Observation of some Kan'ei Tsūhō Namisen Attributes

Joseph Hayden, June 5, 2022

- Summary

Conventional numismatic wisdom teaches that 11 wave Kan'ei Tsūhō Namisen of 4 mon value from the Meiwa period appear "brassy", Bunsei period (with some lead addition) have a reddish tint, and Ansei period pieces (with a high lead content) have a blackish or dark appearance. The color is stated to be caused by changes in the alloy composition; or, to trace contaminant(s) in the starting raw metals. With this backdrop, eight 11 wave Namisen were judged for color, measured for density and magnetism, and semiquantitativly evaluated for major elements in the composition. The results suggest that coin composition varied over a wide range and that color may not be a reliable indicator of casting period. On the other hand, lead content and, in the absence of chemical analysis capability, the coin density, may be more suitable; however, in the latter case, the wide range of observed density values may make confident identification of some coins impossible.

- The Target Composition of 4 mon Kan'ei Tsūhō Namisen

In his 1891 paper "Abridged History of the Coins of Japan", van de Polder gives us the following target compositions by casting period.

Period	Copper	Zinc	Tin	Lead
Meiwa (casting 1769-1788)	68	24	8	0
Bunsei (casting 1821-1825)	75	15	0	10
Ansei (casting 1857-1859)	65	15	0	20

This information has been repeated numerous times, for example in Hartill's 2011 text "Early Japanese Coins" and Robert Jones 2007 text "A History and Guide to the Copper Cash Coinage of Japan".

On May 10, 2022 at https://www.japanese-wiki-corpus.org/history/Kanei-tsuho.html and its original Japanese site https://www.japanese-wiki-corpus.org/jp/history/寛永通宝.html the composition of Meiwa period coins was given as 68% of copper, 24% of zinc, and 8% of lead, that is, Van de Polder's 8% tin is replaced by 8% lead. Potentially important is that the Bunsei and Ansei compositions match, thus, with each advancing casting period, the target lead content was increased up to 20 weight percent.

- Predicted Density as a Function of Composition

Metal density is straight-forward to predict from composition. Using both Meiwa compositions we have the predicted densities for all three periods given in the table below.

Period	Color	Target Composition	Density [gm/cc]
Meiwa	Brassy	68 Copper 24 Zinc 8 Tin 0 Lead	8.30
Meiwa	Brassy	68 Copper 24 Zinc 0 Tin 8 Lead	8.58
Bunsei	Reddish	75 Copper 15 Zinc 0 Tin 10 Lead	8.81
Ansei	Blackish	65 Copper 15 Zinc 0 Tin 20 Lead	8.99

Not surprisingly, the predicted density increases with lead content.

- Visual Inspection and Density of Eight 4 mon Kan'ei Tsūhō 11 Wave Namisen

Eight coins were randomly assigned letter designations A through H. Color was judged under sunlight illumination concentrating on the surface of the outer rim as similar to the method taught by Ogawa in his 1969 text "Shin Kan'ei Sen Kanshiki to Tebiki". The following language was used to denote color: Brassy, Less Brassy, Little Bit Dark, Little More Dark, Darkest, Reddish, and Blackish. Note that the first five terms are possibly all "brassy" coins in order of increasing tarnish on the surface. In the table below, Obv and Rev indicate the obverse and reverse faces, respectively.

Density was measured by the Archimedes method (weighing the sample first in air and then supported in DI water of known temperature) and is given below in gm/cc. The density measurement was replicated five times for each coin and standard deviations ranged from 0.02 to 0.08 gm/cc. For coins A, G and H, the standard deviation was 0.02, 0.04 and 0.04 gm/cc, respectively, probably at the limit for distinguishing Bunsei from Ansei based on density alone.

				Assignment Based on		
Coin	Obv Color	Rev Color	Density	Obv Color	Rev Color	Density
A	Reddish	Reddish	8.98	Bunsei	Bunsei	Ansei
B	Brassy	Little More Dark	8.33	Meiwa	Meiwa/Ansei	Meiwa
C	Less Brassy	Brassy	8.31	Meiwa	Meiwa	Meiwa
D	Little Bit Dark	Less Brassy	8.15	Meiwa/Ansei	Meiwa	Meiwa
E	Little More Dark	Little Bit Dark	7.93	Meiwa/Ansei	Meiwa/Ansei	Meiwa
F	Darkest	Darkest	8.35	Meiwa/Ansei	Meiwa/Ansei	Meiwa
G	Reddish	Reddish	8.83	Bunsei	Bunsei	Bunsei
H	Blackish	Blackish	7.98	Ansei	Ansei	Meiwa

A B C D

E F G H

Coins B through F are possibly all “brassy” with some tarnish; but, to be conservative, the color assignment for darker faces was made as "Meiwa/Ansei". On the other hand, A and G are distinctly reddish and coin H is definitely blackish (much darker than even F). But the key take away was that color and density suggested different assignments for coin A (reddish, should be Bunsei, but density is too high, close to Ansei with the target composition) and coin H (blackish, should be Ansei, but density is less than predicted for even a tin containing Meiwa coin). The wide density range, many much less than even the lowest predicted density of a Meiwa piece, also suggests a wide range of coin compositions!

- Chemical Analysis

All eight samples were submitted for chemical analysis by wavelength dispersive X-ray fluorescence (XRF) spectroscopy. We emphasize here that lacking a reference standard the results are only semiquantitative, the values below are not the measured composition just intensity values. However, one immediate finding was that none of the eight coins showed a strong signal for tin. Focusing only on the observed three major components of copper zinc and lead, the signal levels are given below.

Coin	Obv Color	Rev Color	Copper	Zinc	Lead	Lead Assignment
A	Reddish	Reddish	73.3	9.4	15.3	Ansei
B	Brassy	Little More Dark	72.3	21.1	1.6	Meiwa
C	Less Brassy	Brassy	80.2	18.7	1.1	Meiwa
D	Little Bit Dark	Less Brassy	79.6	19.5	0.9	Meiwa
E	Little More Dark	Little Bit Dark	81.6	16.0	2.4	Meiwa
F	Darkest	Darkest	84.6	14.8	0.6	Meiwa
G	Reddish	Reddish	82.8	10.0	7.3	Bunsei
H	Blackish	Blackish	85.2	13.9	1.0	Meiwa

Also detected at lower levels (but still 10 times over background) compared to copper and zinc were silicon (possibly carry over from the sand molds as the analysis depth for this element is only 0.002mm), aluminum (actually assigned to the coin holder in the XRF instrument), iron, sulfur, phosphorous, magnesium, calcium, chlorine and alkali metals. Three distinct signal levels for lead are revealed in the results: 15.3, 7.3 and less than 2.4. The signal levels less than 2.4 were comparable with that of some of the other contaminants found in the spectroscopic data, and near absence of lead helps to account for many of the coins having lower than expected density values. Most importantly, the three lead signal level ranges again suggest assignments at issue with those based on color alone but consistent with the density results.

- Other Links to Coin Color

To search for another cause of color variation two checks were completed. First, it was observed that some of the coins exhibited magnetism and it was considered if residual iron contamination might be a cause of color variation (after all, rust often has a reddish hue). Magnetism was evaluated as an "equivalent gm weight of force" (denoted by M below) by measuring the ability of a fixed magnet to both lift and translate each coin suspended by a thread under tension through an angle away from vertical. The angle, X, when the fixed magnet can no longer be attached and releases the coin gives M by $M = m (\sin X / \cos X)$ where m is the measured weight of the coin in gm (thus factoring in and accounting for the different coin weights). This measurement was repeated at least five times using a different location on the coin edge for each trial and the standard deviation for all but coin F was less than 0.1 units. Coin F was highly anisotropic in its magnetic property, appeared to be more concentrated in iron in one quadrant of the coin, and had a standard deviation of 0.5 units.

Second, as is well known in the metal community, brass color is often simply a function of composition even in the absence of impurities. We thus inspected the results for any correlation between bulk chemistry and perceived color. Below, the ratio values for lead to copper (Pb/Cu) and zinc to copper (Zn/Cu) multiplies by 100 are included.

Coin	Obv Color	Rev Color	M [gm wt of force]	100xPb/Cu	100xZn/Cu
A	Reddish	Reddish	0.0	20.3	12.5
B	Brassy	Little More Dark	0.7	2.1	27.3
C	Less Brassy	Brassy	3.4	1.4	23.3
D	Little Bit Dark	Less Brassy	0.7	1.2	24.5
E	Little More Dark	Little Bit Dark	0.6	2.9	19.6
F	Darkest	Darkest	3.8	0.7	17.5
G	Reddish	Reddish	0.0	8.8	12.1
H	Blackish	Blackish	3.1	1.1	16.3

Key observations were that reddish coins show no magnetism but the blackish coin shows magnetism strength bracketed by the various non-blackish coins. We believe there is no link evident between iron and coin color. The XRF results for iron did not track with the measured magnetism, and we believe the latter is a better indicator of iron content and the former subject to high uncertainty (as a point of fact, none of the contaminant levels observed by XRF correlated with coin color, but the expected high uncertainty for contaminants means this was not a rigorous check).

On the other hand, there appears to be a trend with both ratio values of lead and zinc to copper. In particular, a zinc to copper ratio less than 14 is reddish, a ratio between 14 and 20 are dark to blackish in color (with darker color for smaller ratio value), and a ratio value greater than 20 appears brassy to the eye. Again, these results are semiquantitative, other equipment might give different ratio values, but the trends should be preserved.

For comparison, consider modern "red brass" and "yellow brass". On May 21, 2022 from https://www.rocheindustry.com/red-brass-vs-yellow-brass/ we have
Red brass is 88% copper, 8%-10% zinc, and 2%-4% tin and
Yellow brass is 60-70% copper, 30-40% of zinc, tin, and lead in traces.

This web site also states that red brass is associated with higher copper content and yellow brass takes its color from the higher zinc content. These statements are consistent with small Zn/Cu value being reddish and large Zn/Cu value being brassy (yellow).

What does this then tell us about assignment to the Meiwa, Bunsei and Ansei periods?

Period	Color	Target Composition	Target Zn/Cu Ratio x 100
Meiwa	Brassy	68 Copper 24 Zinc 8 Tin 0 Lead	35.29
Meiwa	Brassy	68 Copper 24 Zinc 0 Tin 8 Lead	35.29
Bunsei	Reddish	75 Copper 15 Zinc 0 Tin 10 Lead	20.00
Ansei	Blackish	65 Copper 15 Zinc 0 Tin 20 Lead	23.08

The values above suggest the target compositions (independent of lead or tin in Meiwa coins) follow the same pattern between predicted color and target Cu/Zn ratio (remember, the XRF chemistry values are all semiquantitative, so only watch for trends, not quantitative agreement with prediction). So, the target compositions might be expected to give the reported colors. But, in the case of the eight coins discussed here, the actual retained metal contents in the coins are evidently far from the target levels.

- One Other Possibility

The four mon coin contained only a little more copper than a one mon coin. Thus, it was an attractive target for illegal coin casting by the various clans across Edo period Japan. One would expect that the official 4 mon pieces would have enjoyed more accurate production methods and have density values close to target. If the density and chemistry variation reported here is from private casting operations, we might then propose that, since coins D, E and H in fact have density lower than the entire target range, they might be counterfeits of that time period. However, all the other coins have a density close to one of the target values, and we would still have to wonder at reddish coin A with density essentially matching an Ansei coin but then having the wrong coloration. Either official or illegal, the implication is that a serious collector should consider attributes beyond color to make period assignments of Kan'ei Tsūhō Namisen.

- Conclusions

The retained chemistry of the Namisen in this study covered a wide range of compositions, many far from target based on density alone. If there was a gradual addition of lead over time from Meiwa to Bunsei to Ansei periods as reported elsewhere, the lead level may be a more reliable method to identify casting period. Although lead may be a contributing factor, variations in retained zinc and copper in the coins studied here appear to determine coin color INDEPENDENT of the assigned mint period based on color alone. Assignment to specific casting periods might then best be done by quantitative evaluation of lead content. This might also be done semiquantitative as the case here; and, in the absence of chemical analysis capability, coin density might be a surrogate indicator. However, the wide variation in coin density may make specific assignment of some coins impossible by this property alone.

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