The Metallurgy of Honduras Provincial Reales

by John Lorenzo

Introduction

Brian Stickney in his recent authoritative work "A Monetary History of Central America" describes the minting issues in the Tegucigalpa mint quite clearly of their crudeness on page 158 when he cites: There was little incentive to forward bullion to the mint in Tegucigalpa, once that facility was fully established and operating. The government's policy of debasing its coins from the beginning was a problem, but throughout the 1830's, 1840's, and 1850's the mint was constantly plagued by a series of problems, including a high turnover of personnel, lack of machinery and spare parts, fires, delays by the government in upgrading facilities, and at times requirements that government employees be paid in the same debased coins that mint officials were ordered to produce. Stickney then cites the noted traveler William Wells who gave an apt description of the Tegucigalpa mint in his travel log which is worth repeating here in full to confirm these metallurgical findings for these issues. Wells states - The mint at Tegucigalpa is a fair illustration of the reign of terror which, in successive administrations, has blighted the prosperity of Honduras. My old friend, Don Jose Ferrari a naturalized Italian, is the director. By his invitation, I visited the establishment which is a portion of the cuartel building. The machinery is simple and rude, consisting of a perpendicular screw (i.e., screw press) on the lower part of which is affixed a stamp of the coin intended to be made. A horizontal bar passes through the upper part, forming two levers, or handles, like capstan bars. A couple of blacks were alternately setting up and unscrewing this bit of mechanism, a copper coin, of the value of a cent, dropping out at each heave. The rim of the coin is made of an equally simple process. The room was bare, dark and silent; the walls shrouded with cobwebs and black with dirt. On a table near the coining apparatus were heaped up several thousand bright pieces of copper money, in which, as Don Jose informed me, was a considerable percentage of silver, the exact amount of which he is prohibited from divulging.

In examining these coins with XRF, SEM/EDS analysis and with visual observations based on my experience the following comments are being offered to the reader:

1. These coins do not appear to be mixed with silver say in any type of fineness. What these coins do posses in my opinion is the presence of surface silvering or no presence of surface silvering. When we read in Stickney on pages 160-162 we see comments suggesting for certain years that these issues were either 4, 10, 20, 33.33 or 50% silver by composition. In the beginning years such as for the 1832 1/2R, 1R and 2R's we see silver fine values of 33.33 or 50% and these should not be confused with the debased silver issues of 1830-1832 by the Central American Republic for Honduras. So the silvering appears to be relegated just to the surface in my opinion. So the first task of this paper is to prove the silvering is strictly of a surficial type as we see for example of mercuric silvering found on contemporary circulating counterfeits for any denomination of 1/2R to 8R as in the Portrait 8 Reales as described in Gurney (3).

2. In my previous U.S. Colonial collecting days we came across a phenomenon called the Jim Spilman "Isostasy Effect." The late Jim Spilman was a past editor of the ANS Colonial Newsletter and in my opinion his major strength was his knowledge of U.S. Colonial period coin making. In observing crude contemporary circulating counterfeits of the 18th century of English/Irish halfpence we came across pieces which had letter or numeral punches with the same effect as we see in these crude Honduran Reales. The central numeral and letter puncheon areas was raised and the surrounding areas were flattened sometimes distorting the letter or number punches but to be honest the "level" of Isostasy Effect in terms of its predominance is much more and even universal with these so-called copper Honduras Reales! This is where the die wears down and the collar is weakened and the letters and numerals are then pulled to the outer edges or are forced to an area of less resistance causing their stretched distortions. It appears the dies for these pieces were used till exhaustion or breakage and their use in a screw press device give this "Isostasy Effect" we see only on occasion with contemporary circulating counterfeits of British/Irish 18th century being another common example.

3. We do read that lead was used in the 8R series as we see in Stickney for C269 the 8-Reales in 1856 we see copper only and for 1857 the suggestion lead is beginning to be alloyed with copper probably due to lack of good copper and is a form of debasement. Does this lead enter into the other denominations and earlier periods? Does it exist solely for the 8 Real issues? Does it start in 1857 or is it present from 1856-1861? Lead is normally used for casting coinage with tin bronze issues and normally at a percentage of 1-5%. When lead is higher or even at this higher level in a striking scenario this will lead to alloy immiscibility and will result in planchet laminations being common-place as we see in almost all Honduran copper Reales particularly in the later period for each denomination. One good example of high lamination occurrences is for the U.S. Jefferson nickel during World War II with this level of

9% manganese which results in my opinion the most commonly found U.S. coin in the 20th century with surface lamination issues due to alloy mixing problems. We see this same effect with these Honduran eight Reales with severe lamination streaks plaguing many examples due to this lead addition in my opinion.

Copper when not almost pure say at or above 95% will have issues in being brittle or have lamination issues as we see in these pieces which have high lead which generally will separate out and create severe surface laminations. The analysis seems to confirm my initial speculation in this matter.

Phil Mossman in one of his classic works with friend and colleague Dr. Smith in the April 1998 Colonial Newsletter on Cast Counterfeits cited a very important reference : S.L. Archbutt and W.E. Prytherch – "Effects of Impurities in Copper" – British Non-Ferrous Metals Research Association – Research Monograph No.4 (1937) and cites the following important paragraph on copper planchet production:

To produce a copper coin, the purity of the copper is kept rather high. Even in the case of struck counterfeit coins studies have shown that even when copper was used the purity was normally better than 95% pure. Since most additives to copper produce alloys more harder or brittle than copper, to reduce the tendency of splitting or delaminating of metal layers such as this case here with lead and copper probably during the rolling of the planchets and to facilitate successful striking, copper was kept rather pure. Interestingly, when Sir Isaac Newton was appointed Master of Tower Mint in December, 1699, he issued a directive that only pure copper be used for coining, and he employed a simple test. When pure copper is heated red hot, placed on an anvil and beaten with a hammer it will not crack whereas if alloyed with tin, lead or zinc it will split. This test was used to accept or reject copper delivered by smelters to the Tower Mint. Blister copper straight from the smelter would work and would be sufficiently pure without further processing. Blister copper is normally 96-99% pure and produced by smelting which has a blistered surface due to sulfur dioxide bubbles permeating off the surface. We see these Honduras Coppers with these surface laminating issues from the lead and its other impurities and it appears most collectors do not appreciate these issues due to their poor metallurgy – but these were the times of provincial coppers and silver pieces during these early times.

4. In Krause for KM 17 (1/2R) – KM 21 (8R) we see various terms of silver, copper and copper-lead for certain years. Again the classifications are vague and we need to address and be more specific what form of silvering occurs on these issues and if lead is used more universally than described both in Stickney and Krause.

5. Probably the leading expert in Mesoamerican Metallurgy Dorothy Hosler in her work titled "Mesoamerican Metallurgy: The Perspective from the West (4, 5) discusses briefly how the technology of copper making was brought *north* from Central America and South America to Mexico from their early civilizations through maritime trading initially to the west coast of Mexico. This being said and after the Spanish contact period this copper metallurgy is *impossible* in being any form of an alloying accident. Copper in these regions were normally alloyed with arsenic, tin and sometimes silver but never lead. Lead in this case is introduced therefore into copper *intentionally* for two main reasons: 1- To reduce the melting point of the alloy (Cu/Pb) to make it easier to work and handle in the planchet production process and 2- To extend the use of the more difficult metal to be procured for coin production - copper. The large differences in melting points between lead (621.4°F) and copper (1,984°F) is the primary root cause why we see severe lamination effects on these pieces since their mixing was *not* homogenous. Suffice to say that most numismatists of course have no real appreciation for this crude alloy and we normally see the grading of these pieces by third party grading almost always being incorrect due to the irregular striking differences and laminated fields based on the crude equipment utilized. On some pieces examined we can see some areas which have die polishing lines and other areas the motifs do not even come struck up clearly as in the denominations left and right of the Ceiba tree. Grading services have at times called this type of observational phenomenon F-VF pieces from pieces I have seen in slabs!

Patio Process - Silver Extraction

To understand if mercury and silver was applied to the surface of these coins some background on the Patio Process and mercury extraction is in order in my opinion as the same principle is used to apply silver to the surface using mercury whereas silver is mixed with mercury then annealed (i.e., evaporated off using heat).

The Patio process was developed and used to refine both silver and gold in the 15th century, principally in the European silver mines that were producing silver for Venice. The process was first described in 1540 by Biringuccio in *De La Pirotechnia* and is notably missing from Agricola's 1556 publication *De Re Metallica*. Biringuccio, however, seems to have described

the mercury amalgamation as a small scale solution to recovering precious metals from slag and sweepings, rather than a primary method of silver extraction.

The Patio process was introduced to Mexico in 1556 by the German Gaspar Lomann and was followed a year later by the Spaniard Bartolome de Medina who is most often credited with the introduction of the process to the New World. Medina was instructed in the process in Spain by a German known as Lorenzo as follows;

Grind the ore fine. Steep it in strong brine. Add mercury and mix thoroughly. Repeat mixing daily for several weeks. Every day take a pinch of ore mud and examine the mercury. See? It is bright and glistening. As time passes, it should darken as silver minerals are decomposed by the salt and the silver forms an alloy with mercury. Amalgam is pasty. Wash out the spent ore in water. Retort residual amalgam; mercury is driven off and silver remains.

Medina then spent two years in Pachuca experimenting with the process with mixed success due to the different silver ore compositions from Europe to the Americas before successfully adapting the process to the local silver-rich, polymetallic ore.

The process was then introduced at Potosí in 1570 by the Viceroy Francisco de Toledo, where silver production increased by 800 per cent in a decade as a result.

The rate at which the process was adopted in Spanish America was rapid, which can be gauged by the amount of mercury being imported from the Almaden mercury mine in Spain to be used in the process at the time. During the period 1550-1556, 40,370kg of mercury was imported, increasing to 136,080kg during 1561-1565. When the Huancavelica mercury mine in Peru began large-scale operations in 1563, the abundance of mercury available for silver extraction in Spanish America meant that minimal effort was put into recovering used mercury for further use. As a result, it is estimated that up to 200,000 tons of mercury evaporated into the atmosphere or washed down rivers in Spanish America during the use of the Patio process from 1556 to the 1880s, causing long term environmental impacts.

The process consists of crushing the ore in brine (salt water) to make a fine paste, and mixing it with mercury. Copper sulphate is added as a later refinement to the process.

The resulting paste was then spread out in a shaded area (generally on a patio) to about 30-60cm thick, and further mixed by mules, horses or occasionally people walking through it over a period of several weeks. At this point, the silver would have formed an amalgam with the mercury and could be recovered from the rest of the ore. The silver was then extracted from the amalgam by heating and evaporating the mercury. The amount of mercury lost during the whole process was between one and two times the mass of the silver recovered.

The Patio process can be described using the following equations. Silver sulphides are first converted to silver chloride, before the mercury reduces the silver chlorides to elemental silver, which is then amalgamated by the excess mercury. The elemental sulphur produced will also combine with the mercury to create cinnabar (Hg2S).

$Ag2S(s) + 2Cu2+(aq) + 8Cl-(aq) \rightarrow 2AgCl(s) + 2[CuCl3]2-(aq) + S(s)$

$(n + 2)Hg(l) + 2AgCl(s) \rightarrow Ag2Hgn(l) + Hg2Cl2(s)$

The process is now understood to be equivalent to hydrometallurgical chloride leaching, in which metal sulphide ores, which have been reacted with chloride ions in brine (NaCl -salt), are oxidized by air in the presence of coppers salts acting as a catalyst. The oxidation process is continuously regenerated by the constant agitation of animals and humans walking through the mix and breaking it up to expose new surfaces to the air.

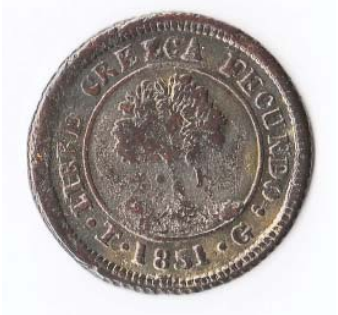
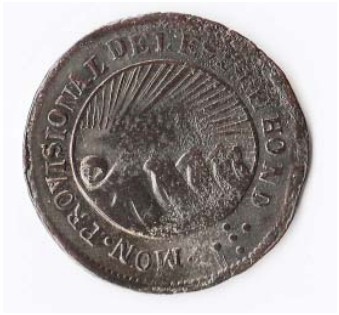
The Patio process was the principle method of silver extraction until the adoption in the 1880s and 1890s of the MacArthur-Forrest process for extracting gold and silver from ores using cyanide extraction.

Findings/Conclusion

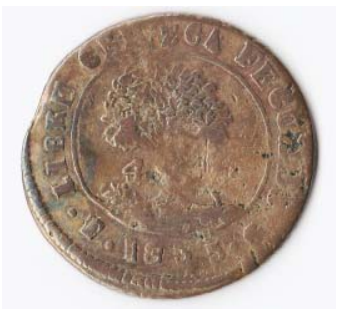
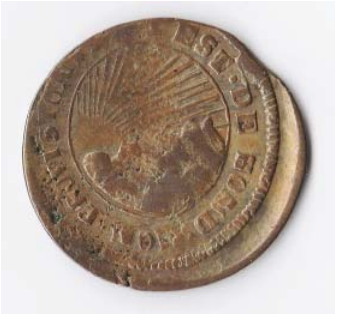
The findings show mercury may have not been used but the analytical instrument used here has a high instrument detection limit for mercury with an Instrument Detection Limit accuracy at only 0.1% and a confidence level only above 1.0%. Mercury may be present with any silver being found but no direct conclusions can be made at this point since it did not appear in any specimens but we do know this mint operation did have access to mercury based on historical confirmation records

as noted in Stickney (1). Lead was not seen universally but may be present but is probably not homogenous in these Cu/Pb Honduran alloys. On looking at these coins we do seem to see areas of lead separated from the copper or areas appearing as copper but coupled with grayish areas also in the patina. More work is needed here. We do see high sulfur which confirms a poor copper annealing operation for ingot copper from improper annealing during planchet production. The author has seen this type of phenomenon in other crude copper coinage operations with high sulfur being indicative of a poorly run operation in terms of the final annealing and treatment of copper prior to the striking of the blanks such as comparing State Coppers with imported English Coppers of the 18th century. Iron is probably an ore contamination source as well originating from the copper production process. We do see thin and thick pieces but on analyzing two very thin pieces the fabric and metallurgical assays did not "suggest" they were of a contemporary circulating counterfeit nature in my opinion due to similar metallurgy results as with the other pieces in this study. As previously suggested the lead was introduced to lower the melting point of the overall alloy since the working operations as already indicated by several authors was of the crudest type when producing these copper Reales of 1851-1858. It appears in my opinion that surface silvering probably occurred from the beginning (i.e., 1851) and surface silvering may have been performed through 1858 but the silvering on these pieces disappear quite quickly particularly with specimens even in preservations of XF or lower. In some ways even a visual examination of near mint state specimens as in the Dana Roberts collection and then to ask this question is in order – "Is the silvering present or not on these specimens?" - may even be more accurate in many ways than a metallurgical study obviously on lower grade pieces at XF or below! So both the lead which has probably separated out and not mixed very uniformly with copper and the ease in which the surface silvering was removed quickly after these pieces entered circulation explains in my opinion why these two metals (Ag & Pb) are not uniformly found in all of the specimens when viewing the analysis table in this small population of analyses. Multiple surface analyses and possibly central core testing of these pieces may be in order to fully explain the metallurgy of these pieces moving forward. It's probably also a strong possibility that if the silver was mixed throughout the blank in a homogenous manner and not as a silver surface type application that we would see silver found uniformly in all examples if added initially even in this small grouping for this paper. The use of lead here was also quite ingenious in that lowering the overall melting point of the Cu/Pb alloy with lead made the working much easier to achieve when making these blanks but of course creating lamination issues in many examples. One last thought – it seems the silvering as Stickney alludes to although again not clear in his book due primarily to a lack of historical minting records may be more prevalent in the earlier issues than the later issues however in this study we see silver present in both in 1851 and 1857 4 Reales examples. The levels are irrelevant as in the presence or absence of lead as these are non-homogenous alloys but never the less the high amount of silver in the 1857 example was indeed interesting.

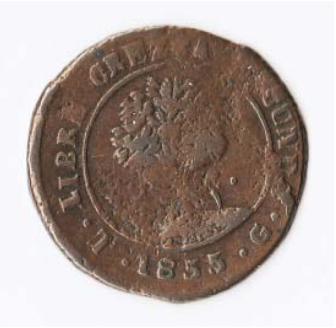
The reader may then ask after going through this study what definitive results from my initial observation on these Honduran pieces were found? We can conclude that more surface analysis or more spot analyses are required with more sophisticated equipment is required and mercury should be searched for in specimens of high silvering. We can see these are primarily composed of copper and the lead does not appear to be that high in these specimens (i.e., possibly less than 10%?) although unquestionably not well mixed in these planchets creating severe surface laminations. Iron is an ore contaminant and future studies need to concentrate on these three major metals: Copper, Lead and Mercury with some very low grade common year examples requiring to be cut in half to confirm that silvering is primarily at the surface regardless if mercury is confirmed in future studies on the surface. The actual lead content may be difficult as the lead which future microstructure studies will probably confirm is not uniformly mixed with the copper creating some areas of high lead accumulations due to lead and copper's vastly different melting points and therefore falling victim to a term called the "coring effect" thereby creating this non-homogeneity in the Cu/Pb alloy due to their vastly different melting points.

Coin # 1: 1851

Coin # 2 - 1855



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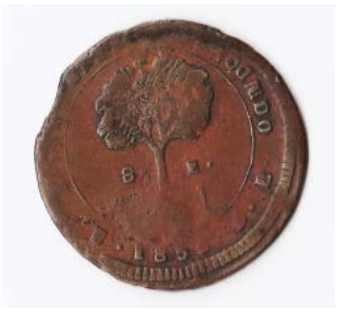
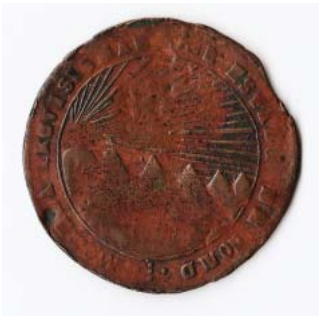
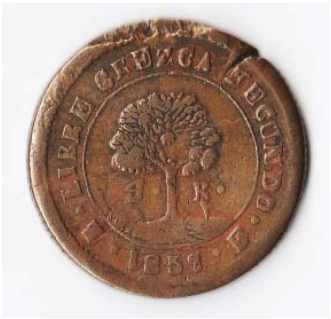
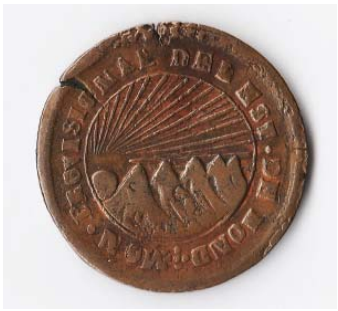


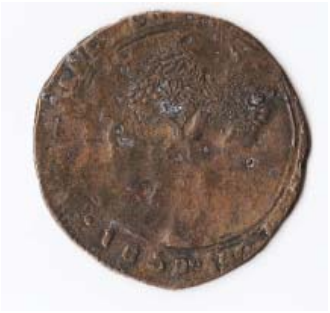


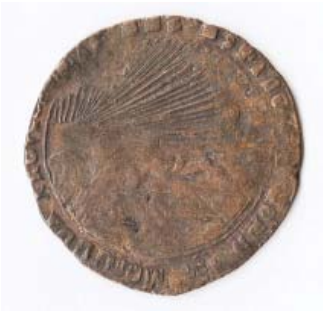
Coin # 4: 1856



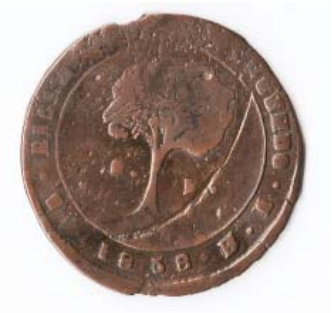


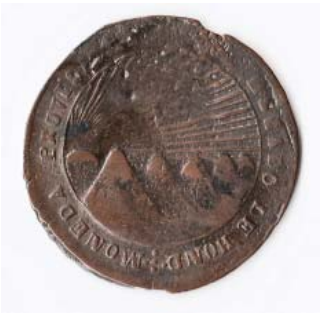
Coin #5: 1857





Coin # 6: 1858





Coin # 7: 1858

Date of Issue	KM# Denom.	Diameter/ Weight	Silvering Visible?	Cu	Pb	Ag	S	Fe	Hg	Comments (See Note 1)
1. 1851	20-a, 4R	29.6 mm ; 7.1 gms.	Yes	96.8	ND	1.63	ND	0.36	ND	Iron probably as an ore contaminant. High copper with trace silvering on this early piece. We generally do not see silvering on later pieces. The silvering does not appear to be of a mercuric silvering nature? More testing needed

2. 1855	20-d, 4R	29.2 mm; 8.2 gms.	No	97.0	ND	ND	2.14	0.87	ND	VF/XF grade. The grade of specimen #1 was AU which may account for traces of surface silvering be present or not in my opinion.
3. 1855	20-d, 4R	28.9 mm; 6.4 gms.	No	98.9	ND	ND	0.79	0.21	ND	These Honduras pieces have high sulfur which is indicative of a poor smelting operation of Cu.
4. 1856	21-a, 8R	39.11 mm; 11.0 g	No	98.4	ND	ND	1.46	ND	ND	Thinner piece and low weight. No lead found. Again we see the high sulfur confirming a poor copper annealing operation.
5. 1857	20d, 4R	31.4 mm; 13.8 g	Yes	81.16	ND	17.2	0.56	ND	ND	This surface analysis as we see was run in triplicate. We see a high silver area and lead being introduced. Perhaps silver was used throughout and this specimen is XF/AU. The silver may retain obviously on higher preserved pieces. The lead used for easier metallurgy to reduce the high melting point of copper.
				99.1	0.9	ND	ND	ND	ND	
				97.9	1.81	ND	ND	0.22	ND	
6. 1858	21-a, 8R	34.75mm; 9.14 g	No	90.6	7.3	ND	ND	1.95	ND	The previous owner thought maybe a forgery of the period with an 8R weight of only 9.14 grams. High lead seen in a grayish surface area intentionally scanned. The lead is anything but homogenous in these alloys in my opinion.
7. 1858	21-a, 8R	38.2 mm, 13.8 g	No	92.5	ND	ND	4.1	3.3	ND	No lead seen here but the lead is not uniform in these alloys so more work is needed on when lead was introduced to ease the copper metallurgy process and if silver occurred throughout these pieces from 1851-1858? Iron and sulfur are universal contaminants.

Notes:

1. For this study the alloys found will be classified as follows using Dungworth and Stanley debris alloy classifications. Specifically bronze - an alloy rich in tin (Sn>5%) with lower levels of zinc (<5%). Brass with Zn (Zn> 15%) and low tin (Sn<5%); Copper with Tin and Zn < 5% and gunmetal with moderate levels of zinc and tin both with Zn> 15% and Sn> 5%.

2. It appears the earlier pieces for the lower denominations (1/2R-4R) were silvered and with time the silvering was reduced. It does not seem apparent that the copper was alloyed with silver but that the silvering was simply applied to the surface. Without cutting open or slicing any specimens and doing core studies we do see some earlier pieces of lower denominations without surface silvering. These results suggest only silver surface silvering was performed in my opinion.

3. Some KM listings for the Eight Reales such as KM#20d for 1856TG, 1856TF and 1857TF in a copper alloy may be questionable.

4. For the 4 Reales we see the earlier dated pieces to the later dated pieces going through this 0.17/0.10/0.0625/0.04/ zero drop in silver content. This may be based on mint records but specimen examinations are not bringing this out in this preliminary study. Perhaps in the future some very low grade pieces of a common date like the 1850TG 4 Reales can be cut in half and core to surface readings can be performed to confirm all silvering was strictly at the surface and not mixed in with ready to strike planchets.

5. William V. Wells in his 1857 book in Explorations of Honduras describes the Patio Process as we see in Mexico. Using the "maquina" or mill at El Chimbo for crushing or grinding the the ores from in this case the mines of Santa Lucia where its made into montones or heaps or cakes which is then mixed with salt prior to amalgamation with quicksilver (i.e., mercury) which had the local name "El Patio." However mercury in this case is applied with silver poweder and then placed upon the surface of the coins. Then heated mercury burned off or annealed leaving a silver film on the surface as we see in contemporary circulating counterfeits of this period. The mercury here therfore should not be confused with remants of the Patio Process but a final mint production method to these coins making them appeared silvered. The silvering is not a fineness of any level but strictly a surface application method sometimes applied or not (?) applied to certain denominations during certain years of striking coinage.

6. As pictured in my latest book *Forgotten Coins of the North American Colonies - 25th Anniversary* - Plate Coin #79 in the Foreign Contemporary Counterfeits section on page 207. It was reported in the Evening Post of August 17, 1835 that a vessel from Bellevile, New Jersey was confiscated heading probably into several Central and South American ports with $1200 worth of counterfeit copper of Brazil later to be silvered if desired by the buyer. These 1833's Two Reales of Honduras are better executed as we see no form of die deterioation or isostasy (i.e., worn out letter or number punch) effects but "crisp" motifs all around the obverse/reverse legends and the date also being larger numerals and crsip well defined numerals. The 1828 Haiti or Specimen #76 50 Centimes may also be from the same Belleville, NJ source. The Haiti piece is easy to differentiate as the regal is silver with a distint weight but the Honduras 2 Reales as with other 1833's need to be identified simply with their better executuion of die work as both regals and counterfeits of 1833 indicate surficial silvering using the mercury silver amalgamation process. Silver mixed with mercury as a paste is applied to the surface and then mercury is annealed off by a post heat treatment method leaving the silvered surface end product. These pieces however have not shown to be of a mercuric silvering process but more work is needed here on this topic.

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