Determination of Lead, Tin, and Silver Content in Ancient Bronze Coins via Flame Atomic Absorption Spectrometry

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Introduction

Metal composition analysis has become one of the leading methods of determining the provenance of ancient corroded coins. Comparison of the concentration values obtained with previously published values aided in the identification of the coins. Flame atomic absorption spectroscopy (FAAS) was chosen in analyzing the coins because although a destructive technique, it gives a better idea of the whole composition of the coin compared with surface measurements. Missing data were identified for lead and tin data sets. Acid digestion of coins followed by FAAS analysis was performed; external calibration was used for the lead analysis, while standard addition calibration was used for the tin analysis. Correlation coefficient for lead was found to be 0.99496, and the correlation coefficients for tin were found to range between 0.99000 and 0.99996. The silver method detection limit was found to be 0.00014% (1.4 ppm) by weight in bronze, which was deemed sufficient for the study requirements. The linear dynamic range for lead, tin, and silver was also established. It was determined that the FAAS gave a linear response between 0 ppm and 48 ppm for lead, 0 ppm to 200 ppm for tin, and 0 ppm to 12 ppm for silver.

Instrumentation

- **SCP Science DigiPREP Jr. digestion system with 50-mL volumetric digestion vessels**
- **Thermo Elemental S Series Atomic Absorption Spectrophotometer**

Results

Coin	Experimental			Literature		
	% Pb	% Sn	% Ag	% Pb	% Sn	% Ag
1	1.847 (6)	4.452 (2)	0.0614 (3)	1.76	4.72	9.18
2	1.4507 (6)	0.615 (2)	0.0328 (8)	1.58	0.48	0.16
3	0.2421 (6)	< 0.029 (2)	0.0245 (8)	0.43	0.01	0.07
4	1.7204 (6)	< 0.029 (2)	0.0465 (8)	1.57	0.02	0.16
5	9.2821 (4)	-	0.0462 (7)	9.79	6.25	0.00
6	13.826 (2)	5.495 (2)	0.0752 (4)	13.86	7.28	0.04
7	8.171 (2)	0.205 (2)	0.1068 (2)	8.59	0.54	0.21
8	18.01 (2)	2.44 (2)	0.0505 (2)	17.41	2.64	0.27
9	27.692 (2)	0.525 (2)	0.1524 (2)	25.25	1.74	0.99
10	6.825 (2)	3.157 (2)	0.0910 (2)	6.46	3.97	1.49
11	19.789 (2)	4.668 (2)	0.0395 (2)	20.36	5.23	0.07
8 Fall '06	11.31 (2)	-	0.083 (2)	11.47	1.30	0.50
9 Fall '06	24.51 (2)	-	0.25 (2)	25.24	2.4	0.00
10 Fall '06	7.08 (2)	0.56 (3)	< 0.02 (2)	6.60	0.65	0.00
11 Fall '06	17.73 (2)	1.92 (2)	< 0.042 (2)	16.75	2.47	2.25

Coin	L.H. Cope Values			
	Mint	Obv Leg	Reverse	Ruler
1	ROME	GALLIENVS AVG	IOVIS STATOR	Gallus
2	UNMARKED	IMP CARAVSIVS P F AVG	PAX AVG	Carausius
3	ROME	-	-	VESP
4	ALEX	GAL VAL MAXIMINVS NOB CAES	CONCORDIA MILITVM	DAIA
5	IMITATION	DIVO CLAVDIO	CONSECRATIO, eagle	Cladius II
6	IMITATION	-	-	Domitian
7	ARLES	DN GRATIANVS AVGG AVG	GLORIA NOVI SAECVLI	GRAT
8	CYZ	DN CONSTANTIVS P F AVG	FEL TEMP REPARATIO phoenix, g	Cs2
9	Trier	DN CONSTANS P F AVG	FEL TEMP REPARATIO hut	Cn
10	Ost	IMP C MAXENTIVS P F AVG	FIDES MILITVM AVG N	Maxt
11	ROME	IMP C M Q TRAIANVS DECIVS AVG	DACIA S C	T DEC
8 Fall '06	ROME	DN FL CL CONSTANTINVS NOB CAES	FEL TEMP REPARATIO fh	Gallus
9 Fall '06	CYZ	DN CONSTANTIVS P F AVG	SPES REIPVBLICE	Cs2
10 Fall '06	Cons	DN THEODOSIVS P F AVG	VOT X MVLT XX	Th1
11 Fall '06	Trier	DN CONSTANS P F AVG	FEL TEMP REPARATIO galley	Cn

Conclusions

- **Coin matching agreed nicely with published literature values.**
- **Table 2 shows the proposed identity of all coins based on lead, silver, and tin content.**
- **A coin database was developed in collaboration with Prof. Traynor from the Computer Science Department.**

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References

1. Dumas, A. Quantitative Spectroscopic Characterization of Ancient Roman Bronze Coins. Saint Anselm College, Chemistry Dept Senior Thesis, Manchester, NH, 2004.
2. Donais, M. K.; Whissel, G.; Dumas, A.; Golden, K., Analyzing Lead Content in Ancient Bronze Coins by Flame Atomic Absorption Spectroscopy. An Archaeometry Laboratory with Nonscience Majors. *Journal of Chemical Education* 2009, 86, (3), 343.
3. Lebel, C. Determination of Tin in Ancient Coins via Flame Atomic Absorption Spectroscopy. Saint Anselm College, Chemistry Dept Senior Thesis, Manchester, NH.
4. Golden, K. Investigation to Improve Digestion Method for Bronze Coin Analysis. Saint Anselm College, Chemistry Dept Senior Thesis, Manchester, NH, Fall 2006.
5. Cope, L. H., King, C.E., Northover, J.P., *Metals Analysis of Roman Coins Minted Under the Empire*, British Museum Occasional Paper Number 120; The British Museum, 1997.