92}Sn_4Zn_4$	64	9	$Sn_{45}Pb_{55}$	1	2	0	SnPb
Com97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	$Cu_{88}Sn_6Zn_6$	58	14	$Sn_{11}Pb_{89}$	1	2	1	
Com72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	$Cu_{91}Sn_4Zn_4$	51	24	$Sn_{23}Pb_{77}$	1	2	1	SnPb
Com36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	SnPb
Com47	27	$Cu_{86}Sn_4Zn_{10}$	48	24	1	1	2	27	$Cu_{86}Sn_4Zn_{10}$	73	$\boxed{Sb_{33}Pb_{67}}$	1	3	27	$Cu_{86}Sn_4Zn_{10}$	58	15	1	2	1	-	-	-	-	-	-	-	-	
CO184A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	$Cu_{85}Sn_7Zn_7$	46	32	$Sn_{16}Pb_{84}$	1	2	1	SnPb
Com50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	$Cu_{86}Sn_7Zn_7$	54	23	$Sn_{29}Pb_{71}$	1	2	1	SnPb
CO88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	$Cu_{81}Sn_{10}Zn_{10}$	19	71	$Sn_{14}Pb_{86}$	1	2	7	SnPb
Com73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	$Cu_{83}Sn_8Zn_8$	58	12	$Sn_{13}Pb_{87}$	1	2	0	
Com78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	$Cu_{84}Sn_8Zn_8$	64	9	$Sn_{19}Pb_{81}$	1	2	0	
Com11	25	$Cu_{77}Sn_{13}Zn_{10}$	59	16	1	1	2	25	$Cu_{77}Sn_{13}Zn_{10}$	75	$Sb_{22}Pb_{78}$	1	3	25	$Cu_{77}Sn_{13}Zn_{10}$	39	36	1	2	1	24	$Cu_{79}Sn_{11}Zn_{11}$	39	37	Sn_2Pb_{98}	1	2	2	
Com77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	$Cu_{77}Sn_{12}Zn_{12}$	50	26	Sn_4Pb_{96}	1	2	1	
Com45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	$Cu_{85}Sn_8Zn_8$	63	8	$Sn_{37}Pb_{63}$	1	2	0	SnPb
Com10	30	$Cu_{84}Sn_5Zn_{11}$	47	23	1	1	2	30	$Cu_{84}Sn_5Zn_{11}$	70	$\boxed{Sb_{33}Pb_{67}}$	1	2	30	$Cu_{84}Sn_5Zn_{11}$	56	15	1	2	1	-	-	-	-	-	-	-	-	
Com51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	$Cu_{79}Sn_{10}Zn_{10}$	59	15	$Sn_{11}Pb_{89}$	1	2	1	
CO92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	$Cu_{73}Sn_{14}Zn_{14}$	29	55	$Sn_{15}Pb_{85}$	1	2	3	SnPb

3) Samples with Zn < 100, not showing Cu/Sb correlation.

	Unalloyed Cu + SnPb + Sb							Unalloyed Cu + $Sb_{42}Pb_{58}$ + SnPb (free)							Bronze $Cu_{90}Sn_{10}$ + SnPb (free) + Sb							Bronze $Cu_{90}Sn_{10}$ + $Sb_{42}Pb_{58}$ + SnPb (free)						
Sample ID	Cu	SnPb		Sb	Cu	Sb	SnPb	Cu	$Sb_{42}Pb_{58}$	SnPb		Cu	$Sb_{42}Pb_{58}$	SnPb	$Cu_{90}Sn_{10}$	SnPb		Sb	Cu	Sb	SnPb	$Cu_{90}Sn_{10}$	SnPb		$Sb_{42}Pb_{58}$	Cu	$Sb_{42}Pb_{58}$	SnPb
CO365	19	74	$Sn_{17}Pb_{83}$	7	1	0	4	19	16	64	$Sn_{20}Pb_{80}$	1	1	3	21	72	$Sn_{15}Pb_{85}$	7	1	0	3	21	62	$Sn_{17}Pb_{83}$	16	1	1	3
CO58C	17	76	$Sn_{38}Pb_{62}$	7	1	0	4	17	16	67	$Sn_{44}Pb_{56}$	1	1	4	19	75	$Sn_{37}Pb_{63}$	7	1	0	4	19	65	$Sn_{42}Pb_{58}$	19	1	1	3
CO121B	24	58	$Sn_{10}Pb_{90}$	18	1	1	2	24	42	33	$Sn_{17}Pb_{83}$	1	2	1	27	55	Sn_5Pb_{95}	18	1	1	2	27	31	$Sn_{10}Pb_{90}$	42	1	2	1
CO233C	21	47	$Sn_{11}Pb_{89}$	33	1	2	2	-	-	-	-	-	-	-	23	44	Sn_6Pb_{94}	33	1	1	2							
CO122	22	23	Sn_7Pb_{93}	55	1	3	1	-	-	-	-	-	-	-														
CO24	17	28	Sn_5Pb_{95}	55	1	3	2	-	-	-	-	-	-	-														

4) Samples with Zn < 100, not showing Cu/Sb correlation.

	Brass + SnPb + Sb						Brass + $Sb_{42}Pb_{58}$ + SnPb (free)						Gunmetal + SnPb + Sb						
	Brass	SnPb	Sb	Cu	Sb	SnPb	Brass	$Sb_{42}Pb_{58}$	SnPb	Cu	$Sb_{42}Pb_{58}$	SnPb	Gunmetal	SnPb	Sb	G.	SnPb	Sb	
CO58B	11 $Cu_{89}Zn_{11}$	65 Sn_9Pb_{91}	24	1	2	6	11 $Cu_{89}Zn_{11}$	57	32 $Sn_{19}Pb_{81}$	1	5	3	-	-	-	-	-	-	
Com90	23 $Cu_{94}Zn_6$	22 Sn_8Pb_{92}	55	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	
Com39	7 $Cu_{95}Zn_5$	89 Sn_9Pb_{91}	4	1	1	13	7 $Cu_{95}Zn_5$	9	87 $Sn_{10}Pb_{90}$	1	1	12	-	-	-	-	-	-	
Com54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO96	25 $Cu_{93}Zn_7$	63 $Sn_{13}Pb_{87}$	12	1	0	3	25 $Cu_{93}Zn_7$	28	47 $Sn_{18}Pb_{82}$	1	1	2	-	-	-	-	-	-	Sn/Pb
Com12	26 $Cu_{89}Zn_{11}$	37 Sn_5Pb_{95}	37	1	1	1	-	-	-	-	-	-	27 $Cu_{84}Sn_7Zn_{10}$	37 Sn_5Pb_{95}	37	1	1	1	
CO230	15 $Cu_{76}Zn_{24}$	81 $Sn_{20}Pb_{80}$	4	1	0	5	15 $Cu_{76}Zn_{24}$	9	76 $Sn_{21}Pb_{79}$	1	1	5	-	-	-	-	-	-	
Com40	15 $Cu_{80}Zn_{20}$	77 $Sn_{12}Pb_{88}$	8	1	1	5	15 $Cu_{80}Zn_{20}$	19	66 $Sn_{14}Pb_{86}$	1	1	4	-	-	-	-	-	-	Sn/Pb
Com71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO100A	19 $Cu_{90}Zn_{10}$	72 $Sn_{19}Pb_{81}$	8	1	0	4	19 $Cu_{90}Zn_{10}$	20	61 $Sn_{23}Pb_{77}$	1	1	3	-	-	-	-	-	-	
CO325	17 $Cu_{88}Zn_{12}$	78 $Sn_{12}Pb_{88}$	5	1	0	5	17 $Cu_{88}Zn_{12}$	13	70 $Sn_{13}Pb_{87}$	1	1	4	-	-	-	-	-	-	Sn/Pb
Com37	24 $Cu_{93}Zn_7$	62 Sn_8Pb_{92}	14	1	1	3	24 $Cu_{93}Zn_7$	32	43 $Sn_{12}Pb_{88}$	1	1	2	-	-	-	-	-	-	
Com96a	20 $Cu_{80}Zn_{20}$	73 $Sn_{15}Pb_{85}$	7	1	0	4	20 $Cu_{80}Zn_{20}$	16	64 $Sn_{17}Pb_{83}$	1	1	3	-	-	-	-	-	-	Sn/Pb
Com52	26 $Cu_{91}Zn_9$	56 $Sn_{10}Pb_{90}$	18	1	1	2	26 $Cu_{91}Zn_9$	43	31 $Sn_{17}Pb_{83}$	1	2	1	-	-	-	-	-	-	
Com13	11 $Cu_{86}Zn_{14}$	86 $Sn_{10}Pb_{90}$	3	1	0	8	11 $Cu_{86}Zn_{14}$	7	82 $Sn_{11}Pb_{89}$	1	1	7	-	-	-	-	-	-	
Com98	14 $Cu_{84}Zn_{16}$	79 $Sn_{15}Pb_{85}$	7	1	1	6	14 $Cu_{84}Zn_{16}$	16	70 $Sn_{17}Pb_{83}$	1	1	5	-	-	-	-	-	-	Sn/Pb
Com66	14 $Cu_{81}Zn_{19}$	81 $Sn_{18}Pb_{82}$	5	1	0	6	14 $Cu_{81}Zn_{19}$	13	73 $Sn_{20}Pb_{80}$	1	1	5	-	-	-	-	-	-	
Com02	15 $Cu_{80}Zn_{20}$	84 $Sn_{11}Pb_{89}$	1	1	0	6	15 $Cu_{80}Zn_{20}$	3	82 $Sn_{12}Pb_{88}$	1	0	5	-	-	-	-	-	-	Sn/Pb
Com95	20 $Cu_{94}Zn_6$	76 Sn_9Pb_{91}	4	1	0	4	20 $Cu_{94}Zn_6$	10	70 Sn_9Pb_{91}	1	1	4	-	-	-	-	-	-	
Com94	13 $Cu_{83}Zn_{17}$	85 $Sn_{16}Pb_{84}$	2	1	0	7	13 $Cu_{83}Zn_{17}$	5	83 $Sn_{17}Pb_{83}$	1	0	6	-	-	-	-	-	-	Sn/Pb
CO530	25 $Cu_{75}Zn_{25}$	74 $Sn_{18}Pb_{82}$	1	1	0	3	25 $Cu_{75}Zn_{25}$	2	73 $Sn_{18}Pb_{82}$	1	0	3	-	-	-	-	-	-	
Com48	25 $Cu_{76}Zn_{24}$	74 $Sn_{22}Pb_{78}$	1	1	0	3	25 $Cu_{76}Zn_{24}$	1	73 $Sn_{22}Pb_{78}$	1	0	3	-	-	-	-	-	-	

	Gunmetal + Pb + Sb							Gunmetal + SbPb						Gunmetal + $Sb_{42}Pb_{58}$ + *Pb (free)							Gunmetal calc. + $Sb_{42}Pb_{58}$ + SnPb (free)								
	Gunmetal		Pb	Sb	Cu	Sb	SnPb	Gunmetal		SbPb		G	Sb	Gunmetal		$Sb_{42}Pb_{58}$	Pb	G	$Sb_{42}Pb_{58}$	Pb	Gunmetal		$Sb_{42}Pb_{58}$	SnPb		G	$Sb_{42}Pb_{58}$	SnPn	
CO58B		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	$Cu_{80}Sn_{10}Zn_{10}$	57	31	$Sn_{15}Pb_{85}$	1	4	2	
Com90	24	$Cu_{88}Sn_7Zn_5$	21	55	1	2	1	24	$Cu_{88}Sn_7Zn_5$	76	$Sb_{73}Pb_{27}$	0.5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Com39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	$Cu_{90}Sn_5Zn_5$	9	84	Sn_9Pb_{91}	1	1	11	
Com54	27	$Cu_{96}Sn_2Zn_2$	64	10	1	0.4	2	27	$Cu_{96}Sn_2Zn_2$	73	$Sb_{13}Pb_{87}$	1	3	27	$Cu_{96}Sn_2Zn_2$	23	50	1	1	2	-	-	-	-	-	-	-	-	
CO96	-	-	-	-	-	-	-	-	-	-	-	-	-								27	$Cu_{87}Sn_6Zn_6$	28	45	$Sn_{14}Pb_{86}$	1	1	2	Sn/Pb
Com12	27	$Cu_{84}Sn_7Zn_{10}$	36	37	1	1	1	27	$Cu_{84}Sn_7Zn_{10}$	73	$Sb_{51}Pb_{49}$	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO230	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Com40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Sn/Pb
Com71	20	$Cu_{84}Sn_5Zn_{11}$	16	64	1	3	1	20	$Cu_{84}Sn_5Zn_{11}$	80	$Sb_{80}Pb_{20}$	0	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO100A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	$Cu_{82}Sn_9Zn_9$	20	59	$Sn_{20}Pb_{80}$	1	1	3	
CO325	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	$Cu_{79}Sn_{11}Zn_{11}$	13	68	$Sn_{10}Pb_{90}$	1	1	4	Sn/Pb
Com37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	$Cu_{86}Sn_7Zn_7$	32	41	Sn_8Pb_{92}	1	1	2	
Com96a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Sn/Pb
Com52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	$Cu_{84}Sn_8Zn_8$	43	29	$Sn_{11}Pb_{89}$	1	1	1	
Com13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	$Cu_{75}Sn_{13}Zn_{13}$	7	80	Sn_9Pb_{91}	1	1	6	
Com98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	$Cu_{73}Sn_{14}Zn_{14}$	16	68	$Sn_{14}Pb_{86}$	1	1	4	Sn/Pb
Com66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Com02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Sn/Pb
Com95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	$Cu_{89}Sn_5Zn_5$	10	69	Sn_8Pb_{92}	1	0.5	3	
Com94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	$Cu_{71}Sn_{14}Zn_{14}$	5	81	$Sn_{14}Pb_{86}$	1	0.3	5	Sn/Pb
CO530	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Com48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	