ARCHAEOMETALLURGICAL STUDY OF TWO ANCIENT COPPER COINS

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A scientific study of two copper coins from 1851 and 1853 reveals well-preserved symbols of a growing, newly independent Chile nation.

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A set of coins created in the mid-19th century for the Republic of Chile was studied to confirm its composition and manufacturing method. A one-cent coin from 1851 belongs to a private collector and a half-cent coin from 1853 was rescued from the Historical Fort May 25 Village archaeological site and is currently exhibited in the Narciso Sosa Morales Museum in Argentina. Through the study of currencies, the relationship between money and nations can be observed; they are a material testimony of the identity of a people, of an era, and of the monetary policies that have animated the economy. Engravers and craftsmen have shaped in metal many of the most significant characteristics of the history of a nation, as well as its artistic development. The rich iconographic heritage shows the historical symbols of these countries and gives a sense of identity. For example, the relatively new (at the time) nations of the Americas used new symbols such as erupting volcanoes, the sun, eagles, condors, Andean camelids, hands swearing on the constitution, and the figures of the Republic and Minerva as representations of freedom, among others.

In the country of Chile, through the enactment of the law of January 9, 1851, the Chilean monetary system was transformed, going from reales and escudos to pesos and centavos, with the following equivalence 1 peso = 8 reales. The aforementioned law, in article 4 said, "There will be two kinds of copper coins, called cents and half a cent of refined copper without mixing any other metal." The law of March 19, 1851 established that, "The copper coins will bear on the obverse the central star of the shield with the inscription: "Republic of Chile" and year of issue; and on the reverse the expression of its value, a bouquet of circular laurel, and the motto: "Economy is wealth." Throughout the numismatic history of Chile different versions of the coat of arms have been used on coins. Initially, when Chile was a Spanish colony, the coats of arms of Spain were used. Later, when independence came, Chile's coat of arms represented the Earth on a pillar. There were more simplified versions in which only the central flat star is shown, as in the case of the 1851 coin. The 1853 coin shows the coat with a five-pointed star with additional relief.

CHILEAN AND ENGLISH MINTS

To comply with this law, copper was commissioned from the Carlos Lambert smelter in Coquimbo (Chile). The plates produced were taken to Santiago where they were minted at the Casa de Moneda. Unfortunately, defects in the plates resulted in coins that were inconsistent in weight, which ranged between 8.388 and 9.400 g. This added to the technical deficiencies of the Mint in making of copper coins, being the first time such large quantities were produced, and led to the end of production of these coins in the country.

The Birmingham Mint, a coining mint, originally known as Heaton's Mint or Ralph Heaton & Son's Mint, in Birmingham, England, started producing tokens and coins in 1850 as a private enterprise, separate from, but in cooperation with the Royal Mint. In 1851 coins were minted for Chile. The same year copper plates were made for the Royal Mint to convert

Fig. 1 — The 1853 copper coin before (a and b) and after (c and d) electrolytic cleaning.

Fig. 2 — Obverse and reverse of 1851 historical coin, after electrolytic cleaning.

Fig. 3 — Example of the 1853 half-cent coin in good condition.

TABLE 1 – COIN CHEMISTRY COMPOSITION

Coin	% Zn	% Ni	% Fe	% Mn	% Cu	% Pb	% Si	% As	% Bi
1853, Half cent	0.076	0.099	0.090	0.015	96.2	0.10	0.26	0.091	0.11
1851, One cent	0.063	0.069	0.062	0.016	80.0	0.066	0.48	0.10	0.079

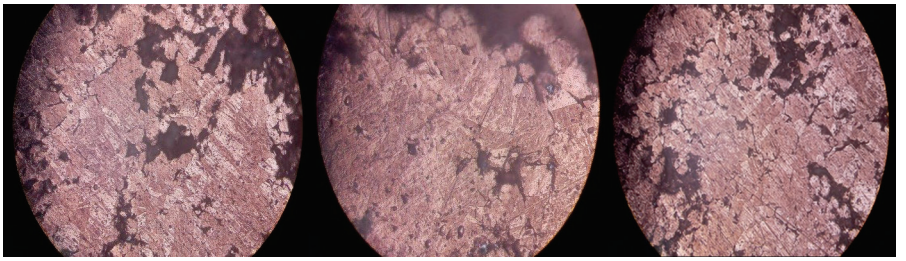

Fig. 4 — Micrograph of the 1853 historical copper coin showing corrosion from pitting. Reagent: Alcoholic solution of 2% ferric chloride ($FeCl_3$). Magnification: 100x.

Fig. 5 — Example of the 1851 one-cent coin in good condition.

into pennies, halfpennies, farthings, half farthings, and quarter farthings. In 1852, the Mint won a contract to produce a new series of coins for France. In this, the Mint was a pioneer in the minting of bronze. In 1853, the Royal Mint was overwhelmed with the production of gold and silver coins. They even re-minted copper coins for Chile. The Birmingham Mint won its first contract to mint finished coins for Great Britain: 500 tons of copper, minted between August 1853 and August 1855, with another contract in 1856. During the peak of operation, the four presses of hit around 110,000 coins a day.

CLEANING BY ELECTROLYTIC REDUCTION

The two copper coins in this study were in good condition, having a well-preserved metallic core and an original surface that was covered with non-deforming corrosion products that could be reduced back to the metallic state. The researchers decided to use electrochemistry to clean the coins by electrolytic reduction[1]. This treatment creates a galvanic battery in which the metallic object to be treated acts as a cathode and a galvanized steel sheet (zinc) or an aluminum sheet acts as an anode, with a 1% M sodium hydroxide as the electrolyte. When the galvanic reaction takes place, the less noble metal, in this case the aluminum or zinc, loses electrons in favor of the most noble (copper), producing a reduction of some corrosion products back to the metallic state. At the same time, the reaction produces hydrogen, which when released in the form of bubbles mechanically removes some corrosion products from the metal surface.

The results were achieved in 2 hours, a fraction of the typical time for metal cleaning, and with a degree of cleanliness that revealed all the details of the copper coin surface. Different results can be obtained depending on the intensity of the applied current, and can affect the rate of reduction of corrosion products to the metallic state and mechanical cleaning by the action of bubbles of hydrogen on the surface. In general, it is advisable not to work with very high currents due to the complexity of the chemical reactions that could affect the cleaning process[2].

Figures 1a and b show the state in which the 1853 copper coin was received and Figs. 1c and d show the coin after electrolytic cleaning. Figure 2 shows the 1851 coin after cleaning. The clean and polished coins show their origin, year of issue, monetary value, legend, and two laurels. The material is primarily copper with alloying elements that do not play a major role in the chemical composition (Table 1). The calamine formed (green) patina on its surface behaved as a protective barrier over time preventing corrosion; that is why the coin has an almost perfect state of preservation.

METALLOGRAPHIC OBSERVATIONS OF THE 1853 HALF CENT COIN

Figure 3 shows an example of the half cent 1853 Chilean coin as listed in the Standard Catalog of World Coins, also known as the Krause catalogs. The obverse side says “REPUBLICA DE CHILE” with the five-pointed star in relief, and year of minting 1853 between two points. The reverse side says “ECONOMIA ES RIQUEZA” (in English: economy is wealth), and the denomination in words is surrounded by laurels with a four-pointed star on the bottom. Note than in the 1853 coin from the study, the letter Q of “RIQUEZA” has a short outer tilde.

The coin’s microstructure was investigated after etching with an alcoholic solution of 2% ferric chloride

($FeCl_3$). The 1853 coin shows a grain structure typical of hot working and annealed with some visible twin grains, variable grain size, and some porosity seen as dark holes due to corrosion (Fig. 4) There is no evidence of second phase. Some intracrystalline cracks have also occurred due to copper corrosion.

METALLOGRAPHIC OBSERVATIONS OF THE 1851 CENT COIN

Figure 5 shows an example of the one cent 1851 Chilean coin as listed in the Standard Catalog of World Coins. Similar to the 1853 coin, the obverse side says "REPUBLICA DE CHILE" with the five-pointed star in relief, and year of minting 1851 between two smaller stars. The reverse side says "ECONOMIA ES RIQUEZA," the denomination in words is surrounded by laurels united with a double loop. There are variants regarding the shape of the letter Q in the word RIQUEZA (Fig. 6). The first type has the Q tilde outside of the letter (most common) and in the second type the tilde crosses the letter (rare). There is another variant, even rarer still, with the accent similar to that of the letter (Ñ). The 1851 coin from the study is quite worn due to the passage of time, but when looking at the letter Q, it is seen that the tilde crosses toward the inside of the letter[3] (Fig. 7).

Fig. 6 — Three images of 1851 one-cent coins for the morphological comparison of the letter Q.

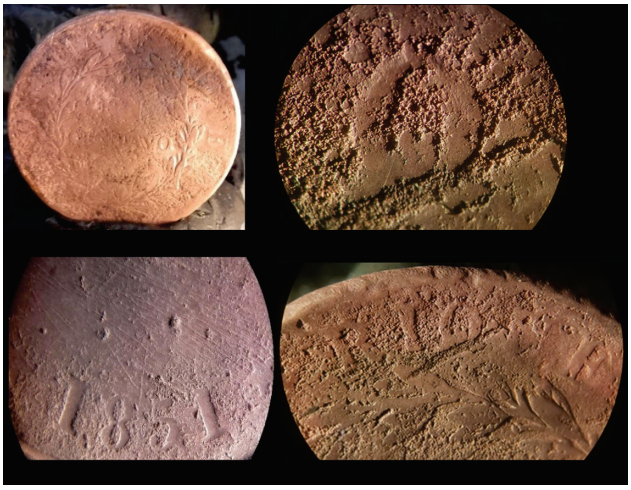

Fig. 7 — Historical coin macroscopy of 1851 one-cent coin.

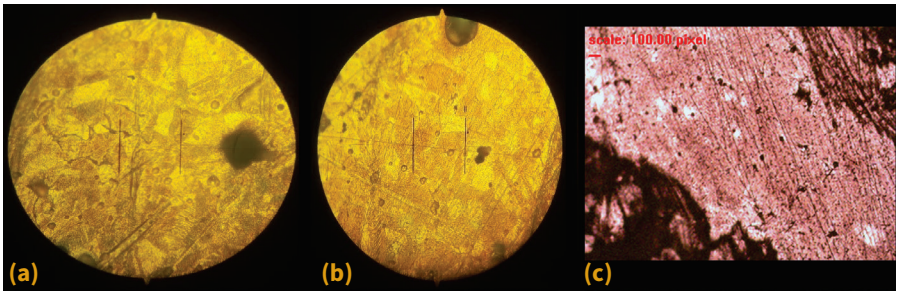

Fig. 8 — Micrograph of the 1851 historical copper coin. Corrosion at the grain edge and detail of slight porosity. Reagent: Alcoholic solution of 2% ferric chloride ($FeCl_3$). Magnification: 400x (a, b) and 100x (c).

For the 1851 coin, the 2% alcoholic ferric chloride solution ($FeCl_3$) was also used as the etching reagent, which shows a structure with a well-formed recrystallized grain matrix with straight twin lines, and very little porosity (Fig 8). There is no evidence of a second phase. X-ray fluorescence analysis of both coins confirms that only minor, trace-type alloy components are involved, with copper being the main component. Chemical composition and metallographic evidence indicate that the alloy is of a single phase and aligns with the aforementioned decree of January 9, 1851, which said coins were to be made of refined copper without mixing any other metal. Table 2 lists hardness values for both coins.

TABLE 2 – COIN VICKERS MICROHARDNESS

	1853 half-cent coin		1851 one-cent coin	
1°	146 HV	138.7 HB	137 HV	130.15 HB
2°	132 HV	125.4 HB	109 HV	103.55 HB
3°	121 HV	115.0 HB	101 HV	95.95 HB
AVERAGE	133 HV	126.36 HB	116 HV	109.88 HB

MINTING PROCESS

According to the manufacturing method used at that time, metal was melted in crucibles in a coal furnace, and poured into prepared rails to form solid ingots. Ingots that did not meet the required thickness were passed between two rollers that pressed the metal strip, stretching it to the desired thickness. When the rail hardened it was necessary to anneal it to relaminate it. If the rail was too long, it was cut into smaller pieces.

After the rails were a thickness equal to the blanks, they were annealed to make them more workable. To protect against oxidation from annealing, the rails were put in ovens in sealed boxes.

Automated machines were used to drill the rail and obtain the blanks. These machines were manually fed, and the operator had to move the metal strip forward to the rhythm of the machine. The cut blanks then went through the press, creating a pre-listel, a rim or raised border, which, among other things, helped protect the engraved pattern. The press was formed

by a conduit through which the flange passed while the coin was pressed in its edge, raising it and creating its pre-listel and eliminating the burrs left by the cut of the coin. Afterward, the coin was annealed to soften it, eliminating internal tensions. The annealing of the blanks was followed by washing to eliminate any rust formed during annealing. They were washed first in a chemical solution and then with a bath of soap and water that left its surface shiny. The coins were dried initially on trays with hot sawdust, and years later in drying machines[4].

SUMMARY

Chile in the 1850s, as a growing nation, adopted emblems and symbols in line with new concepts of freedom, union, force, and independence. One way the country demonstrated these new images was in its currency, with a law passed in 1851 directing the minting of copper coins.

Two Chilean copper coins from this time period were studied. Knowing these coins were virtually pure copper, electrolytic cleaning using sodium hydroxide was used to clean them, though it is not recommended for copper alloys and silver alloys. All the products of corrosion (greenish layer of malachite) were separated in around 60 minutes. The entire surface could be seen and studied in detail. In addition, the good state of preservation of these ancient coins was verified. Coin-collector catalogs verified that the currencies are legitimate and confirmed where and how the coins were minted. **~AM&P**

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References

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3. Images used for comparison: First type: courtesy of Classical Numismatic Group St. James's Auctions LLC and Second type: courtesy of Heritage Auctions (www.ha.com).

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HEATON'S MINT

An interesting part of this study was the research done into the history of where and how the coins were made. Because they were minted in England, news stories and other documentation are available to tell a fuller story.

Ralph Heaton II (1794–1862) was the son of Ralph Heaton I, an engineer, inventor, and businessman in England. Ralph Heaton II was a die sinker operating independently of his father. In December 1817 Ralph I conveyed to his son land and buildings to enable him to develop a separate company. Ralph II engaged in brass founding, stamping, and piercing. Brass chandeliers were made for the newly invented gas lighting and he patented a "bats wing" burner.

At an auction In April 1850, Ralph Heaton II bought four steam screw presses and six plate presses for making blanks from metal strapping from the defunct Soho Mint, created by Matthew Boulton around 1788.

A newspaper of the time also reported that the complete set of presses, pneumatic pumps, and other machinery for minting, were acquired by Ralph Heaton and Son, with the intention to take over Soho's contracts. Unlike the government-owned Royal Mint, Heaton was able to get permission to produce coins for foreign powers. In 1851 Heaton and Son began producing currency for other nations including Chile, as well as minting coins outsourced by the Royal Mint.