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Paul Craddock (1985)

"Most programs of copper alloy analysis have concentrated on material from Bronze Age cultures, yet it is only at the end of this period that an interesting range of alloys , including for the first time ternary and quaternary alloys, was in regular use [...]"

From the end of the Bronze Age the problems of multiplicity of sources and mixing of scrap metal have been deemed too daunting for [scientific] study and consequently relatively few analyses have been published from which information on the alloying practice might be obtained"

Paul Craddock (1985)

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Economic tokens, art objects, high quality dates, social signifiers, but also pellets of metal.

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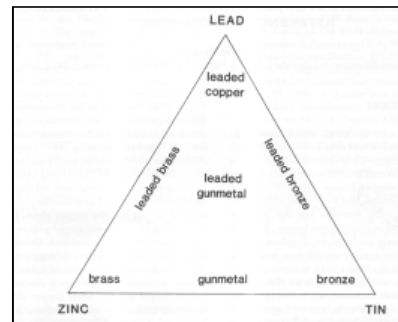
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Coins are (extremely) complex!

Economic tokens, art objects, high quality dates, social signifiers, but also pellets of metal.

How do they compare with the domestic metalwork – which is also (extremely) complex, and can act as economic tokens, art objects, dates, social signifiers, and ingots of metal.



STAGE ONE

Chemical Characterisation – capturing variation

We need to deal with 80,000 chemical composition sets, of varying quality, produced with different techniques, over the past 100 years

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Presence Absence groups based upon

Arsenic // Antimony // Silver // Nickel

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STAGE ONE **A style of characterisation that allows for identifying real metal use**

1 16

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Period 1
Period 2
Period 3
Period 4
Period 5

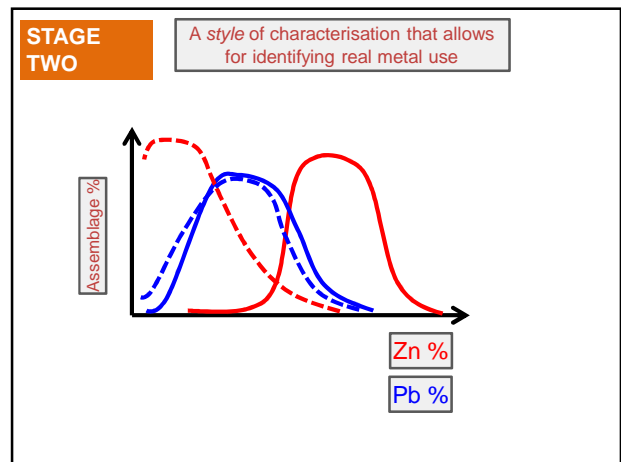
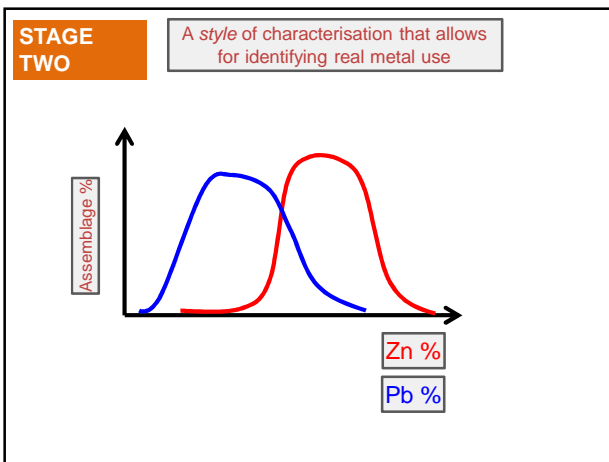
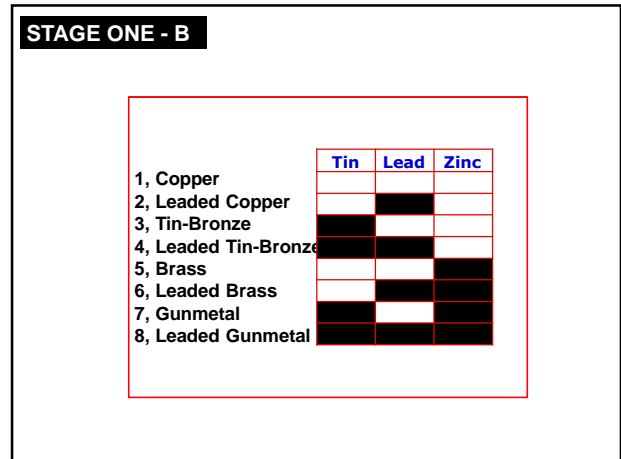
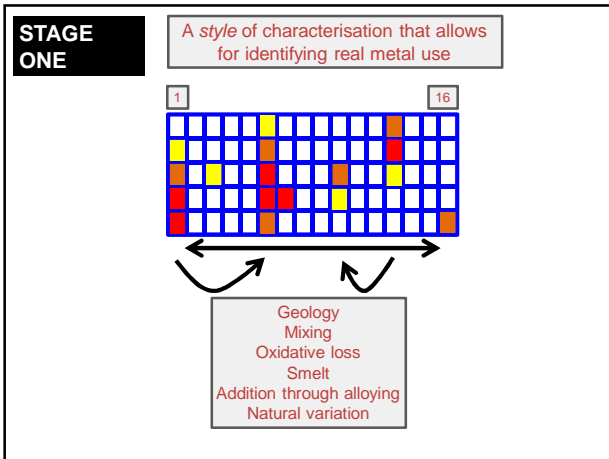
STAGE ONE **A style of characterisation that allows for identifying real metal use**

1 16

England
Ireland
Scotland
Wales
France

STAGE ONE **A style of characterisation that allows for identifying real metal use**

1 16



Some initial results...

In collaboration with Profs. Mark Pollard, Andrew Wilson and Chris Howgego



The Oxford Roman Economy Project

Prof. Andrew Wilson, oxrep.classics.ox.ac.uk

Database of Roman Mining, 174 records for copper mining sites within the Empire

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Mines Database

Database coordinator: Andrew Wilson
Showing records 1 - 28 of 174 Page 1 of 8
Number of records per page: 20 Go to record: 20

No.	Name	Mining Area	Country	Province	Start	End	Au	Ag	Pb	Cu	Fe
1.	Abundantia	Abundantia	Spain	Hispania Baetica	?	?	?				x
2.	Agrotale	Troadae Murethans	Cyprus	Cyprus	?	?	?				x
3.	Agua Tofique	Huelva	Spain	Hispania Baetica	?	?	?				x
4.	Almadenes del Guadale	Coroba	Spain	Hispania Baetica	?	?	?				x
5.	Adlerley	Adlerley	United Kingdom	Britannia	?	?	?				x
6.	Ajalgal	Alemor	Portugal	Lusitania	?	?	?	x	x		
7.	Almadenes del Sotobier	Pedroubas	Spain	Hispania Baetica	?	?	?				x
8.	Alpartir	Alpartir	Spain	Hispania	?	?	?				x
9.	Arrofilia		Spain	Hispania Baetica	?	?	?	x	x		
10.	Asik	Troadae Murethans	Cyprus	Cyprus	?	?	?				x
11.	Arriqde Alamo	Coroba	Spain	Hispania Baetica	?	?	?				x
12.	Asyriq	Troadae Murethans	Cyprus	Cyprus	?	?	?				x
13.	Atalaya	Atalaya	Spain	Hispania	?	?	?				x

The Oxford Roman Economy Project

Coin Hoards of the Roman Empire online database: chre.ashmus.ox.ac.uk

Find spots of Roman Coins Recorded by the Portable Antiquity Scheme between 1997-2010

Copper group, by Emperor(s). Short-reigns merged to reach sufficient data levels
All Analysts, All alloy groups

	CG 1	CG 2	CG 3	CG 4	CG 5	CG 6	CG 7	CG 8	CG 9	CG 10	CG 11	CG 12	CG 13	CG 14	CG 15	CG 16	TOTAL
1 Republic	14.7	17.4	0.0	2.9	20.6	8.8	5.9	0.0	0.0	0.0	2.9	14.7	5.9	2.9	0.0	2.9	34
2 Augustus	8.4	2.2	20.5	1.3	5.3	0.4	1.5	0.7	1.3	1.1	0.4	0.9	5.3	0.4	1.1	2.6	454
3 Tiberius	57.0	0.6	9.8	3.5	32.9	0.0	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	173
4 Caligula	0.0	5.1	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
5 Claudius	0.0	0.0	4.1	0.5	0.9	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	217
6 Nero	70.0	0.0	24.2	2.5	0.0	0.0	1.7	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	120

CG 1
Cu

52 Byzantine | 6.7 | 0.0 | 6.7 | 0.0 | 0.0 | 0.0 | 6.7 | 3.9 | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30

Copper group, by Emperor(s). Short-reigns merged to reach sufficient data levels
All Analysts, All alloy groups

	CG 1	CG 2	CG 3	CG 4	CG 5	CG 6	CG 7	CG 8	CG 9	CG 10	CG 11	CG 12	CG 13	CG 14	CG 15	CG 16	TOTAL
7 Galba to 8 Vespasian	47.1	0.0	25.4	11.8	0.0	0.0	0.0	0.0	0.0	5.9	5.9	0.0	0.0	0.0	0.0	0.0	17
9 Titus to 11 Nerva	10.7	0.0	27.5	6.0	10.7	3.6	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
12 Trajan	10.7	0.0	10.7	14.3	0.0	7.1	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
13 Hadrian	7.9	0.0	25.8	2.6	15.8	0.0	5.3	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	38
14 Antoninus Pius	10.7	0.0	60.7	0.0	7.1	0.0	10.7	0.0	3.6	3.6	0.0	3.6	0.0	0.0	0.0	0.0	28

CG 3
Cu-Sb

Copper group, by Emperor(s). Short-reigns merged to reach sufficient data levels
All Analysts, All alloy groups

	CG 1	CG 2	CG 3	CG 4	CG 5	CG 6	CG 7	CG 8	CG 9	CG 10	CG 11	CG 12	CG 13	CG 14	CG 15	CG 16	TOTAL
Anything goes: The Crisis of the Third Century and several reorganisations and splits in territory																	
15 Marcus Aurelius to 16 Lucius Verus	16.7	0.0	22.8	5.6	22.2	5.6	11.1	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	18
17 Commodus	15.0	10.0	20.0	5.0	15.0	0.0	10.0	0.0	15.0	0.0	5.0	0.0	0.0	5.0	0.0	0.0	20
18 Septimus Severus to 21 Alexander Severus	15.0	0.0	0.0	5.0	10.0	10.0	25.0	0.0	0.0	5.0	0.0	20.0	0.0	5.0	0.0	5.0	20
22 Maximinus to 34 Probus	10.3	0.0	6.9	34.5	13.8	3.4	10.3	13.8	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	29
35 Diocletian	0.0	0.0	5.3	15.8	0.0	0.0	15.8	21.1	10.5	0.0	0.0	21.1	10.5	0.0	0.0	0.0	19
36 Constantius Chlorus	0.0	0.0	0.0	0.0	0.0	6.7	6.7	33.3	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	15
37 Galerius to 40 Maxence	0.0	0.0	0.0	9.1	0.0	0.0	18.2	0.0	40.9	0.0	0.0	31.8	0.0	0.0	0.0	0.0	22
41 Constantine I to 43 Constans	15.6	0.0	0.0	18.8	9.4	0.0	6.3	25.0	0.0	0.0	12.5	12.5	0.0	0.0	0.0	0.0	32
44 Constantius II	4.8	0.0	0.0	19.0	19.0	0.0	4.8	28.6	14.3	0.0	0.0	9.5	0.0	0.0	0.0	0.0	21
52 Byzantine	6.7	0.0	6.7	0.0	66.7	0.0	0.0	6.7	3.3	10.0	0.0	0.0	0.0	0.0	0.0	0.0	30

Copper group, by Emperor(s). Short-reigns merged to reach sufficient data levels
All Analysts, All alloy groups

	CG 1	CG 2	CG 3	CG 4	CG 5	CG 6	CG 7	CG 8	CG 9	CG 10	CG 11	CG 12	CG 13	CG 14	CG 15	CG 16	TOTAL
1 Republic	14.7	17.6	0.0	2.9	20.6	8.8	5.9	0.0	0.0	0.0	2.9	14.7	5.9	2.9	0.0	2.9	34
2 Augustus	24.8	2.2	20.5	1.3	5.3	0.4	1.5	0.7	1.3	1.1	0.4	0.9	5.3	0.4	1.1	2.6	454
3 Tiberius	50.0	0.6	9.5	3.5	32.8	0.6	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	173
4 Caligula	93.6	0.0	5.1	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
5 Claudius	94.0	0.0	4.1	0.5	0.9	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	217
6 Nero	27.8	0.0	24.2	2.5	0.0	0.0	1.7	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	128
7 Galba to 8 Vespasian	47.1	0.0	29.4	11.8	0.0	0.0	0.0	0.0	0.0	5.9	5.9	0.0	0.0	0.0	0.0	0.0	17
9 Titus to 11 Nerva	10.7	0.0	67.3	0.0	10.7	3.6	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
12 Trajan	10.7	0.0	52.8	10.7	14.3	0.0	7.1	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	28
13 Hadrian	7.9	0.0	6.8	2.6	15.8	0.0	5.3	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	38
14 Antoninus Pius	10.7	0.0	60.0	0.0	7.1	0.0	10.7	0.0	3.6	3.6	0.0	3.6	0.0	0.0	0.0	0.0	28
15 Marcus Aurelius to 16 Lucius Verus	16.7	0.0	22.8	5.6	22.2	5.6	11.1	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	18
17 Commodus	15.0	10.0	20.0	5.0	15.0	0.0	10.0	0.0	15.0	0.0	5.0	0.0	0.0	5.0	0.0	0.0	20
18 Septimus Severus to 21 Alexander Severus	15.0	0.0	0.0	5.0	10.0	10.0	25.0	0.0	0.0	5.0	0.0	20.0	0.0	5.0	0.0	5.0	20
22 Maximinus to 34 Probus	10.3	0.0	6.9	34.5	13.8	3.4	10.3	13.8	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	29
35 Diocletian	0.0	0.0	5.3	15.8	0.0	0.0	15.8	21.1	10.5	0.0	0.0	21.1	10.5	0.0	0.0	0.0	19
36 Constantius Chlorus	0.0	0.0	0.0	0.0	0.0	0.0	6.7	6.7	33.3	0.0	0.0	6.7	0.0	0.0	0.0	0.0	15
37 Galerius to 40 Maxence	0.0	0.0	0.0	9.1	0.0	0.0	18.2	0.0	40.9	0.0	0.0	31.8	0.0	0.0	0.0	0.0	22
41 Constantine I to 43 Constans	15.6	0.0	0.0	18.8	9.4	0.0	6.3	25.0	0.0	0.0	12.5	12.5	0.0	0.0	0.0	0.0	32
44 Constantius II	4.8	0.0	0.0	19.0	19.0	0.0	4.8	28.6	14.3	0.0	0.0	9.5	0.0	0.0	0.0	0.0	21
52 Byzantine	6.7	0.0	6.7	0.0	66.7	0.0	0.0	6.7	3.3	10.0	0.0	0.0	0.0	0.0	0.0	0.0	30

Alloy Groups

Copper to Brass to Complex Mixed Alloys

Alloy Groups

Copper to Brass to Complex Mixed Alloys

	Copper	Leaded Copper	Bronze	Leaded Bronze	Brass	Leaded Brass	Gunmetal	Leaded Gunmetal	Total Number of Analysis
1 Republic	5.5	7.7	9.5	60.4	12.1	0.0	1.1	3.3	91
2 Augustus	86.8	0.6	1.9	4.3	5.3	0.2	0.4	0.4	469
3 Tiberius	89.6	0.6	3.3	2.2	4.4	0.6	0.6	0.0	180
4 Caligula	88.0	0.0	0.0	0.0	9.9	0.0	0.0	1.2	81
5 Claudius	87.5	0.0	0.4	0.0	10.8	0.9	0.0	0.0	223
6 Nero	27.8	0.0	0.0	0.0	62.9	8.7	0.8	0.0	126

Alloy Groups

Copper to Brass to Complex Mixed Alloys

	Copper	Leaded Copper	Bronze	Leaded Bronze	Brass	Leaded Brass	Gunmetal	Leaded Gunmetal	Total Number of Analysis
6 Nero	27.8	0.0	0.0	0.0	62.7	8.7	0.8	0.0	126
7 Galba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16
8 Vespasian	3.5	0.9	0.0	0.0	9.8	0.9	0.9	0.0	113
9 Titus	0.0	0.0	0.0	0.0	6.7	0.0	6.7	0.0	45
10 Domitian	3.3	0.0	2.2	2.2	33.5	0.0	8.8	0.0	91
11 Nerva	0.0	0.0	0.0	0.0	84.7	0.0	15.3	0.0	59
12 Trajan	0.0	0.0	0.0	0.0	41.6	0.0	44.5	13.3	375

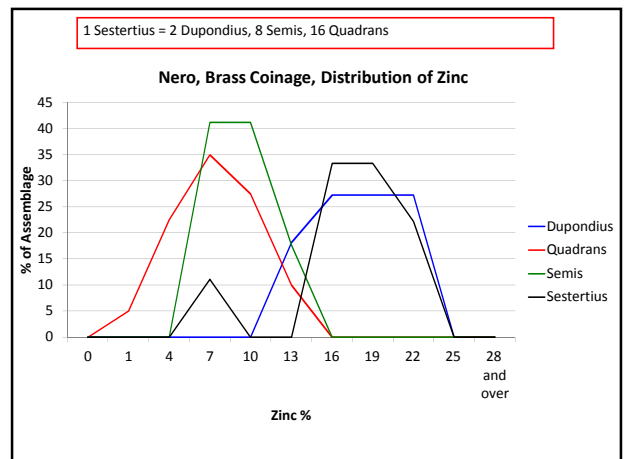
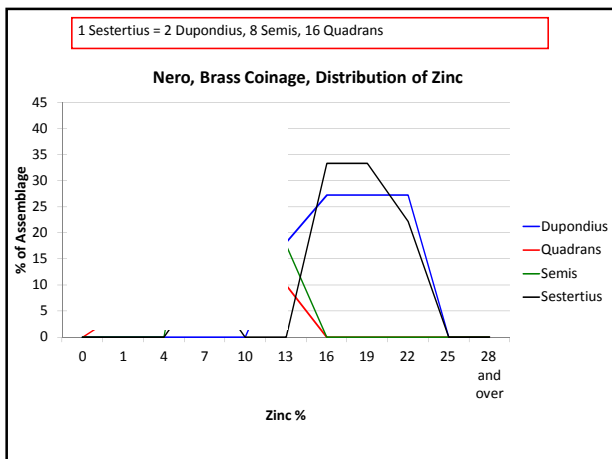
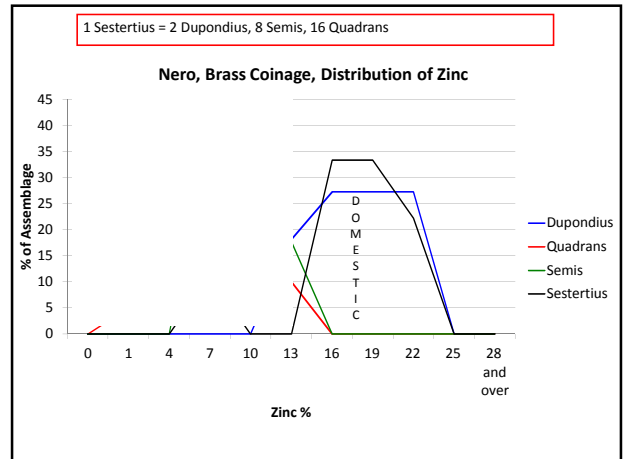
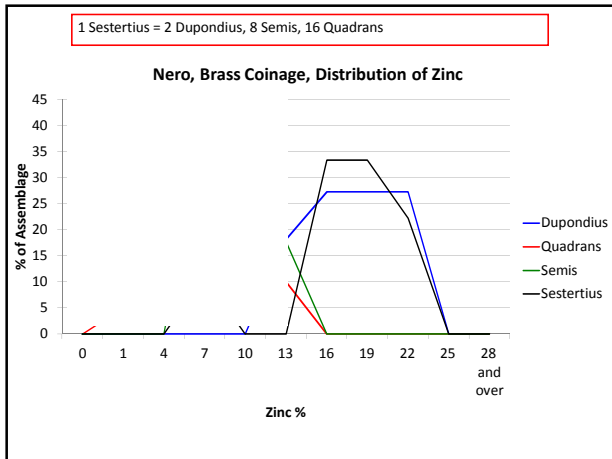
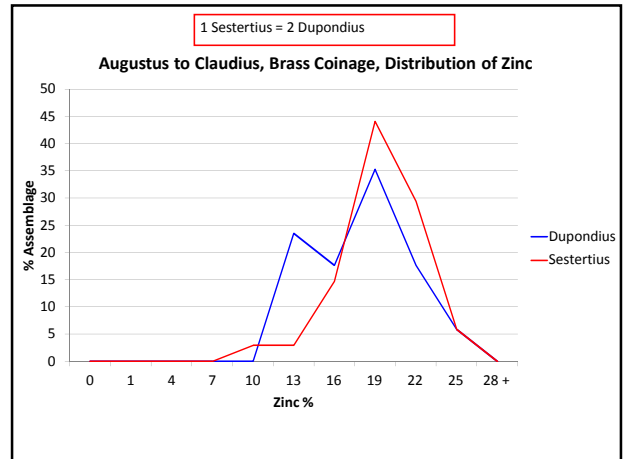
Alloy Groups

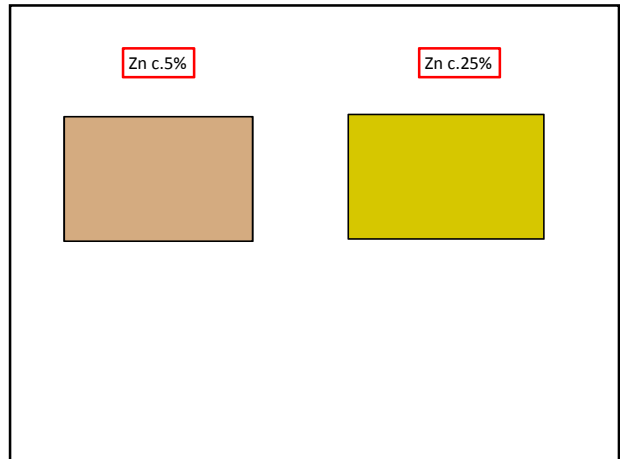
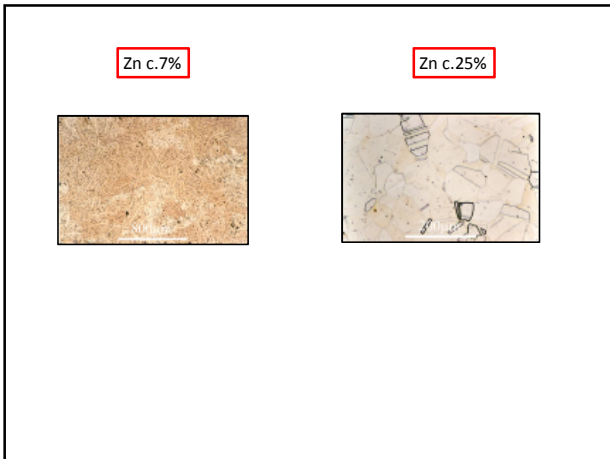
Copper to Brass to Complex Mixed Alloys

	Copper	Leaded Copper	Bronze	Leaded Bronze	Brass	Leaded Brass	Gunmetal	Leaded Gunmetal	Total Number of Analysis
15 Marcus Aurelius and 16 Lucius Verus	5.9	0.0	0.0	0.0	3.9	17.6	2.9	32.4	34
17 Commodus	0.0	0.0	3.6	21.4	0.0	7.1	3.6	64.3	28
18 Septimus Severus to 34 Probus	8.8	0.0	10.0	42.5	0.0	1.3	5.0	32.5	80
35 Diocletian	10.0	0.0	13.3	75.3	0.0	0.0	0.0	6.7	15
36 Constantius Chlorus	6.7	0.0	13.3	75.3	0.0	0.0	0.0	6.7	15
37 Galerius to 40 Maxence	7.1	7.1	28.6	50.0	0.0	0.0	0.0	7.1	28
41 Constantine I	0.0	2.6	0.0	93.6	1.3	0.0	0.0	2.6	78
42 Constantine II to 51 Anthemius	1.6	9.4	3.1	65.6	0.0	4.7	4.7	10.9	64
52 Byzantine	20.0	2.5	17.5	15.0	22.5	0.0	10.0	12.5	40

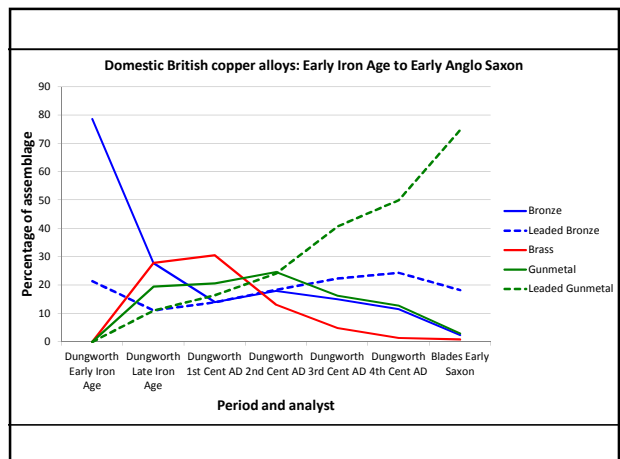
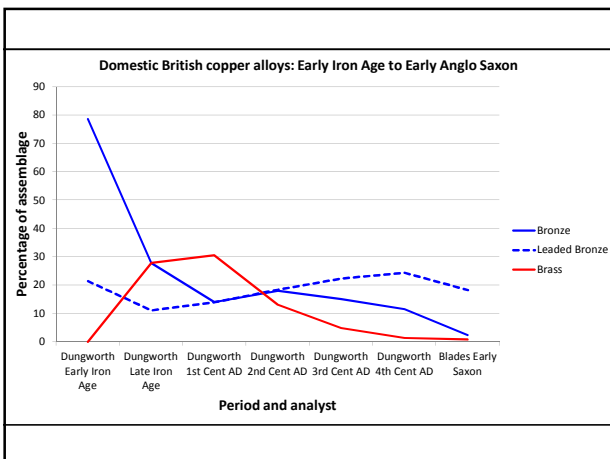
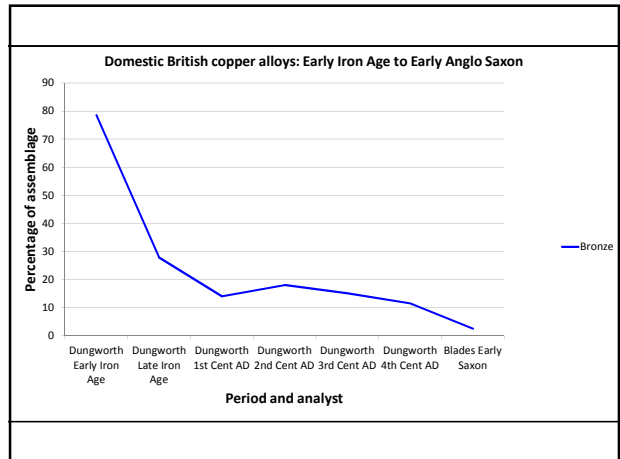
Alloy Groups
Copper to Brass to Complex Mixed Alloys

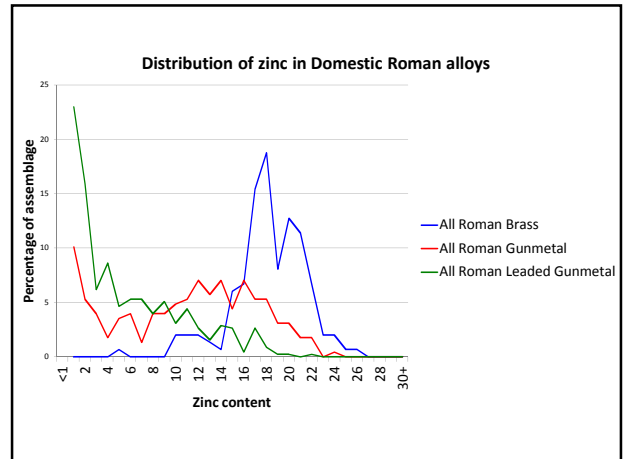
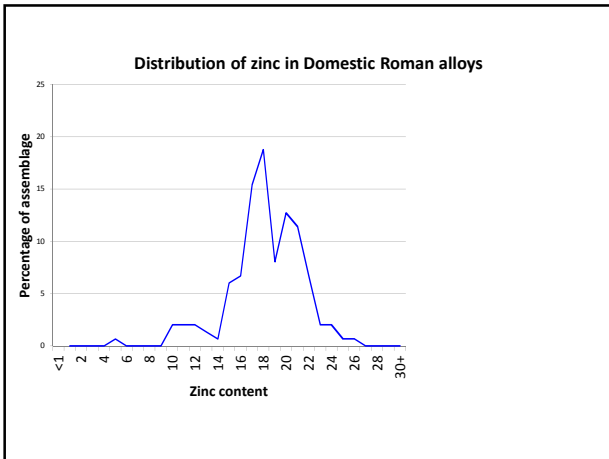
	Copper	Leaded Copper	Bronze	Leaded Bronze	Brass	Leaded Brass	Gunmetal	Leaded Gunmetal	Total Number of Analysis
1 Republic	5.5	7.7	9.9	6.4	12.1	0.0	1.1	3.3	91
2 Augustus	86.3	0.6	1.9	4.3	5.3	0.2	0.4	0.4	469
3 Tiberius	98.5	0.6	3.3	2.7	4.4	0.6	0.6	0.0	180
4 Caligula	88.5	0.0	0.0	0.0	9.9	0.0	0.0	1.2	81
5 Claudius	87.3	0.0	0.4	0.0	10.8	0.9	0.0	0.0	223
6 Nero	27.8	0.0	0.0	0.0	62.7	8.7	0.8	0.0	126
7 Galba	0.0	0.0	0.0	0.0	99.1	0.0	0.0	0.0	16
8 Vespasian	3.5	0.9	0.0	0.0	93.8	0.9	0.9	0.0	113
9 Titus	0.0	0.0	0.0	0.0	93.3	0.0	6.7	0.0	45
10 Domitian	3.3	0.0	2.2	2.2	83.5	0.0	8.8	0.0	91
11 Nerva	0.0	0.0	0.0	0.0	84.7	0.0	15.3	0.0	59
12 Trajan	0.0	0.0	0.0	0.3	41.6	0.3	44.5	13.3	375
13 Hadrian	0.3	0.0	0.0	0.9	91.8	1.2	32.4	13.4	336
14 Antoninus Pius	0.0	0.0	1.1	2.2	89.4	0.0	33.7	2.2	92
15 Marcus Aurelius and 16 Lucius Verus	5.9	0.0	0.0	2.9	17.6	2.9	32.4	38.2	34
17 Commodus	0.0	0.0	3.6	21.4	0.0	7.1	3.6	64.3	28
18 Septimius Severus to 34 Probus	8.8	0.0	10.0	42.5	0.0	1.3	5.0	32.5	80
35 Diocletian	10.0	0.0	35.0	40.0	0.0	0.0	10.0	5.0	20
36 Constantius Chlorus	6.7	0.0	13.3	23.3	0.0	0.0	0.0	6.7	15
37 Galerius to 40 Maxence	7.1	7.1	28.6	50.0	0.0	0.0	0.0	7.1	28
41 Constantine I	0.0	2.6	0.0	93.6	1.3	0.0	0.0	2.6	78
42 Constantine II to 51 Anthemius	1.6	9.4	3.1	65.6	0.0	4.7	4.7	10.9	64
52 Byzantine	20.0	2.5	17.5	15.0	22.5	0.0	10.0	12.5	40





The Domestic British Metalwork from the Iron Age, Roman Period and Early Anglo-Saxon:





Nigel Blades: Chemical Data on British Domestic Copper-Alloys

	CG 1	CG 2	CG 3	CG 4	CG 5	CG 6	CG 7	CG 8	CG 9	CG 10	CG 11	CG 12	CG 13	CG 14	CG 15	CG 16
Roman	9.6	0.0	54.9	4.3	0.0	1.1	20.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Mostly c. 100-200 B.C.

CG 3
Cu - Sb

Cu 7
Cu-Sb-Ag

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	CG 1	CG 2	CG 3	CG 4	CG 5	CG 6	CG 7	CG 8	CG 9	CG 10	CG 11	CG 12	CG 13	CG 14	CG 15	CG 16
Roman	9.6	0.0	54.9	4.3	0.0	1.1	20.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Early Saxon	2.1	0.0	28.1	2.7	0.3	3.2	49.9	0.0	0.3	1.1	1.1	4.8	0.5	2.1	0.8	3.2
Middle Saxon	8.1	5.4	12.1	2.0	2.0	8.1	34.9	0.7	0.7	0.0	0.0	18.1	0.0	0.7	0.7	6.7
Late Saxon	5.5	1.4	41.1	6.8	1.4	6.8	23.3	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	2.7
Early Medieval	8.6	0.0	24.1	3.4	0.0	25.9	17.2	0.0	1.7	1.7	0.0	5.2	0.0	3.4	0.0	8.6
Late Medieval	4.4	0.4	8.1	11.0	2.9	15.8	8.5	0.4	0.4	4.0	0.0	28.8	0.4	2.6	3.3	11.0
Post Medieval	3.3	2.4	6.1	9.9	13.2	2.4	5.7	2.4	0.5	10.8	5.7	13.2	1.4	3.8	9.4	9.9

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Broadly (very broadly) speaking there are close parallels between local domestic metallurgy and the coin issues.

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The same characterisation approach can be used in any metal using context, whether the Roman metal economy, Shang China, Beaker period Europe, late Medieval Germany and so on

Further Work:

- Fine leads and lags in these data

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High quality data is required – sampling problems, pXRF, surface effects

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