LEAD ISOTOPES AND XRF ANALYSES OF SPANISH COLONIAL BELLS FROM GALISTEO BASIN, NEW MEXICO

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INTRODUCTION

Few elemental and isotopic studies have been conducted on bronze bells recovered from the late 16th, early 17th century Spanish Colonial missions. Mission bells shaped daily life as they not only provided a call to prayer and daily tasks, but also served to reinforce the power dynamics of colonialism (Thomas 2017). We recently completed an isotopic and elemental study of 85+ bronze bell fragments recovered from Pueblo San Lazaro, Pueblo San Marcos, Pueblo San Cristóbal, and other sites in the Galisteo Basin of New Mexico.

Surface sampling using X-ray fluorescence (XRF) was used to generate elemental data of the fragments recovered. Elemental variation among different bells reflect possible differences in bronze-casting recipes, differential access to raw materials, and/or intentional manipulation of recipes to affect the sound and/or color of the bells. In our study we quantified the following elements: Fe, Cu, As, Ag, Sn, Mn, Pb, and Bi.

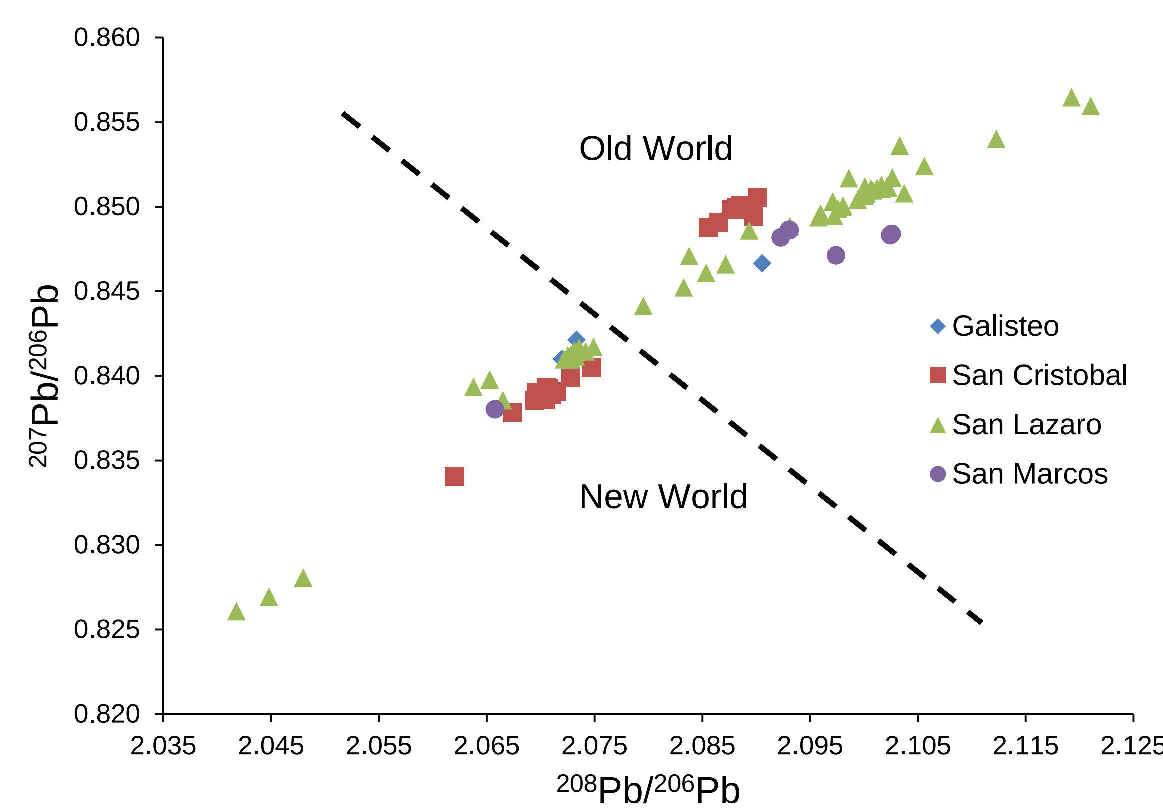
To determine the origin of bells, we measured lead (Pb) isotopes using multiple collector inductively coupled plasma mass spectrometry (MC-ICP-MS). Pb isotope analyses relies on high-precision measurements of ^{204}Pb, ^{206}Pb, ^{207}Pb, and ^{208}Pb. Ratios of these isotopes reflect the unique geologic signature of the ore deposit(s) which when compared to extant data can be used to identify the geographic source of Pb used to manufacture bells and other objects (e.g., Iñañez et al. 2010), in addition to determining whether fragments come from the same bell.

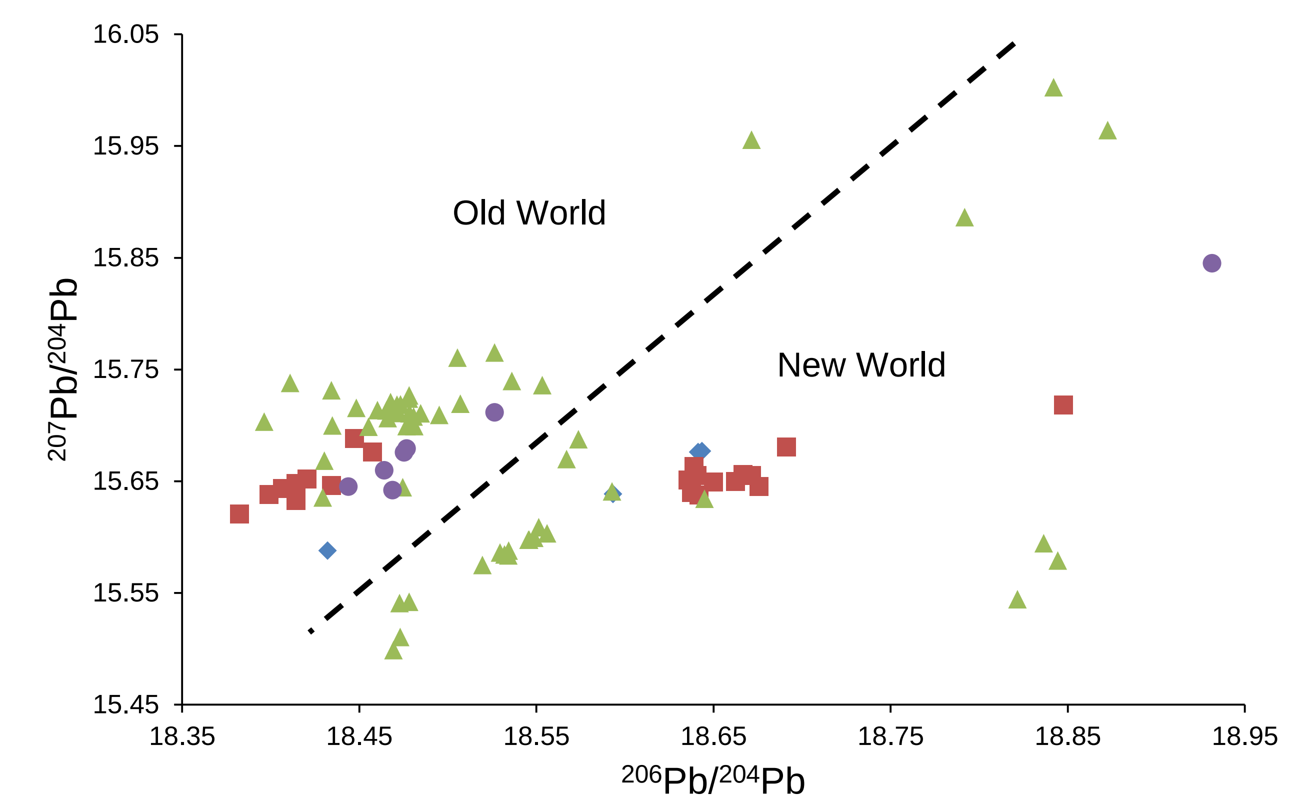
METHODS

Following methods established by Thibodeau et al. (2013), bell fragments underwent two passes of dilute nitric acid on a Q-tip swab. The first cleaned the collection area of any surface contamination and the second provided the sample for the Pb isotopic analyses. The sample swabs were individually sealed in polyvials and sent to the UGA Center for Applied Isotope Studies where the Pb was extracted from the swab by using Nitric acid. The resulting solution was purified through column chemistry using 1N hydrobromic acid and 20% nitric acid. After undergoing column chemistry, the samples were dried down and then rehydrated in 5% nitric acid and analyzed on a Nu Plasma II MC-ICP-MS.

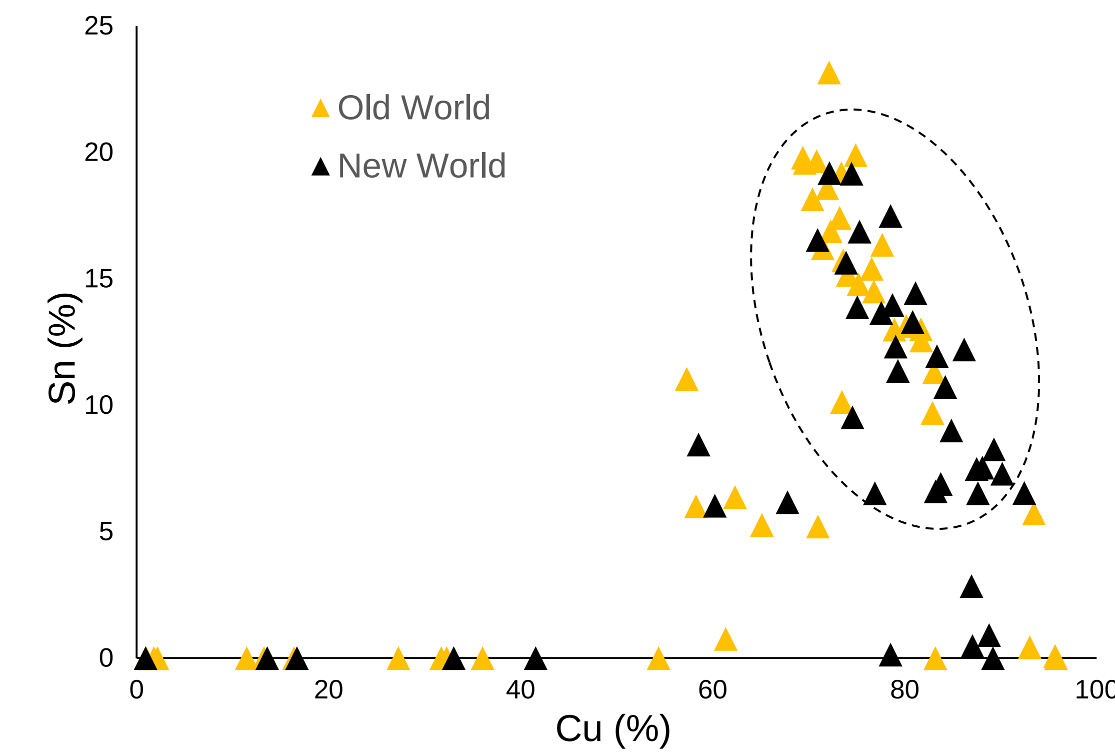
Analysis by MC-ICP-MS measured Pb isotopes (^{204}Pb, ^{206}Pb, ^{207}Pb, and ^{208}Pb). A Tl spike was used to correct for mass bias by monitoring $^{205}Tl/^{203}Tl$ (2.3889). Mercury interference with ^{204}Pb was corrected by monitoring $^{204}Hg/^{202}Hg$ (fixed at 0.22988). NIST SRM 981 was used to monitor instrumental drift during the analyses and assess the precision and accuracy of the measurements.

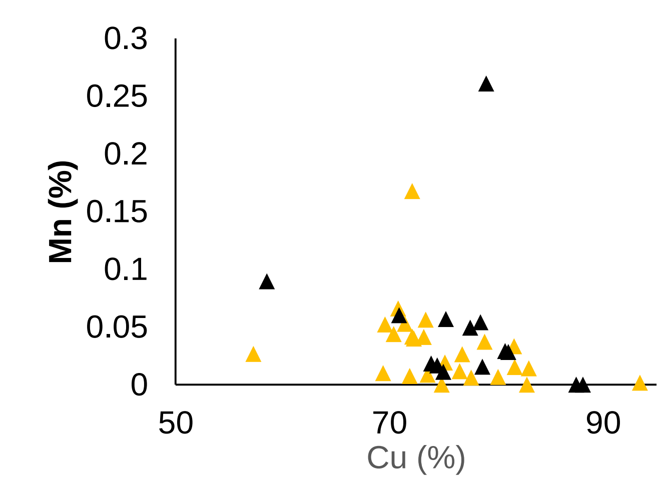
Pb Isotope Results

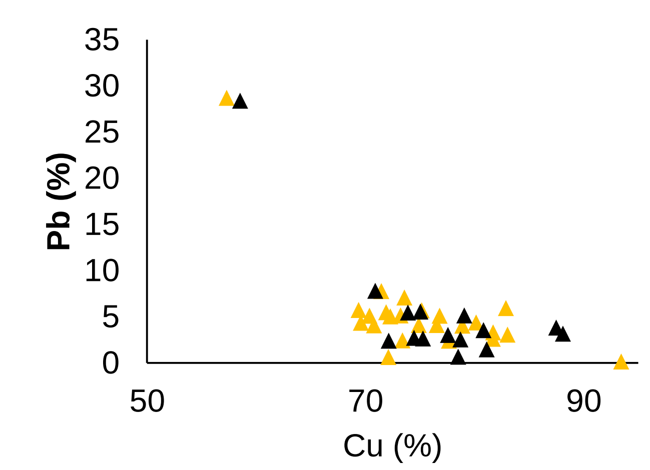


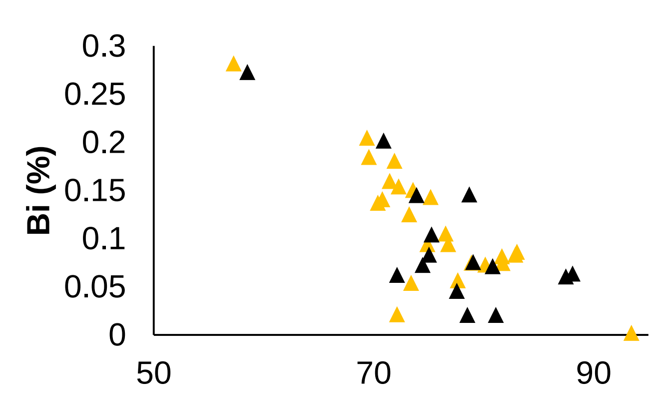


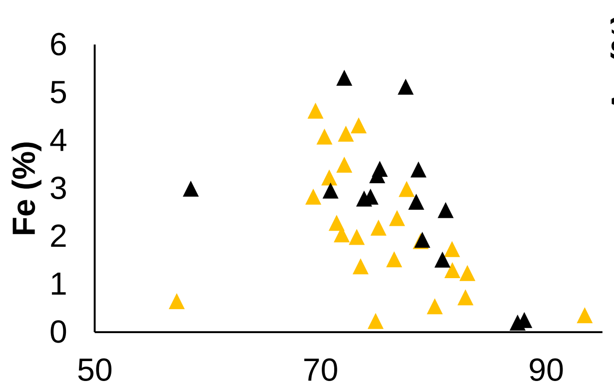
XRF Results

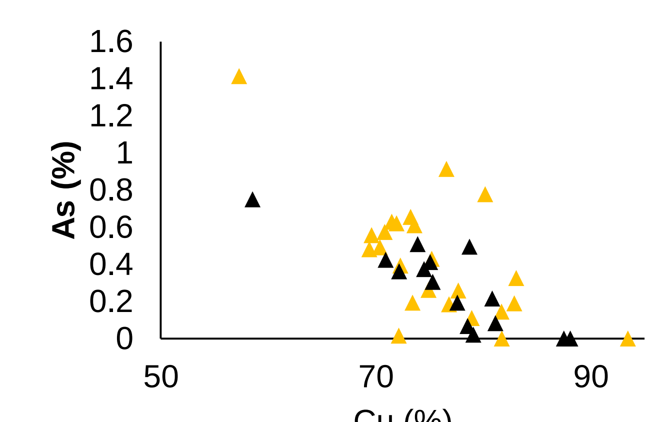


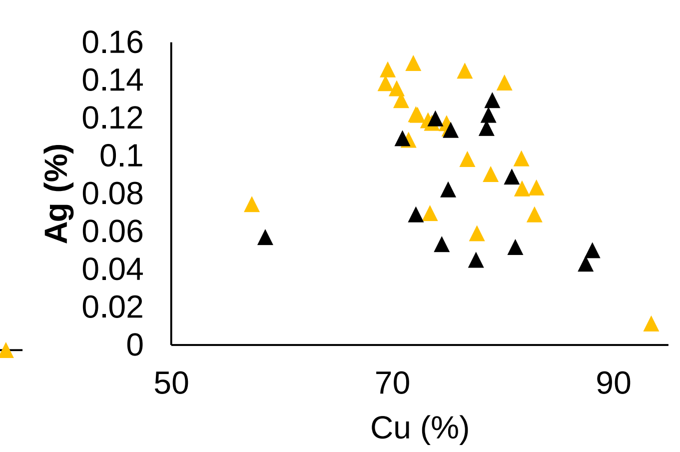












NIST SRM981 comparisons from this study to previously published data

	n	Technique	208/204	σ	207/204	σ	206/204	σ	208/206	σ	207/206	σ
SRM981 (certified values)	--	TIMS	36.7219	-------	15.4916	-------	16.9371	0.00004	2.1681	0.0008	0.91464	0.0003
This Study	9	MC-ICP-MS	36.7532	0.0590	15.5087	0.0233	16.9618	0.0251	2.1668	0.0006	0.9143	0.0002
Galer & Abouchami (1998)	57	TIMS	36.7219	0.0044	15.4963	0.0016	16.9405	0.0015	2.1677	0.0001	0.9148	0.0000
Potra (2011)	43	MC-ICP-MS	36.5751	0.0462	15.4470	0.0152	16.9112	0.0115	2.1628	0.0018	0.9134	0.0005

CONCLUSIONS

Comparison of our Pb isotopic results with extant data indicates that these bells have two different geographic sources: either produced using Spanish ores or ore found in west and central Mexico. Data from the American Southwest (Thibodeau et al., 2013) has shown that local sourcing of ore is highly unlikely.

Our XRF data shows that on average, the major components of bronze are similar regardless of the region. However, there are some elements of interest that show differences; arsenic on average is more elevated for Old World vs New World. Iron also is more elevated for the New World bells as opposed to Old World. This is likely a recipe differentiation or contamination in the foundries where the bells are cast. In the case of arsenic, another likely explanation is a higher arsenical content in the ore itself.

Close overlap of both isotopic values and elemental results can help determine the likelihood of bell fragments not only originating from the same geographical area, but also from the same bell. Further cluster analysis can solidify these findings.

This study furthers our understanding of bronze casting methods of mission bells produced during the Spanish colonial period. Future research will focus on determining specific localities of Mexican Pb ores used for casting and a more expansive study of bells and other Pb containing artifacts related to the Spanish colonization of the new world.

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