Western Precious Metal Ingots
The Good, the Bad and the Ugly

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Introduction

Much controversy has been focused in recent years on historical ingots, purported to be products of western United States commercial, banking, assaying and mining businesses. Advanced numismatic collectors have collectively paid tens of millions of dollars for these ingots, particularly those from the *SS Central America* (*SSCA*) wreck. Precious metal ingots are important to numismatists because they are an integral part of the coining process of making money from ore. Some authors have reported that they are *all* fake without presenting proper evidence to support such an all-encompassing position. Others report that some (or most) pieces are genuine, often without offering proper evidence other than the fact that the assayer or commercial name punched or stamped on the ingot can be shown to have been a real person or company. Certain of these types of ingots have found their way into important institutional collections via the numismatic trade, such as the Josiah K. Lilly Collection as part of the Smithsonian's National Numismatic Collection, and others via the mining industry such as the gold first pour ingot from the famous Portland Mine at Cripple Creek in the Stratton Collection at the Pioneer Museum in Colorado Springs and a host of others.

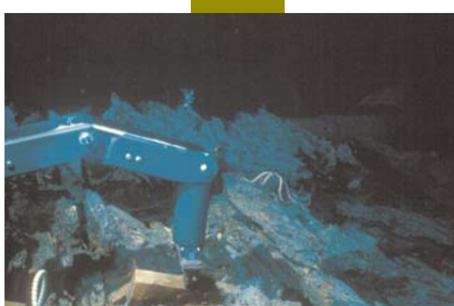
Fig. 1


Fig. 2

Additionally, numerous spurious ingots have appeared in the numismatic market and on eBay for sale in recent years causing yet another level of much needed and very serious debate regarding authenticity. Two papers regarding precious metal ingots were published in *Coin World* recently, one discussing ingot manufacture methodology and the other discussing several authentic ingots in the Smithsonian collection.[2]

Fortunately, new findings are providing standards with which to evaluate authenticity. Over the past fifteen years more than 1500 historical ingots have been recovered from the ocean floor allowing study and comparison to precious metal ingots made in the twentieth century. Methods used today have been passed down for centuries, as has the methodology for fire assaying used to determine precious metal purity and subsequent value. The discovery and recovery of the *S.S. Central America* provided the most important standard for study to date of precious metal ingots. Among the thousands of pieces of gold recovered were 532 unquestionably genuine gold ingots from five prominent California assay firms produce during 1857, the year the ship sank. The companies that produced these ingots were in the business of buying


Fig. 3


Fig. 4

1 Fred Holabird has managed two open pit mines in Nevada and had an extensive 25 plus year career in the mining business. David Fitch managed exploration for Rancher's Exploration and Hecla Mining Co. over his thirty plus year career. Both Holabird and Fitch live and work in Nevada. Robert D. Evans was the chief scientist for the *SS Central America* project. , , . Web sites: www.holabird.org, www.igeologist.com
2 "Original Sources: Mining Industry Offers Wealth of Information on Assay Ingots" by Fred N. Holabird, July 12, 1999 and "Disputed Smithsonian Bars Genuine" by Fred N. Holabird, September 24, 2001,. The title of the latter is a product of *Coin World's* editorial staff.

gold dust and ingots from mines, miners, and commercial entities, often performing the first analysis of the purity of the native gold mined in the region. With each melt from each customer, the measured gold purity established the dollar value of the gold and silver in the ingots, allowing the customer to be paid in coin or by taking possession of the ingot itself after taking a fee for the assaying and melting process.

It is fortunate for those interested in the authenticity of historical ingots that these ingots or bars, sealed for over 130 years in a deep-ocean time capsule, can now provide a partial standard against which to judge other historical ingots, primarily those of the California gold rush period, but for other western mining periods as well, since little has changed in the methods of pouring ingots in the past 150 years. The *SSCA* ingots are pieces of an important United States treasure, but they can also be viewed as documents. They show a consistent style of presentation of information, from which we have derived certain benchmarks for testing the authenticity of other ingots. These characteristics are supported in their entirety by the written and photographic historical record.

Over the past ten years new methods of analysis have been devised which allow a closer and detailed inspection of these authentic ingots. Using a thorough understanding of the manufacturing methods of the period combined with an understanding of the metallurgical process and microscopic study of the ingots, certain techniques are now available to unequivocally document these pieces. These techniques combine analytical methods with the written historical record. Until recently, no clear standards existed to test authenticity of historical precious metal ingots. There is no simple black box equation or solution for the determination of authenticity of precious metal ingots. Inspection of the evidentiary trail leading to an authenticity opinion is a complicated process involving modern advanced scientific study in conjunction with a thorough knowledge of the written and photographic historical record.

Other areas of antiquities are constantly coming under scrutiny by the scientific community. In a current article in the *American Scientist*, the authors discuss the increase in the production and quality of forgeries:

> *As collectors and scholars learn to recognize the fakes, the forgers create new improved versions. In this way, generations of fakes have developed as one side learns of the other's methods. Ironically, the scholars who try to identify fakes contribute to the increased quality of the next generation.*[3]

This is a problem we hope to avoid. Modern forgers should be aware that more evidence regarding the fraudulent manufacturing of precious metal ingots is available than that published in this paper.

The Reasons Ingots Were Made

In evaluating any gold or silver ingot it is important to consider the reasons why they were made. In the 19th Century, precious metal ingots were produced in the western United States for a number of reasons. The first of these is obvious, and gives the ingots their standing as numismatic collectibles.

Fig. 5

1. Medium of Specie Exchange between Mines, Commercial Assay Houses, Commercial Enterprises, Banks, U.S. Assay Offices, and U.S. Mints. The ingots from the *S.S. Central America* treasure are prime exam-

3 Pickering, Robert, and Ephraim Cuevas; "The Ancient Ceramics of West Mexico," in *American Scientist*, May-June, 2003 published by the Scientific Research Society, p249 ples of ingots made for specie exchange between commercial enterprises, commercial assay offices, U. S. Assay Offices and U. S. Mints.

Fig. 6

2. Presentation ingots were made for commemorating an event such as a first mill product or pour, or honoring an individual such as a mine superintendent or financier.

Fig. 7

3. Exhibition ingots. These were made for major mining exhibitions such as the Paris 1867 Exhibition or the Denver Mining Expositions of the 1880-1900 period. Many were also made for World's Fairs and other public exhibitions that were not necessarily mining specific.

Fig. 8

4. Industrial ingots were made for private trade, particularly jewelry and dentistry by the U. S. Mints and/or U. S. Assay Offices. They are generally 900 fine and are shown regularly in the annual Report of the Director of the Mint. In specific cases, large bars were traded for small bars less charges: "Large gold bars exchanged for gold coin, and redeposited for small bars, less charges and fractions paid in gold coin."[4] This proves the existence of small bars issued by the U. S. Assay Office.

Benchmark Attributes of Most Authentic Historical Precious Metal Ingots

All 532 ingots from the *S.S. Central America* treasure share certain characteristics, and they present a consistency of style. The paper trail of these and similar ingots is known as the written historical record. This record is composed of original historical documents of the period and closely parallels the physical attributes found on the *SSCA* gold ingots and other authentic precious metal ingots that were made as and for a medium of specie exchange. These methods of marking ingots were the standard of trade in the bullion industry. We have not seen *one single exception* to these accepted standards in the examination of approximately ten thousand original bullion receipts made for mining companies, regional assayers, U. S. Assay Offices and U. S. Mints.[5] Indeed, the United States Mint regularly discussed the acceptable format of receiving ingots in both Reports to the Director of the Mint and in advertisements of fees associated with acceptance of ingots at the Mint.

Exceptions to the above standards exist in physical form on the ingots themselves only in very rare instances. Genuine ingots do exist, for one reason or another, where certain characteristics are not present. For each such exception the examiner must carefully consider the reasons for the variance. Examples have been found in the *SSCA* treasure.

4 *Report of the Director of the Mint Upon the Production of the Precious Metals in the United States for the Calendar Year 1887* by James P. Kimball, page 47 under the classification "Value and Composition of Bars for Industrial Use, Issued at the United States Assay Office at New York, During the Calendar Year 1887." The term industrial ingot seems to have changed definition with the U. S. Mint system through time. At one point it included ingots from jewelers of uncertain purity.

5 This number is not an idle speculation. The following manuscript collections are representative of the many collections viewed: Savage Mining Co., about 400 pieces; Con Virginia and California MC, about 500 pcs; Hale & Norcross MC, about 1000 pcs; Sutro Tunnel Co., about 500 pcs.; Yellow Aster MC, about 500 pcs.; various Bodie Mines, about 100 pcs; various California Mother Lode region mines, about 1500 pieces; Bullion, Exchange Bank, Carson City archive, containing more than 5,000 bullion receipts from western mines; Van Wyck Assayer archive, about 250 pieces; Weigand archive, about 100 pcs; Kellogg & Humbert later Hewston archive, about 150 pieces; Manhattan Silver MC archive, about 500 pcs; and numerous mine and assayer ledgers and journals in institutional collections. Most of the previous specific citations are privately held, though parts of these archives may now be institutionally held. The majority relate dire3ctly to Comstock (Virginia City, Nevada), California, and Montana mines.

The standard bullion marking attributes reveal the following benchmarks for genuine historical ingots:

Fig. 9 Ophir Mine bullion punch

1. The Assay House's name punched or stamped as a standard logotype or "gang" stamp. These are mostly single bullion punches.

2. An ingot or serial number. This number will directly correspond to the identical number on an original assay receipt for each specific ingot.

Fig. 10

Fig. 11

3. Weight is expressed in hundredths of a Troy ounce and punched thus using single digit bullion punches. The notation of Troy ounces is often abbreviated and made with a single gang punch. The abbreviation varies from assayer to assayer. Examples include *OZ*, *Oz*, and *Oz* or with two small dots under the *z*.

Fig. 12

4. Purity is expressed in fineness measured in thousandths. These three digits are individually punched using single digit bullion punches. The word "fine" is usually a single gang punch of varying size and style specific to each assayer.

5. The dollar value of the gold is punched, calculated at $20.67 per ounce.

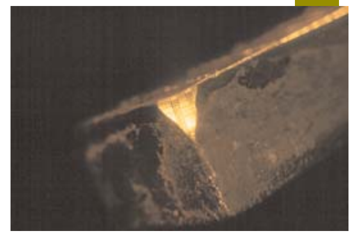

Fig. 13

6. Two assay chips are cut from diametrically opposite corners of the bars after pouring to determine the fineness. On certain small ingots only a single chip may have been taken.

Presentation ingots, Exhibition ingots and Industrial ingots are best studied and compared to those found in the written and photographic record. Some of these ingots still exist today. Many are found in relatively obscure museums, particularly those located at or near mining centers where the original ingots were produced. These include the William Sharon silver dinner plate ingots and the first mill product of the Portland Mine at Cripple Creek. Each of the latter have solid accounts from the written historical record of the period. Other forms of first mill product pieces have been known to numismatic collectors for years, including the 1867 Pahranagat, Nevada silver coin made by the F. Prentice Mining Co. in New York.

No central cataloguing effort has ever been made of historical ingots in American and European museums as a whole. Mining researchers have known of at least 50 pieces in American museums. The only cataloguing effort we are aware of was done by the World Gold Council who inventoried more than 500 different gold ingots from around the world dating from circa 1920 to 1998. The work centers around the Council's museum in Singapore. This type of effort should be undertaken in America, but currently lacks a funding mechanism.[6]

Methods of Manufacture

The knowledge of the methodology of manufacture of the western assay house ingot is necessary

6 Desebrock, Nigel; *The Industry Catalogue of Gold Bars Worldwide*; 1998; 344pp. Another similar effort was made in 1980:*The Gold Ingot Mark Book; Gold Refiners of the World and their Identifying Ingot Marks*; The Gold Institute, Washington D. C.; unpaginated, about 50pp.

in understanding the scope of investigation of false ingots. The manufacture of these ingots generally falls into one of four categories: A) melting of gold dust or nuggets by a regional assayer, B) milling of ores at hard rock mines and pouring dore ingots. (Dore [pronounced door-AY] is a term meaning that the ingots are produced directly from the extraction of gold and silver out of their ores.[7]) C) Regional assayers will sell or resubmit their ingots to a U.S. Assay Office or U. S. Mint for remelting and payment, and D) a commercial enterprise, such as a large mine, will skip the local assayer and sell ingots directly to the U. S. Assay Office or U. S. Mint. In each of these cases the ingots will conform to the standard industry practice of marking their ingots in the fashion discussed earlier with ingot number, assayer's punch, weight in Troy ounces, fineness and dollar value. This custom continues to this day. It also allows for proper internal tracking and a solid chain of custody.

Modern methods of ingot manufacture are nearly identical to those of a century or more past. The best reference work on modern bars is the World Gold Council's *Industry Catalogue of Gold Bars Worldwide*, 1998, by Nigel Desebrock.

The Dust Trade

Many dealers in gold dust during the 1850's to early 1860's in both California and Colorado were completely unfamiliar with the formal gold trade. Merchants found that it could be profitable to purchase gold dust from prospectors or other merchants at a discount in exchange for much-needed United States gold and silver coin. They were operating *completely outside of the known and accepted gold bullion business*. When the California gold rush exploded in 1848, merchants brought with them their own customs of dealing in gold. The most common business was the jewelry business, related through the use of precious metals. Jewelers brought with them their customs of weighing metals that eventually developed into the gold dust business in California.

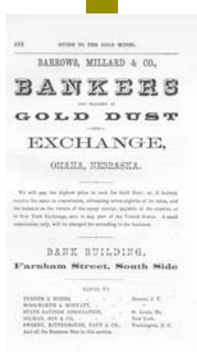
BARROWS, MILLARD & CO.,
BANKERS
GOLD DUST
EXCHANGE,
OMAHA, NEBRASKA.
BANK BUILDING,
Farnham Street, South Side

Fig. 14

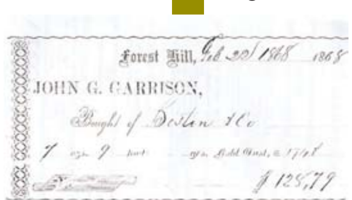

Fig. 15

For about a decade these merchants and gold dust dealers sometimes used another custom when recording gold purchases. Though not acceptable in the large-scale, commercial bullion trade, dust dealers sometimes dealt with prospectors using Troy ounces and pennyweights, a custom passed down from the British. A pennyweight is one-twentieth of an ounce, and used the notation of "DWT" on gold dust purchase receipts. Accepted standards in the bullion trade used only hundredths and/or thousandths of an ounce.[8]

This form of reporting dust weight is inconsistent with the bullion trade and was eventually abandoned. It grew from a lack of understanding about the commercial gold trade, generally used by merchants whose primary business was well outside the gold bullion business. Using the pennyweight system was not acceptable or used by the U. S. Mint, and was the source of much discussion in pre-California Gold Rush *Reports to the Director of the Mint*, particularly in the 1830's and again at the onset of the California Gold Rush, circa 1848-1852.

The possibility exists that one or more of these merchants who were initially operating outside of the gold trade made some crude gold bullion or ingots. Colorado prospector, miner and doctor John Parsons may have been an example. John L. Moffat, a California '49er, was another. This will be discussed at length below.

Unconformity in Ingot Styles

Over the past twenty plus years in the mining business and in serious study of gold rush gold and banking systems, it has become apparent that there is an unconformity in what is known of historical ingots. Some ingots use apparent archaic

7 Dore bars may also be used to study the ratios of gold to silver in the original ores, as well as trace metals.
8 Classic gold dust scales made by Howard & Davis used by Wells, Fargo & Co. and other bankers can be seen at the Wells Fargo Bank History Room in San Francisco and at the Mackay School of Mines Keck Museum in Reno, Nevada on the University of Nevada, Reno campus. These scales postdate 1852 and predate 1858.

weights and measures systems that do not conform to standard practice in the bullion industry. Ingots bearing these attributes become immediately suspect to those of us in the mining industry who recognize a set of standards that are, in some forms, centuries old.

This unconformity in some of the very early California and Colorado ingots involves the use of unusual terms that are also found in parts of the historical record such as early California newspapers. The terminology is *not* found in technical works of the period. Some of these ingots still exist today. Specifically, these are ingots that are punched in a manner not conforming to industry standards set within the bullion, banking, or mining industry. Ingots such as Moffat & Co. of California have strong historical records dating back to news articles in 1849-1851 California newspapers as well as such early numismatic works as Edgar Adams' *Private Gold Coinage*, published in 1913. Some of the traits present on these ingots have confounded professionals for decades, and the problems have never been publicly addressed. Indeed, the attributes of the Moffat ingots are so far afield of standard practice within the bullion industry that it seemed implausible they could be authentic. However, it was in just that statement that the answer was found, hiding behind a transparent screen of historical obfuscation:

> *The answer to the question about the use of strange weighing systems and purity stamped on early California gold rush bars is simple. The unconformity was caused and created by nonconformists.*

The nonconformists were the first opportunists to recognize the need for a gold dust trade, and with it a bullion trade leading to sales of precious metals to the Mint or U. S. Assay Office, though it was not yet developed in California in 1849. These nonconformists were probably all friends of sorts. They certainly must have known each other. All came from the same city. The trades that they came from were all closely related, but were not associated, either directly or indirectly, with the mining, bullion or banking business. They were astute enough to get to California early in the gold rush, recognize a critical business need, be close enough to the trade to start up their businesses, and finally they were able to recognize their shortcomings and hire professional assayers, or become assayers themselves. None had U. S. Mint training. They are household names to numismatic historians and students of private California gold coinage. Hailing from the city of New York were: John L. Moffat, silversmith; Frederick D. Kohler, jeweler; Augustus Humbert, jeweler and watch case maker. Directories of New York from the 1832-1847 period clearly show the nature of their businesses.[9]

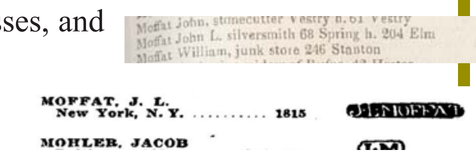

Fig. 16 Moffat hallmark and directory listing

The pattern that developed is very clear. These men practiced in fields other than mining and bullion. As such they were *outside* of the standard practice of the mining industry. Banks, small miners and merchants who regularly used gold dust as a form of money, developed and used their own standards that involved the use of the pennyweight.
They brought to the new California gold bullion business sets of weights and measures that were specific to their trades, i.e. *jeweler's standards*. Others, such as Dr. John Parsons in Colorado, may have brought druggist or medical weighing systems as well. The use of terms such as carats and pennyweights caused significant confusion within the bullion industry, which was accustomed to the use of terms such as fineness expressed in thousandths and weights expressed in Troy ounces. The new breed of gold dealers using many different sets of weights and measures caused the Director of the U. S. Mint James Snowden in 1852 to publicly announce the problem

9 Longworth's *American Almanac, New York Register and City Directory*, 1832; pp379, 415, 489. Moffat's status as a silver smith is well known among American silver collectors. His personal hallmark, J. L. Moffat, is found on silver pieces dating from about 1815 to about 1845. It is possible that a son, Charles, took over the business. See Seymour Wyler's *Book of Old Silver*, New York, 1937, p349. Moffat was gone from New York by 1842, having left for the Georgia gold fields, according to Adams. [*New York Directory for 1842-3*, Doggett Jr.]

and insist on a resolution.[10] Moffat appears to be one of the first to acknowledge the problems and switch systems, as his own bullion receipts from 1850 testify, noting a deposit in Troy ounces and fineness in thousandths, as evidenced by a single surviving bullion receipt in a private collection today.[11] It would take only a few years for California gold merchants to begin using the same system of weights and measures once forced to do so by the U. S. Mint and U. S. Assay Office about 1852. The U. S. Mint system deemed non-standard sets of weights and measures unacceptable, forcing private assay firms to conform to bullion industry standards.

Weighing and Purity Systems

Understanding weighing and purity systems is an integral part of understanding the methodology used in marking both historical and modern ingots.

When dealing with weights and measures, it is not enough to discuss them in modern terms. Sometimes meanings can change significantly through time. To look at the usage of these terms that are sometimes found on faux ingots, we must turn to scientific literature of the reputed faux ingots' period. In this case, 1850-1880.

The use of these systems stems from long time Mint Director Robert Paskell Patterson, M. D., Director of the U. S. Mint from 1835 to 1851. Patterson was credited with "revolutionizing" the American coining process because of steam engines, and adopted the weighing and fineness systems of the French Mint.[12]

The *Carat*

The carat, or carate, is derived from an ancient weighing system involving beans of the species *erythina* of the Kuara tree, a relatively uniform-sized bean from parts of the Shangallas district of Africa, as Andrew Ure reported in his *Dictionary of Arts, Manufactures, and Mines; Containing Exposition of their Principals and Practice,* published in 1853.[13] The discovery and first use of gold is discussed by famous historical works, from the work of Pliny with his first written record of mining c50 A.D., to mining engineer T. A. Rickard in his *History of American Mining* treatise[14], these men cite the Pactolus River in Asia Minor as the first gold bearing site mined by humans.[15] Here, gold dust was traded regularly, and a weighing system was soon developed.

> *…The dry seeds of this pod are always of nearly uniform weight, the savages have used them from time immemorial to weigh gold… The beans were transported to India, at an ancient period, and have been long employed there for weighing diamonds… The carat of the civilized world is, in fact, an imaginary weight, consisting of four nominal grains, a little lighter than four grains Troy…* [16]

Carat as a weight was thus transferred to the weighing of diamonds and gems, used to this day. Carat with respect to *gold* moved away from weight and took on a new meaning in the definition of purity with respect to fineness (purity.)[17] It is in such a manner that many of the early or ancient historical

10 Snowden took over as Mint Director technically on June 3, 1853. His appointment followed that of Thomas Pettit in April of that year who died suddenly. Pettit's predecessor George Eckert, M. D. left the job after his appointment on July 1, 1851 in less than two years. It is fair to state that the Director's position was in a bit of turmoil at the time Snowden took over. (George Evans, *The History of the United States Mint and American Coinage*; 1885, p103.) It is interesting to note that the 1850's Reports of the Director of the Mint were often very short and void of detail. Some of this was probably a result of the rapidly changing directors. During this period, it is sometimes necessary to consult other works to obtain the Mint data, particularly technical journals such as *Mining Magazine* edited by William Tenney, New York, beginning with Volume 1, July to December 1853, pp620-621 etc.

11 The Moffat bullion receipt was in the Henry Clifford Sale. It is in the hands of a California collector today who graciously shared his collection with me in 2002-fh.

12 Evans; *History of the United States Mint*, 1885, p102.

13 Ure's massive two volume text and supplement is arguably the most respected scientific reference of the period.

14 McHraw-Hill, 1932, New York and London

15 Several references refer to the Pactolus as in Egypt. *Encyclopedia Britannica*, 1964, states that it was in Asia Minor.

16 Ure, p578

17 A curious spelling variant is thought to appear at this time in change of definition, *karat*. More research is needed here.

ingots are marked. Indeed, ingots from Spain, England, and Rome are marked with their fineness in terms of carats punched in Roman numerals on the ingots dating from historical times to at least 1750 A.D. Some of these ingots can be seen in the British Museum, Royal Bank Museum, and the Smithsonian today. The only early discussion easily locatable with regard to *carat* in an 1854 United States *Report to the Director of the Mint* discussion of bullion or coins was for fineness "…gold coins from Portugal or Brazil, not less than 22 carats, 916 2/3 thousandths…"[18] The terminology was *only* used in conjunction with foreign coins, and at no time for American coinage or ingots. These fractions in fineness as well as carat notations would be dropped completely within just a few years. They were, in fact, officially dropped by Congressional law and the US Mint in 1852 or earlier.[19] Please note that at no time was the term carat used for weighing purposes – only for fineness, and that was generally pre-California gold rush, generally gone domestically by 1852, and gone almost completely by 1855. In the gold dust trade the term was also rarely used. Assayers measured fineness in thousandths (three decimal places). Among the last references to carat in this sense was in an article on assaying in the *Mining and Scientific Press* July 20, 1861.[20] Curiously, this same mention came in an issue where the United States Mint discussed Mint Rules, Charges and Operations. All weights were to be in Troy ounces and fineness expressed in thousandths.[21] Another brief mention of the carat was made by Phillips in the *Mining and Metallurgy of Gold and Silver*, 1867.[22] As a London mining engineer, Phillips was unfamiliar with the American gold trade.

Later authors greatly discussed the problems associated with the use of the term carat and the inconsistencies in the use of this "unit" of measure. The problems were well exposed by the time of the International Congress of Weights and Measures held in Chicago in 1893 in conjunction with the Columbian Exposition. Even though U. S. Mint Director Snowden had manifested changes in the use of the term as early as 1852-3, specifically in the use of precious metals, not all trades using the term understood the need for change and uniformity of use. By 1914, Geologist and gemologist George Fred Kunz published a paper redefining the carat as an international standard of measurement. Kunz's comments appropriately address the misuse of the term:

> *The manifold inconveniences resulting from the absence of a uniform standard of mass for determining the weight of precious stones have long been obvious. This lack has been keenly felt in commercial transactions, and those who have devoted time and research to the study…have had frequent occasion to deplore the absence of such a standard in the past.*[23]

Pennyweights

Discussion of weights used in actual weighing of the precious metals are also discussed in Ure and elsewhere. Consistently, historic scientific authors discuss weighing samples in milligrams, grams, grains, or Troy ounces, often using a conversion to Troy by simple calculation, including decimals to the thousandth place. Nowhere did we find a mixing of weighing methods such as carats (as used for diamonds, not gold), pennyweights (DWT's) and permutations followed by fractional amounts. Other authors discussed this article as well, including J. S. Phillips in the *Explorer's and Assayer's Companion*, San

18 Snowden, 1854

19 Snowden, J.; *Report of the Director of the Mint*, 1854 p6, and 1855, p30

20 Volume 3, No. 17, p2, column 2.

21 The U. S. Mint Rules were also subsequently published in the *Mining and Scientific Press* again on 8/31/1861 and 9/7/1861, both on page 2, column 2, as well as many succeeding weeks.

22 Published in London generally for the British market.

23 Kunz, G. F.; "The New International Diamond Carat of 200 Milligrams"; in T*he Mineral Industry, Its Statistics, Technology, and Trade During 1913*; Edited by G. Roush, Volume XXII, p892. The quote applies to the unit of measure, whether used for gold historically or gems. U.S. Mint Director Snowden was the first to address this problem, which persisted for another 50-60 years in the jewelry trade.

Francisco, 1879[24], in which he discusses weights used for weighing purposes in assaying as being in grains, which were in units of ten, allowing "advantages for calculations by every necessary decimal division."[25] Tables were printed for the calculation of the value of ingots based on weight in Troy ounces and specific fineness, since the value of gold was fixed at $20.67. These guides routinely tell the assayer to report "Assays for thousandths fine from any decimal weights."[26] They used a conversion factor of 480 grains per Troy ounce. We see no record of assayers using a pennyweight system of 20 pennyweights per ounce and 24 grains per pennyweight. This was considered the *English grain weight* system, not the *American* weight system, as described by Bruno Kerl in *The Assayer's Manual*, Philadelphia, 1889[27], and others. A pennyweight "is so-called because such was the weight of a silver penny in the reign of Edward I *(1239-1307);* when the *P* was first adopted; abbreviated thus dwt."[28] Guido Kustel, one of the most accomplished metallurgical engineers of the gold rush and Comstock era, wrote a book in 1863 regarding processing of gold and silver ores and bullion. An essential tool, he said, was "a fine assay balance…the weights are Troy ounces."[29] Another prominent mining engineer, William Ralston Balch and others agreed.[30]

The Director of the Mint in 1854 was aware of the problems associated with multiple weight systems in the world and their possible use domestically:

> *The Mint has done as much as it can (and in this step it has been followed by the Bank and Mint of England) in repudiating pennyweights and grains in the mode of weighing and keeping accounts, using only the Troy ounce and its decimal fractions. The sanction of law had previously been obtained for doing away with carats and carat-grains, in the expression of fineness of gold, and of equally cumberous notation for the fineness of silver, substituting the simple millesimal form introduced by the French assayers, and becoming general in Europe.*[31]

The Mint Director's comments appear to be aimed at early California Gold Rush gold dealers such as John L. Moffat, whose small gold ingots were noted as early as 1849 by Adams in *Private Gold Coinage*.[32] Moffat had worked outside of the regular group of precious metal producers and Mint employees. He came to California in 1849 from New York, where he was reportedly in the gold dust "refining, assaying and metallurgical business."[33] More likely, he was a banker and gold dust dealer, as suggested by Bancroft,[34] after having had a business for at least fifteen years as a silversmith.

More than a dozen authors of period or important publications on assaying concur with the concept that the use of carats and pennyweights was archaic and non-standard practice. We found none that did

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24 It could not be easily ascertained whether John A. Phillips and John S. Phillips were one in the same man. This is not a typographical error by the current authors.
25 Phillips, p299
26 Phillips p348
27 Second American Edition, p70.
28 *The American Dictionary of Commerce, Manufactures, Commercial Law, and Finance*; L. De Colange; 1881; v2, p877
29 *Nevada and California Processes of Silver and Gold Extraction*; F. Carlton, publisher, San Francisco, p48
30 Balch; *The Mines, Miners, Mining Interests of the United States*, Philadelphia, 1882, p754
31 1854, p6
32 Adams, *Private Gold Coinage*, 1913, p15
33 Adams, *Private Gold Coinage*, 1913, p14.
34 Bancroft, *History of California*, 1883, V6, pp 183, 416, 629, 668. Moffat was a silversmith in New York City in 1833, according to Longworth's *American Almanac*, v57, 1832-1833, p489. Kohler and the A. Humbert family were also listed as a jeweler in New York that same year at 32 Elizabeth and 224 William, respectively, p415, p379. Moffat was not listed in the 1831 *American Advertising Directory* in New York. Only one silver manufacturer was listed that year, John Kurtz at 110 Fulton Street.

not.[35] The Mint Director was also referring to comments made in the California press regarding the problems of multiple weighing systems in the California gold fields. In one issue of the 1848 *Californian*, "Buckelew delivers an essay on the difference of weights by which gold and grosser substances are weighed, and offers to adjust scales and weights to the Troy standard."[36] This well illustrates the problem that Moffat and other men had when entering the gold bullion business with only a jeweler's experience.

Ingot Analysis

Precious metal ingots are made for several reasons as previously mentioned. Those made for the mining industry are called dore, a French term meaning gold and silver combined. These are made from the processing of ores from certain ore deposits. They contain the gold and silver in the ingot in the same approximate proportions as the original ore. Most skilled assayers and metallurgists remove the impurities (such as copper and iron) during the melting process, using various chemicals (flux), particularly borax. If the amounts of other metals are significant and potentially economic, certain milling procedures might be instituted to recover a maximum amount of metal. The oxide portions of gold and silver deposits are often relatively free of large amounts of other metals.[37]

Ingots produced from placer gold are also a form of dore. They contain gold and silver as originally found in the lode deposit of their origin, as well as trace metals specific to each ore deposit. No lode or placer gold deposit has ever been found to contain 999 fine gold.[38] Some of the highest purity gold was found on the *SS Central America*, with a single ingot which Henry Hensch assayed at 973 fine. This high a purity of gold in placer or lode gold deposits is extremely rare in nature.

Refining gold is a detailed, careful process that separates the gold, silver, and trace metals. It was not done commercially on the west Coast until the establishment of private refineries generally after 1860, and that refined metal was sold directly to the

35 *The Assayer's Guide; or the Practical Directions to Assayers, Miners, and smelters*… by Oscar Lieber, Philadelphia, 1852 discusses the scales and weights necessary for the assayer: "…with an elegant mahogany box, containing weights of platinum down to one-tenth of a milligramme…" Pierre de Peyster Ricketts, one of the top chemists of his day, followed suit: "The weights employed by the assayer are- …b.) Troy for gold, silver, etc. c.) the French system based upon the gramme as a unit. These weights can be used for weighing ores, fluxes and results; and will always be found convenient, as they are on the scale of ten. d.) the assay weights, which is a system made up from a comparison of the three foregoing…" [*Notes on Assaying and Assay Schemes*, New York, 1876, p20] In another example of the confusion of terminology and non-standard weighing systems, other references used the gram for precious metals: Later standard references continue the trend of weighing in grams: "A good assay balance, used carefully and intelligently is capable of weighing to 0.01 milligram…" [p71, Ed Bugbee, *A Textbook of Fire Assaying*, New York, 1922. Bugbee was asst. Professor of Mining Engineering and Metallurgy at M. I. T. at the time] Other authors concur on the subject of weights, particularly the highly respected work by E. Smith (1913 and 1947) in *The Sampling and Assaying of the Precious Metals*..., still in print and used today. Smith was the son of the founder of the Royal School of Mines in Britain. T. K. Rose in *The Metallurgy of Gold* (various editions c1905-1937) also discusses these issues in fair detail.

Some of the more primitive assayer's guides published before and at the time of the beginning of the California gold rush (c1840-1851) provide instructions with weights in grains instead of grams. Many of these do not discuss the importance of proper weighing or the calculations necessary for the end result. These are often not too accurate and leave out critical steps, which the beginning assayer would have found disastrous. Fred Overman's *Practical Mineralogy, Assaying and Mining*…Philadelphia, 1851 is one such book, and was likely carried by would-be miners headed west to find their fortune.

The earliest American reference I found quickly was the 1831 (revised fourth edition, 1852) *Encyclopedia Americana; A Popular Dictionary of Arts, Sciences, Literature, etc*… edited by Francis Lieber, in 15 volumes. "1 Troy ounce = 480 grains = 20 pennyweight. These are the denominations of Troy weight when used for weighing gold, silver, precious stones, except diamonds." "The carat, used for weighing diamonds…the term, however, when used to express the fineness of gold, has a relative meaning only." [Vol.V, p549, Vol. XIII p110, 111] Clearly this 1831 reference was prior to the Federally mandated changes in National weights and measures referred to by Snowden in his *Report of the Director of the Mint*, probably made before 1850.

36 Kemble, E. C., *A History of California Newspapers, 1846-1858*, 1962, p83

37 Discussing specific ore depositional environments is beyond the scope of this paper and interested readers should refer to their local university geology departments or various state bureaus of mines and geology.

38 999 Fine is a number representative of 0.999. The two are interchangeable, but could be slightly confusing to those not used to this nomenclature.

U. S. Mint.[39] Internal refined gold and silver by the Mint was retained or shipped to New York or Philadelphia Mint facilities as can be best ascertained from the Reports of the Director of the Mint.

Historical Assaying of Gold and Silver

Historical, centuries-old methods of assaying gold and silver are basically no different than similar methodologies used today. The fire assay was the universally accepted method of analysis. There is little difference in modern methodology, but the equipment used to get the end result is much improved. Perhaps the most advanced components are the furnaces. Furnaces of the 1850's were coal fired, while those of today are either gas-fired or electric furnaces. Equipment varied in melting rooms depending upon the specific needs and requirements of each company.

Accuracy has improved greatly over the years. Sloppy assayers using the measurement of carat as purity were sometimes accurate only to 1 or 2 decimal places. Some assayers used the *touchstone* as a measurement of purity, an archaic method matching specific colors on a streak plate known as a *touchstone*.[40] This may be the source of some of the odd measurements of carats using fractions, such as California gold rush assayer Fred Kohler stating a purity of 20 15/16 carats on an ingot.[41]
Measurements using a touchstone are based on the users ability to interpret and compare colors on a streak plate. The method was commonly used by goldsmiths before and at the onset of the California gold rush.[42] These measurements are not a quantitative analysis remotely comparable to the fire assay and have inherent inaccuracy unacceptable to the bullion industry. Regardless, measurements in carats and fractions thereof led to great inaccuracies that would result in large scale errors if used on bullion shipments. For example, gold settlements today are done by a proofing process involving multiple fire assays accurate to four significant figures, measured in thousandths, known as a *fire assay bullion analysis*. As an example, a touchstone "measurement" might show a "purity" only accurate to plus or minus 7.5%, a completely unacceptable number for settlement. For example, if your shipment was 10,000 ounces of gold, this represents a discrepancy of 750 ounces. Today that equates to $281,250 at $375 per Troy ounce gold. Using this illustration, it is easy to understand why the assay method critically matters.

Comparisons with Modern Assays

Modern fire assays are routinely performed on gold and silver samples. Industries needing gold and silver analyses use a variety of analytical methods to determine gold and silver. Each of these methods is used within the understanding of its limitations. For example, the term *fire assay* can cover various methods, some of which may be less accurate than others. The size of the analytical sample (assay charge) is important because gold is usually erratically distributed in rock samples. Analytical samples generally range from one quarter to five assay-tons in size.[43]

39 There were reportedly several "refineries" operating in California in the late 1850's. One such company was Justh & Hunter (and/or other partners,) who reportedly "refined $10,000,000. in gold" from March 14, 1857 to August 8, 1857, according to a short promotional summary published in Langley's 1858 *San Francisco Directory* [page not noted] quoted in Dan Owens' *California Coiners and Assayers*, 2000, p209. This appears highly unlikely, since the amount would be one fifth of the total production of the entire state that year produced from a refinery that only operated sporadically between 1857-8. The *SS Central America* recovered gold treasure contained 83 Justh & Hunter ingots out of a total of 532 ingots, approximating on a piece basis the proportionate one-fifth ratio. However, all of the Justh & Hunter ingots were dore, *not refined ingots*, thus illustrating that the $10 million total was probably not refined metal but *processed* metal. On June 30, 1858, an article in the *Alta Californian* sheds light on the issue of refined bullion versus unparted (dore) bars. Congress did not provide for "preferential treatment of refined precious metal at the U. S. Branch Mint," therefore there was no business advantage to refine gold and silver. (The previous quote is from Owens, p210)

40 Touchstone is an old method, mentioned in *Pirotechnia* by V. Biringucci circa 1540 (1959 Harvey Mudd Translation) and Agricola's *De Re Metallica* of 1556

41 Illustrated in *A Guidebook to United States Coins* by R. S. Yeoman, page 282, 1998 edition. We don't know if Kohler ever used the touchstone, but the use of *carats* to express purity on any ingot could have been made by the touchstone method.

42 Oscar Lieber's *The Assayer's Guide* published in Philadelphia in 1852 states that the method was "commonly used … by goldsmiths" (jewelers) but was supposed to be a preliminary measurement made prior to proper assay. Misuse of the method appears widespread and deserves more research.

43 A one-ton fire assay contains 29.167 grams of sample. Each of the other assays has a proportionate amount. In this manner, the results in grams equal ounces per ton. There are 29167 Troy ounces in a short ton.

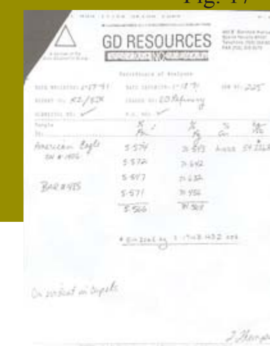
The quarter assay–ton sample is the smallest, requiring the least amount of original sample. It is also, therefore, generally the least accurate. The five assay-ton sample is the largest, consuming the most sample. It is the most accurate and usually the most expensive. The larger sample size usually produces better reproducibility, rendering more accurate results.[44]

Another analytical method commonly used at mine sites is atomic absorption spectrometry (AA or AAS). This instrument is used to quantify the amount of gold and silver present in solutions that have leached the metals from ore samples. Aqua regia (a mixture of hydrochloric and nitric acids) or a solution of sodium cyanide are commonly used to dissolve the precious metals out of the ore sample. This is a very fast analytical technique used when very high volumes of samples are required over a short period of time such that an important decision can be made immediately, such as choosing between ore and waste. The homogeneity of the metal content in the ores is one important factor that dictates the analytical method, and most mines experiment constantly in various ore bodies trying to find methods that work most efficiently and economically.

Trace element analyses are used for just that…*traces* or very low concentrations of precious metals or other trace elements present in the samples. These methods include Atomic Absorption (AA), ICP-AES (inductively coupled plasma-atomic emission spectrometry), ICP-MS (inductively coupled plasma-mass spectrometry), LA-ICPMS (laser ablation-inductively coupled plasma mass spectrometry), and XRF (X-ray fluorescence spectrometry). These methods are not suited to the accurate measurement of elements present in very high concentrations such as gold or silver in precious metal bullion analysis. Certain aspects of the mining and mineral exploration business use all of these analytical methods to their full advantage.

The most accurate method of analysis for precious metals bullion is the Fire Assay Bullion Analysis. It involves four separate analyses in a "proofing" process. Small amounts of metal are removed from the bullion and analyzed. Three samples of the bullion are taken: 1) by the refiner, 2) by the mining company, and 3) an archive sample just in case an umpire is necessary (all taken at one time). The results are closely compared, and if the two show some variability, an umpire is called in to assay the third sample. This is the only acceptable methodology used today for bullion settlement by mining companies. All other methods render too great a margin of error. Over many years of production from three different mines, we had a variance of more than 1% only once or twice. This may vary from mine to mine and bullion to bullion, depending upon the nature of the ore deposit.[45]

Fig. 17



Fire Assays of *SS Central America* Gold Ingots

A few dozen ingots from the S.S. *Central America* treasure have been used as a gold source to produce modern commemorative products. Sixty-nine Kellogg & Humbert ingots were used to derive gold for a modern re-strike commemorative of the *S.S. Central America* treasure. The commemorative pieces were struck using dies produced by transferring the design from the original dies used to make the 1855 Kellogg & Co. $50 gold pieces. Additionally, seven Justh & Hunter ingots were used as the source for another commemorative issue, this one based on the Baldwin $10 "Horseman" design of 1851. These programs allowed for the sampling and assaying of the gold by fire assay.

The gold used for the Kellogg $50 re-strike program was fire assayed in a commercial laboratory at Hoover & Strong, Richmond, Virginia. The results of fifty-six fire assays of individual bars are presented in the following table, along with the original fire

44 Inhomogeneity of sample results is from what we usually call the "nugget effect."

45 Holabird's comments refer to the Moho Mine in Esmeralda County, the Gold Bar Mine in Nye County, and the Flowery Mine in Storey County, all in Nevada.

assays as punched on the ingots.

The availability of small samples from certain of those ingots allows us an initial investigation into the chemistry of the ingots themselves, and the accuracy of the original assayers' work. Certain samples were analyzed by multiple techniques, offering a comparison of the accuracy and applicability of different methods. Some of those data are shown in the following chart and by graph. All ingots are originally from Kellogg & Humbert Assayers, the chief assay firm on the west coast in 1857.

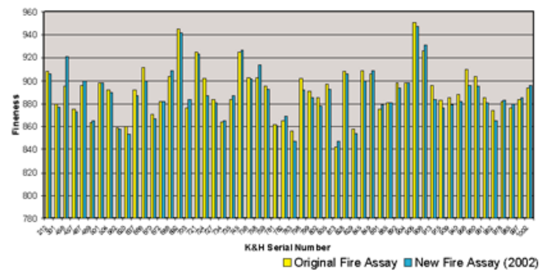


Fig. 18

K&H Serial Number	Original Fire Assay (fine)	2002 Fire Assay (fine)[46]	Variance	% Variance
212	908	906	.002-	0.2
301	880	877	.003-	0.3
456	895	921	.026+	2.9
457	875	873	.002-	0.2
467	896	900	.004+	0.4
469	863	865	.002+	0.2
501	898	898	.000	0.0
504	892	890	.002-	0.2
562	859	858	.001-	0.1
620	860	853	.007-	0.8
637	892	887	.005-	0.6
666	911	900	.011-	1.2
670	871	867	.004-	0.5
672	882	882	.000	0.0
686	904	909	.005+	0.6
692	945	942	.003-	0.3
703	876	884	.008+	0.9
721	925	923	.002-	0.2
724	902	887	.015-	1.7
727	884	881	.003-	0.3
734	864	865	.001+	0.1
735	884	887	.003+	0.3
745	925	927	.002+	0.2
756	903	901	.002-	0.2
758	903	914	.011+	1.2
759	895	893	.002-	0.2
781	862	861	.001-	0.1
782	865	869	.004+	0.5
783	856	847	.009-	1.1
798	902	892	.010-	1.1
799	891	885	.006-	0.7
802	885	878	.007-	0.8
805	897	893	.004-	0.4
813	842	847	.005+	0.6
828	908	906	.002-	0.2
829	858	854	.004-	0.5
845	909	900	.009-	1.0
849	906	909	.003+	0.3
861	875	879	.004+	0.5
885	881	881	.000	0.0
892	898	894	.004-	0.4
904	898	898	.000	0.0
905	951	947	.004-	0.4
906	926	931	.005+	0.5
913	896	884	.012-	1.4
915	883	876	.007-	0.8
939	885	879	.006-	0.7
940	888	882	.006-	0.7
956	910	896	.014-	1.6
960	904	895	.009-	1.0
961	885	881	.004-	0.5
962	874	865	.009-	1.0
978	882	883	.001+	0.1
985	876	880	.004+	0.5
997	884	885	.001+	0.1
1002	894	896	.002+	0.2

46 Hoover & Strong Assays. Much other data on many of these samples has been gathered allowing further study and the determination of methodology necessary into the investigation of fake ingots.

The average variance is .000 for the 56 data points.[47] This data set is typical of those we found in the mining business, though in a mine production situation we would have rerun those samples with a variance in excess of .010 oz/ton gold, or 1%, at the choice of the mine manager. The fifth column is particularly important to illustrate that fire assays are very close with very small tolerances.[48]

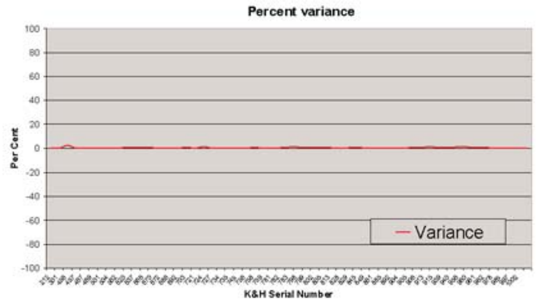


Fig. 19

Modern Methods of Advanced Scientific Analysis

There have been significant and impressive new advances in instrumentation over the past decade that allow for more sophisticated analyses of ingots and coins than ever before. Consider the modern concept of "*fingerprinting*" ingots and coins using the new LA-ICP-MS (Laser Ablation-ICP MS) instrumentation to identify and semi-quantify the gold or silver, and its unique packet of trace elements, characteristic of that particular gold sample. This method of analysis is sort of like a DNA-type concept where the history of the gold is preserved in its associated trace elements and isotopes. Fingerprinting is being used to validate coins and ingots, and in some cases may be used to track a metal back to its regional mine source.[49] It is also used in forensic science to positively identify stolen gold.[50] It is an exciting new development, and in our opinion is one of the important tools of the future for ingot and coin analysis, aided by the SEM-EDS (scanning electron microscope with energy dispersive x-ray spectrometer).

The best choice of instrumentation is only part of the equation. It is necessary to decide what information is needed, then choose the right method, and then correctly interpret the information. In many cases more than one method is used on an ingot or coin to arrive at a correct interpretation. Throwing an ingot or coin into an analytical instrument and expecting a print-out to confirm authenticity is not likely to be successful. The "black box" approach doesn't work.

Data interpretation is every bit as important as the performance of the tasks themselves. Technical instruments demand a thorough understanding of their procedures in order to deliver quality data. In this regard, a researcher should consider using analysts that are trained in the fields under consideration, particularly persons who perform these tasks daily. For this study, we have used some of the leading members of the scientific community surrounding gold issues. The Mackay School of Mines at the University of Nevada, Reno and the Nevada Bureau of Mines and Geology are leaders in fields of study relating to gold and silver. Nevada has been the leading producer of these metals for more than a decade and these institutions are the center of advanced study in America for precious metals.

We have generated virtually hundreds of tests of known precious metal products, from coins to *SSCA* ingots adding greatly to our data base of coins and ingots under study. These tests have been performed with resultant data interpretation by the leading experts in their fields, Dr. John McCormack of the Mackay School of Mines Electron Microbeam Lab and Dr. Paul Lechler, Chief Geochemist for the Nevada Bureau of Mines and Geology. Understanding metal analyses is critical in the study of ingots. The accumulation of technical and historical data and subsequent interpretation is a coordination of effort between researchers subject to peer review.

47 Individual data points are both positive and negative.
48 The authors have an entire separate detailed database similar to the *SS Central America* data on a series of Comstock ingots from the c1860-1880 period as well as for a series of Carson City silver coins. Presentation and discussion of this data within this paper would double the size of the finished work, and hence is left for a future publication.
49 Budd and others, 2000
50 Herbert and Watling, 1995

The necessary ingredients and criteria for successfully verifying an ingot or coin are based on:

1. The overall skill and experience of the team doing the work.
2. An understanding and application of history to the item.
3. The scientific background to understand and manage a rigorous sample preparation, and to interpret the results.
4. Proper technical choice of method or methods of analysis.
5. The ability to recognize limitations in the procedure.

All precious metal ingots and coins, no matter how pure, consist of a mixture of elements. The mixture includes the major metal of gold or silver, together with minor metals in the range of 0.1% or more, and trace elements in the parts per million or parts per billion range. The trace elements may be carried by the gold, or by the other elements. This fact, while often overlooked, drives the choice of an analytical technique. First, do you want to analyze a mixture (eg: the entire ingot)[51] or do you want to be able to see and analyze specific points under the electron microscope?[52] Then do you require the technique to be non-destructive[53], or is minimal destruction a fair trade-off for the best method?[54]

Classical Analytical Methods:

Fire assay bullion analysis. Bullion assay is for accurately determining high concentrations of gold and silver for settlement of values and payment on the contained gold or silver sold to the mint or refinery. It is the best method to compare ingot results to historic mint records. The method is more complex than that for fire assay of ores and samples. *Gold bullion* is that which contains more than 50% of precious metals of which more than half is gold, and with less than 10% of base metals. The assay of gold and silver bullion is expressed in parts per thousand, known as fineness. A bullion containing 990 parts gold per 1000 is 990 fine (99.0%). Silver bullion is that which contains more than 50% precious metals, of which more than half is silver, and with less than 10% base metals other than lead and copper. The sampling of bullion requires extra precautions, and generally a ½ gram (0.016 Troy ounces) sample is taken from the bullion and consumed. The actual location of the samples, which are sometimes drilled from an ingot, and the proper sample preparation are very important. The general method of bullion assay for gold at mints and assay offices is by cupellation and parting together with check assays on synthetic alloys of similar composition. There are many details to the procedure that depend on the various metals present, and bullion assays should be obtained only from well-known laboratories with a history and reputation of quality work, preferably those that perform these analyses routinely as a regular part of the mining or gold business.

Fire assaying, dating to about 2,500 B.C. and *wet chemical analysis* are used to analyze gold and silver content in ores and substances with much lower metal concentrations than in ingots and coins. Typically, gold concentration in samples being fire-assayed ranges from less than 0.2 ppm (parts per million) to much less than 300 ppm. For geochemical samples, fire assay can be followed by AAS or ICP analysis of the bead to arrive at a level of detection of 1 to 5 ppb (parts per billion) gold.

In *wet chemical analysis*, a sample of 5 to 10 grams is digested with aqua regia to leach the precious metals from the sample. The precious metals can then be quantified with either AAS (Atomic Absorption Spectrophotometry) or ICP-AES Induction Coupled Plasma-Atomic Emission Spectrometry.) Importantly, however, there is a severe interference, from iron in the sample on the accurate determination of gold (but not silver) with either instrument. This is circumvented by all reputable laboratories by extracting the gold into organic solvent[55] prior to introduction of the organic solution to the analytical instrument. As with all analytical

51 bullion assay, fire assay, ICP-MS, ED-XRF
52 LA-ICP-MS
53 SEM-EDS
54 LA-ICP-MS
55 MIBK. Methyl Isobutyl Ketone

instruments used for the determination of precious metals, calibration with standards and checking of the calibration with certified reference materials is critical to insuring an accurate analysis. Although inexpensive, the method is used mostly in production or exploration situations in which a large number of samples must be analyzed. The method is not well suited for ingot and coin analysis because of the very high metal concentration in these samples.

Modern Analytical Methods

Tables 1 and 2 summarize the newer analytical methods and their advantages and limitations for analysis of gold or silver ingots and coins. The more promising methods for ingots and coins are discussed first, followed by other methods, some of which are not described in the following text. Many of these methods are used for analysis of other expensive collectibles in the fields of art, conservation and authentication.

Fig. 20 SEM-EDS instrument

SEM-EDS (Scanning Electron Microscope-Energy Dispersive X-Ray Spectrometer) is an analytical method that has benefited from improved technology in the past decade. Basically, the method is a newer version of the XRF-EDS, to include an electron microscope for zooming in to the target at a high magnification of up to 200,000 times, and making an analysis of a specific sample site at the micron level in the cross-hairs. The resulting X-ray fluorescence is detected and displayed as a spectrum of intensity versus energy on a graph on the computer screen. The graph may be saved or printed.

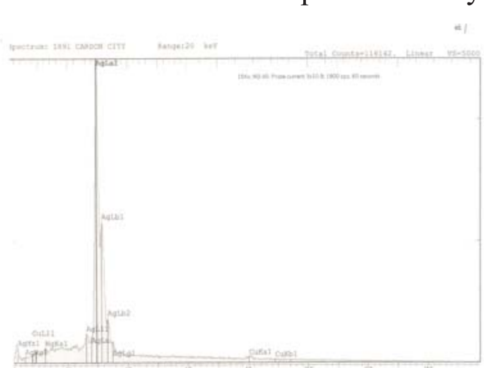


Fig. 21

The positions of the peaks are used to identify which elements are present, using search software with up to 75,000 minerals, compounds and elements. The software is incorporated in the instrument. The intensity (height) of a peak and the area under the curve is not directly proportional to the element's concentration in the sample, especially for ingots and coins. The height of the curve indicates only approximate or relative amounts of the metal, not absolute amounts. The method is qualitative (identifies elements) to semi-quantitative (concentration).

A typical operation begins by defining the mission: What are the goals? What exactly is needed? What is expected? The actual analysis requires a very competent operator at the instrument, and an experienced leader of the analysis. It is basically like a prospecting trip to look for the obvious, the less obvious, and keeping an eye out for the unexpected. There are always unexpected results, or information that is important. These sites can be sampled as encountered to answer questions. Textures are analyzed. What is the homogeneity of the melt? What is its content? What are the impurities? What do they represent? How do these fit in the context of comparative analysis? These questions are answered based on an overview of the sample and analyses made at selected locations. The graphs are printed as needed (with the peaks labeled), as well as occasional backscatter photographs of unusual textures where required. Then follows another period of questions to summarize an interpretation before releasing the sample.

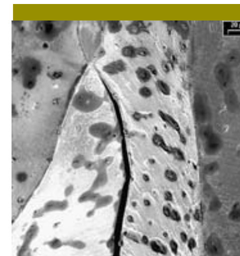


Fig. 22 SEM-EDS view of J&H 4220

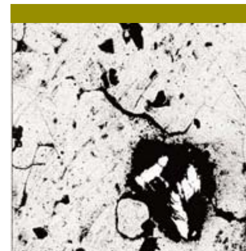


Fig. 23 SEM-EDS view of density differences in ingot

The principal advantages of SEM -EDS are:

- It is non-destructive.
- Rapid analysis of samples.
- Using a feature termed *backscatter*, textures of impurities and uneven mixing of alloys, may be viewed, analyzed and photographed in gray-tones.
- A sample may be zoomed to the micron level and a pin-point analyzed under the cross-hairs. This reveals a sample of metal mixtures.
- Surface oxidation or tarnish may be viewed, and a fresh surface located, if available.
- Samples may be analyzed rapidly, with an experienced technician, and an experienced observer who knows what to look for.
- The instrument takes moderately large samples ranging to teaspoon-size, or small ingots.

The main limitations are:

- Qualitative rather than quantitative.
- Only a thin layer, less than 0.1mm is actually analyzed.
- The limit of detection for trace elements is high (about 200 ppm or 0.02%).

LA-ICP-MS (Laser Ablation-Inductively Coupled Plasma- Mass Spectrometry) This method resulted from adding a Laser Ablation instrument to the front of an ICP -MS instrument. Basically a very high energy laser beam drills a micron-sized hole in the sample and the resulting vapor is analyzed by an ICP-MS for elemental analysis and isotope ratios. The hole drilled by the laser beam is minimal, typically 25 to 50 microns (0.025 to 0.050mm) in diameter and depth. The hole, although small, can be barely be seen by the naked eye, which has caused concern among collectors. Thus, this method has yet to be accepted for use on coins by a number of collectors. We feel that this will be the method of choice in the future for analyzing and certifying of ingots and coins. The quality of information will more than offset the minimal destructive pit, and the pit together with a certified analysis may serve to authenticate the coin. LA-ICP-MS has been successfully used to "fingerprint" gold in forensic investigations in Nevada, Australia and elsewhere since 1994. The fingerprint results from the technique's ability to identify trace and ultratrace element assemblages together with isotope abundances down to the ppb (parts per billion) range. The analysis of an ingot is made within the gold itself, avoiding eutectic unmixing blebs of other metals. Such unmixed zones are common and exhibit an unusual texture that may be observed by the electron microscope. Limits of detection are ultra-low for this method.

LA-ICP-MS Lab, Dr. P. Lechler, Chief Geochemist

Fig. 24

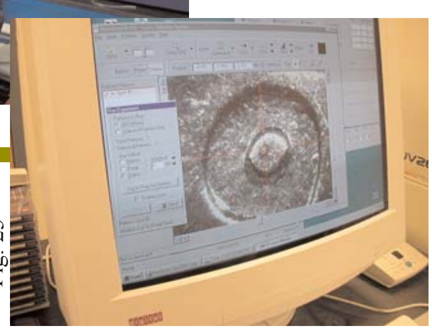


Fig. 25

Fig. 26 5 micron hole in outer of first "9" of date

Fig. 27 45 micron hole in outer of first "9" of date

Fig. 28 100 micron hole in outer of first "9" of date

ICP-AES (Induction Coupled Plasma-Atomic Emission Spectrometry) and ICP-MS (Inductively Coupled Plasma- Mass Spectrometry) are modern methods of very high accuracy and very low detection limits that require dissolving the sample. The sample is excited by an argon plasma, of about 10,000 degrees Kelvin, and in ICP-AES the resulting light emitted by a sample is measured to permit accurate quantitative results for most elements. In ICP-MS the plasma serves as an ion source for the mass analyzer. These methods are used extensively for the analysis of very low-grade rocks and soils and many other types of samples. It is a destructive method so is not used for analysis of coins. It may be used for ingot filings, in cases where that is permitted. Limits of detection are extremely low for these methods. A mass spectrometer is capable of determining not only elemental concentrations, but also ratios of the isotopes of a particular element. Mass spectrometers have been used for years by geologists to date rocks, for example using uranium and lead isotopes.

WD-XRF (Lower Wave length Dispersive X-Ray Fluorescence) and ED-XRF (Energy Dispersive X-ray Fluorescence) is a method that involves aiming an X-ray beam about 40mm in diameter at the surface of an object. This causes secondary (fluorescent) x-rays to be generated; with each element giving off x-rays of its own characteristic energy levels. The resulting fluorescence is detected and displayed as a spectrum of intensity versus wavelength or energy. The positions of the peaks are used to identify which elements are present, using onboard search software with up to 75,000 minerals, compounds and elements. The intensity (height) of a peak is not directly proportional to the elements concentration in the sample, especially for ingots and coins. For accurate quantitative work of gold in ingots and coins it is necessary to use complex standards that match the expected sample. An extensive set of gold standards were developed by the Canadian Royal Mint[56] and a set of 16 gold standards were developed by the Polish State Mint.[57] At this time no commercial laboratories are known to use this method. The principal advantage of XRF is that it is non-destructive, and that appears to be the main reason for continued research to analyze mint products.

Limitations are several:

- For quantification, known standards are required.
- Only a thin layer, less than 0.1mm is actually analyzed. This can give misleading results on samples that are oxidized, corroded, or plated. Silver tarnishes black with a silver-sulfide mineral for example, and results in a sulfur peak, though a sulphur peak might be there anyway. Chlorine, probably from sea-water is commonly present on silver coins recovered from shipwrecks and can confuse or help the analysis. Other elements may show up, suggesting further analysis.
- Sample size limitation. Most XRF machines have a small sample port of 1-2 inches in diameter. There are ED-XRF machines that can analyze large samples for archaeological work, such as vases and up to the size of a statue (Winterthur Museum, 2003).
- Another limitation is that the sample must be flat, and not pitted or rough. Rough surfaces cause x-ray scattering. Interference (overlap) of peaks can obscure an element being sought.
- It is generally not sensitive enough to detect trace metals below about 0.01% in the ingot or coin.

Table 1: Rank of modern instrumental methods as applied to gold or silver ingot and coin analysis.[58] (see next page)

Rank	Method	Advantages	Limitations
1	**LA-ICP-MS** Laser ablation- inductively coupled plasma-mass spectrometry	Allows "fingerprinting." Ultra-low detection level. Highly accurate. Pinpoint micron-specific sample Isotope identification. LA-ICP-MS services becoming more available.	Destructive – But minimal. Requires 25-50 micron divot (0.025-0.050mm).

56 www.rcmint.ca, 2003
57 Stankiewicz, and others, 1998

Rank	Method	Advantages	Limitations
2	**SEM-EDS** Scanning electron micro-scope-energy dispersive x-ray spectrometer	Non-destructive. Micron view alloy textures. Pin-point, rapid analysis. Map different elements.	High detection level (200ppm) Only 0.01mm depth. Qualitative not quantitative.
3	**ICP-AES and ICP-MS** Inductively coupled plasma-Atomic Emission Spectrometry and ICP Mass spectrometry	Ultra-low detection level.Extremely accurate.Isotope identification.	Destructive. Cannot pin-point sample.
4	**ED-XRF** Energy dispersive- X-ray Fluorescence	Non-destructive.	Large scan area.Cannot pin-point sample.Only 0.01mm depth.High detection level (.01%).Qualitative not quantitative.

Table 2: Summary of other modern analytical methods reviewed.

Method	Advantages	Limitations
WD-XRF Lower Wave length dispersive X-ray Fluorescence	Non-destructive.More accurate than ED-XRF.	Not readily availableNot tool of choice
SRXRF Synchrotron micro X-ray Fluorescence	Non-destructive	Now experimental
XANES X-ray adsorption near- edge spectroscopy	Non-destructive	Now experimental
EPXMA Electron probe X-ray Microanalysis Non-	destructiveInstead use SEM-EDS	High detection (0.1%)
FTIR Fourier thermal infrared Reflectance	Non-destructiveAnalyze organic objects; paintings, etc.	Not for metals
(The following require major instrumentation)		
NAA Neutron activation analysis	Ultra low detectionAssays commercially available	DestructiveRequire nuclear reactor
PIXE Particle induced X-ray Emission	Non-destructiveUltra low detection	Require particle accelerator
PAA Proton activation analysis	Non-destructive	Require particle accelerator
PIGE Proton induced gamma- ray emission	Non-destructive	Require particle accelerator

58 Selected References: Budd, P., and others,2000, Copper deposits in south-west England identified as a source of Copper Age metalwork, 3/19/2002. Heady, Howard H., 1976, Assaying ores, concentrates, and bullion, US Bureau of Mines, IC , 8714, 24p. Herbert, Hugh K. and Watling, R. John, 1995, Forensic gold analysis by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), in Randol Gold Forum Perth '95, Gold metallurgy & environmental management, Conference proceedings March 14-17, 1995, Perth, Western Australia, p. 179-190. Janssens, K. and others, 2000, Use of microscopic XRF for non-destructive analysis in art and archaeometry, S-Ray Spectrom, v.29, 73-91. Philips Electronic Instruments, 2002, Application notes, Philips PW2400 sequential spectrometer system, 6 p. Shepard, Orson C., and Dietrich, Waldemar F. 1940, Fire assaying, McGraw-Hill Book Company, Inc., NY, 277p. Smith, Sigmund L., 1979, Fire assaying for gold and silver, Jacobs Assay Office, Tucson, AZ, 87p. Stankiewicz, Wieslaw, Bolibrzuch, Barbara, and Marczak, Milosz, 1998, Gold and gold alloy reference materials for XRF analysis, Gold Bulletin, v31, no. 4, p. 119-125. Winterthur Museum, Art Conservation Laboratories, 2003, . , 2003, Assay services & reference materials, Royal Canadian Mint, Ottawa, Ontario, Canada 6p. , 2003, Research techniques, scanning electron microscopy and energy dispersive X-ray fluorescence. The British Museum, Department of Scientific Research.

Historical Record – Paper Trail

Technical investigation of ingots must be supplemented by the historical record investigation. The historical record is comprised of many parts. Finding them can be an equally exciting treasure hunt to finding the gold bars themselves. The historical record can basically be broken into parts. For the most part, these are primary source materials. These are:

1. Newspaper or magazine articles of the period discussing the pieces in question in fair detail
2. Published works describing the processes and methodology
3. Bullion receipts from the piece itself at the time it was poured.
4. Bullion receipts from the same assayer of the period.
5. Letters discussing the ingots from the time period it was poured
6. Photographic record from the period
7. Accounts of the piece made and published after the piece was poured.
8. Poor research does not mean an ingot is fake, it is only an indication of the background of the writer. Stories are made up far too often. These can be made up because of budget restrictions, ignorance, or intended deceit. In example, an honest auction house can writeup an ingot without the aid of a professional, thinking that their description is fine, even good, but not realizing it is junk and false. The client may never know, but an expert will. Conversely, potential auction clients should be aware that expert descriptions may not be economic if a piece may only sell for $5,000-$10,000. Research is costly. Likewise, clients who consign ingots to an auction house cannot expect expert descriptions if the consignment fee has been whittled to nothing.

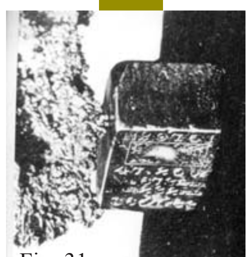


Fig. 31

Many "historians," researchers and authors use secondary or tertiary sources instead of primary source material. This leads to inaccurate reporting, erroneous assumptions, and thus faulty or flawed conclusions.[59] This problem is centuries old. John Andrew Cramer, an early assayer and author on the subject, astutely noted in a 1741 discussion that books on assaying are sometimes written by novices, commonly containing mistakes made by those who have never practiced the trade. When commenting on another author, Cramer remarked:

> *But he seems to write like one who never black'd his Fingers or singed his Beard in metallick Operations.*[60]

Fig. 29 *From: Vischer's Views of CA, 1870*

Fig. 30 *Original Watkins photo of Fricot nugget and ingots, 1867*

This view is important, indicating a need for study by persons who have worked within the field.

Understanding the primary source material is also a necessity. Writers should consult experts in the field before rendering opinions based on flawed judgment or evidence. Flawed historical research is rampant in many disciplines including the numismatic community. It can be difficult to avoid when the entire historical record is incomplete.

Fake Ingots

Technical study and investigation of reported historical ingots will uncover fakes. The numismatic marketplace is no different than other collecting disciplines when large sums of money are exchanged for investment grade collectibles. The art

59 In computer terms: Garbage in- Garbage out.
60 From Cramer, *Elements of the Arts of Assaying Metals*, 1741, London, p452.

of skullduggery and fakes has been going on as long as mankind has exchanged money for goods. Unfortunately, this timeless custom will continue.

News articles of gold swindles of all natures occur fairly regularly in mining camp newspapers and journals. “Bogus Gold Dust – We have recently heard of several cases of bogus gold dust in this region…” wrote one author in the *Terryall Mining Record* of Colorado on August 10, 1861. “Bogus Mining Project. Yet another Swindling Plan to Fleece the Uninitiated,” wrote another author in an article on gold stock swindling in the *Mining and Scientific Press* September 7, 1861. These are just two examples of many frauds involving gold at the time many of the historical ingots were made.

Fake ingots can be divided up into three basic categories: A) Fantasy ingots. These are purely imaginary pieces. B) Spurious Forgeries. These are fakes made without knowledge of what an original looks like, and C) Frauds. These are fraudulent copies of original pieces.

Fantasy Ingots

Fantasy ingots are those made as fantasies and sold originally as articles made up from the imagination. They might be made for the tourist trade or for the general numismatic crowd, available at coin shows. These pieces often never resemble any real ingot. They are not an imitation of anything, but a true fantasy. Examples of fantasy *tokens* known to most numismatists are the large approximate 2” in diameter thin brass “brothel” tokens sold today in tourist souvenir shops. These are pure fantasies. None duplicate anything known to collectors of real brothel tokens. Yet people swear that they are real with an entire barrage of reasons why they have to be real, particularly since their “grandmother” owned them.

Fantasy ingots have been made and circulated for more than forty years. Ed Fleishmann catalogued more than two dozen fake ingots made for the tourist trade and published his findings in the *Numismatist* in three articles published May through July, 1979.[61]

While there are more fake ingots from this series than those shown in the *Numismatist*, they are pure fantasies, except a very few which are designed as exact copies of known ingots. Fleishmann noted that some of these bars were advertised as “genuine pewter paperweights” but they are, in fact, made of tin and slowly oxidize with a dark hue similar to silver. Further, most have been stamped or punched on the edge with a serial number. None appear to be duplicated as the maker cleverly interchanged dozens of punch attributes. While they are not real they are sold on the internet and at coin shows from time to time. We even had one collector purchase one about 1970, carefully placing it in a box in his safe for safekeeping. He swore it was real, purchased from “an old lady.” Forgetaboutit.

Spurious Forgeries

Spurious forgeries are those that are made without knowledge of what the real ingot would look like. They are not exact copies, but made to look real. In this manner, they were made to deceive the public. Often only an expert can determine their authenticity.


Fig. 32


Fig. 33

The most common spurious forgery ingots are the silver Wells Fargo ingots. These have surfaced on eBay over the past three or four years (or more), all apparently originating in California. Dealers have generally caught on, and the last few we have seen have sold for nearly silver spot price. The ingots all use incorrect weighing systems and have other serious faults. They are attractive but are not real because Wells Fargo never made silver ingots.[62] While they are truly spurious forgeries, they are a fraud because they are intended to deceive the buyer.

The following section closely reviews a num-

61 *Numismatis*t, May 1979, pp982-984, June, 1979 pp1228-1230, and July, 1979 pp1450-1451.
62 Dr. Robert Chandler, Wells Fargo History Department, personal communication.

ber of case studies of spurious forgeries. Each of these are probably one-of-a-kind, made with the specific intent of deceiving a buyer. Some of these were purchased recently from the collection of a deceased coin collector with the original envelopes included with attendant asking prices when purchased approximately thirty years ago. At that time, many of these changed hands at the $500-$1200 level.[63]

Case Studies in Spurious Forgeries

Each of the following ingots has the physical description with information punched on the ingot followed by our comments.

Fig. 34

1. **Justh & Hunter** ingot No. 1798 (J&H 1798), Lilly Collection, Smithsonian Institution

On February 2, 2003 two ingots from the Joseph Lilly Collection at the Smithsonian Institution were examined for metallic content. The testing was performed at the Smithsonian Center for Materials Research and Education using the SEM-EDS technique.[64] As a check against the inherent inaccuracies of this technique, specimens of known content supplied by the Royal Canadian Mint were used as an external standard. These check standards and two small samples of Justh & Hunter ingots from the *SSCA* were measured using SEM-EDS and LA-ICP-MS. The use of the external standards allow correction factors to be calculated in order to attempt to arrive at a more accurate approximation of the metallic content of the unknowns.

Analyses of Justh & Hunter No. 1798 (J&H 1798) were obtained from two locations on one surface of the ingot. The results of the analysis of show an average corrected value of .901 Fine for the gold purity and .099 for silver. No fire assays or bullion analyses were taken. The ingot is stamped 900 Fine. This is certainly within acceptable limits.


Fig. 35

However, J&H 1798 shows no real resemblance to ingots recovered from the *S.S. Central America* produced at the Marysville assay office of that firm in 1857. On the *SSCA* ingots the assayers mark is smaller and the word "assayers" is not used. The location "Marysville" and the date "1857" are not used on the genuine ingots. There are other differences as well: the genuine ingots show the weight in Troy ounces and hundredths. J&H 1798 shows the weight in ounces, "D" (presumably pennyweights), and grains. The stamps "THOUS" and "COIN VAL" appear on J&H 1798 whereas no such stamps are used on the genuine ingots. There is no clearly cut assay chip on J&H 1798, although one corner is slightly blunt as if to approximate that effect.

There is also an Internal Revenue stamp double or triple struck into the surface of J&H 1798. This is a fatal flaw. If genuine, this would have been applied at some time between 1864 and 1872, when bullion tax issues were in force. Since the ingot has been punched with an 1857 date, the tax stamp is mis-applied, rendering it a forgery. Additionally, Justh and Hunter were no longer in business during the Civil War.[65] Justh, Hunter & Uznay were in business from 1855-1857. Uznay dropped out of the partnership that year, and the pair continued through July 10, 1858. Justh sold his refinery to Kellogg & Hewston in 1861.[66]

The complete lack of conformity with known bullion punches and standard bullion punch practices apparent on the authentic Justh & Hunter *S.S. Central America* ingots shows this ingot to be a fake. Since the maker of this piece did not and could not know how a genuine piece would look, this specimen is defined as a spurious forgery rather than an outright fraud.

63 Owens, Dan; *California Coiners and Assayers*. Information transcribed by phone.
64 Many thanks to Dr. Douglass Mudd in the numismatic division and others for their keen interest in this subject matter and help.
65 Justh and Hunter are not shown anywhere in California as assayers in the 1867 or 1871 Langley *Pacific Coast Business Directories*.
66 Justh and Hunter are not shown anywhere in California as assayers in the 1867 or 1871 Langley *Pacific Coast Business Directories*.

The Dreaded Bullion Tax, 1864-1872

Tax on precious metals bullion was a disease to the miners and metals merchants of the west coast. Californians and Nevadans debated the issue hotly in the press, but ultimately, they knew a tax was forthcoming.

The bullion tax issue is complex. It began by Congress looking at contracts for processing and delivery of bullion by and between banks, assay houses, mines and miners. Gold and silver were being produced in near record amounts from California and Nevada ore deposits. Their product passed through assay houses, banks, and the U. S. Assay Office. Competition developed between assay houses and banks for the business of the largest producing mines. This led, in turn, to these entities lending money first on the bullion actually produced and waiting for processing at an assay house. As mines continued large scale production with apparent uninteruption, assay houses and banks gradually began lending money based on expected future bullion production. Misuse of lending money on future production by assayers and bankers led to an attempt by the Federal Government to control the amount of time it took to process bullion. Business was so good at regional assay houses that processing of bullion deposits often took three days to a week to complete.

The period of time between the deposit of bullion by a mine and payment for the bullion after processing seemed to keep increasing, therefore increasing the "float time" gold, or its monetary equivalent, was unavailable to the depositor. To control this, the Government put a three day limit on bullion contracts, and instituted a tax thereon March 3, 1863.[67] The system broke down, and the regulation was repealed by the Act of June 17, 1864[68], providing that any contracts for bullion must only be made the day the bullion was made, effectively removing the float time. The Act effectively stopped bankers from going to mine owners at their mines and lending them money based upon future production. Though this lending system is widely used today, there was misuse (and massive failure – hence bank failures) of it then, primarily caused by the inexact nature of valuing ore deposits. Technology today is far advanced, and allows for methodology in ore reserve definition and valuation.

The Act also indirectly addressed the coin shortage in the west, by disallowing payment of loans made in "coin or bullion" stating they be repaid in "money or currency other than coin."[69]

A formal bullion tax was instituted on all bullion deals with the Act of June 30, 1864, Chapter CLXXIII, Section 99:

> *And be it further enacted, that all brokers, and bankers doing business as brokers, shall be subject to pay the following duties and rates of duty upon the sales of merchandise, produce, gold and silver bullion, foreign exchange, uncurrent money, promissory notes, stocks and bonds, or other securities…*[70]

The Act provided funds as a measure of taxation of the western mines to help provide revenue for the Union in the Civil War, more specifically "to provide Internal Revenue to support the Government and pay interest on the public debt, and for other purposes."[71] It went into effect as law in California on September 2, 1864 and probably a similar time period in Nevada.[72] The first precious metals bullion tax imposed was one twentieth of one percent.[73]

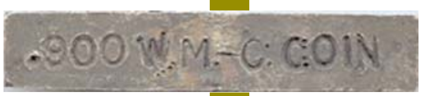
The Act of 1864 was amended by the Act of July 13, 1866 changing the tax rate to one cent per hundred dollars valuation. The laws remained in effect until 1872 when they were repealed by the Act of June 6, 1872, removing and eliminating any bul-

67 Mahler, *U. S. Civil War Revenue Stamp Taxes*, p11-13, Revenue Act of March 3, 1863, Chapter LXXIV, section 4.
68 Chapter CXXVII
69 Mahler, op cite, p17
70 Mahler, op cite, p18
71 Mahler, op cite, p18
72 Chandler, R.; "Gold as a Cumbersome Curmudgeonly Commodity, 1849-1870" in *the Argonaut*, July 2003, a publication of the San Francisco Historical Society, provided to the authors in manuscript form.
73 Mahler, op cite, p18, Section 99

lion tax.[74]

Specific wording of the regulations does not make it clear whether the bullion tax stamp was to be applied to the paper bullion receipt or to the ingot itself. Wording in the Act of July 13, 1866 seems to indicate that the tax stamp should be applied to the specific paper receipt of the bullion, but the wording is not quite specific.[75] The tax stamps themselves were to be provided by the Government. Tax punches for bullion could either be provided by the Government, or by the merchant, who would receive a "discount for furnishing their own stamps."[76] Congress did not appear to be concerned about how the ingots or paperwork were marked, who marked them other than a qualified agent, or where they were physically placed. Their concern was the larger picture, revenue from bullion tax.

2. Wass Molitor silver ingot



"W.M." (Wass Molitor). ".900 W. M. – C. COIN//16 1/4 DWT. $.75"

On opposing long sides is "S.F./ CAL."

We assume that the notation "W.M. – C." is supposed to be for *Wass Molitor & Co*. The ingot is 2" long, 3/8 wide, and 3/16 thick. Square corners. An unnamed California collector paid about $850 for this ingot about 1970.

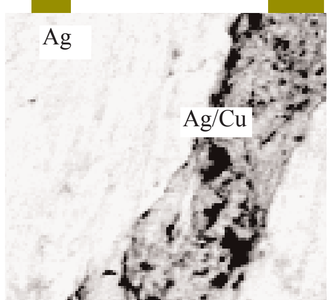


Fig. 36

This is a cut piece of silver, not poured in a mould. The actual weight is 0.82 Troy ounces. The calculated weight 0.8125 ounces, well within the range of accuracy. Wass Molitor never refined silver and never issued silver in coin silver (900 fine) bars as recorded in the written historical record. In addition, the weighing format is incorrect, using pennyweights as might have been used in the gold dust trade, but never used for silver, and was not used by any American assayer of the nineteenth century for silver as far as we know. The standard by which all precious metals are weighed is in Troy ounces. Finally, the exact same punches were used for this ingot and for a Pacific Co. ingot found in the same collection. The "C, S, and F" all have specific characteristics in common that cannot be duplicated by other punches. The ingot is also very dark, with even oxidation throughout, suggesting artificial oxidation. Note the convenient valuation of 75 cents. The WM ingot is a forgery based on the historical record and the physical attributes.

The scientific study of the ingot by the SEM-EDS showed a distinct non-homogeneous bullion mix. Here we found with the backscatter detector areas of obvious density differences and analyzed a number of these sites. The results showed us a clear method of what the maker did when he made this ingot. The mix contains distinct masses of coin silver – that is silver alloyed with copper in the approximate ratio of 90% silver and 10% copper, typical of pre-1964 U. S. silver coins. It also contains distinct separate masses of what appears to be refined silver, probably from melted 999 fine, or nearly so, silver rounds or bars. The non-homogeneous nature of the mix completely exposes the fraud. If it were pure "coin" silver, we would not see this non-homogeneity. Further, someone of Wass Molitor's stature would *never* make such a bar and stamp it thus. The ingot is an unmistakable spurious forgery. There are no known originals nor would we ever expect to find one. This piece was produced with the full intent of deceiving the numismatic field. This is an obvious forgery.

3. Parsons silver ingot.

"PARSONS & CO/ ASSAYERS/ COL/ - 1860 - //CARAT DWT/ 10 . 25" 1 1/8 x 3/4 x 7/16" thick. Heavily ground and polished surfaces.

The real weight is 1.33 Troy ounces and the calculated punched weight is 1.25 Troy, a variance of 6.4%.

74 Chapter CCCXV, Section 36
75 Mahler, op cite, p33, Chapter CLXXXIV Section 9; and p. 35
76 Mahler, op cite, p3

Our ingenious ingot maker has here blown nearly every attribute of the more than 3000 original ingots that we have ever seen. First, Parsons had no silver. He was a miner and beginning coiner from a remote placer gold mining camp in Colorado. More information can be found on Parsons in the "Ingots Under Study" section. While this ingot is remarkably similar to the Parsons gold ingot found pictured in Kagin[77], it is no more than a cheap replica. Second, the weight system is wrong for silver. Third the shape and manner of presentation are wrong. Highly ground and polished surfaces usually are there to hide something. Originals rarely possess this trait. Lastly, the punched weight is also too heavy and generally considered out of the accepted tolerance. Kagin's comment in his *Private Gold Coins* book, "Many false pieces in base metal exist" is appropriate here. This piece was bought by an anonymous California collector for $850 about 1970. This ingot was thought to be fake based on the evidence from physical and microscopic examination before the advanced scientific work was done.

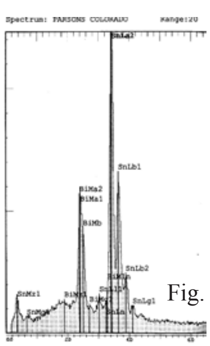


Fig. 37

The SEM-EDS data were even more interesting. The ingot is a tin-bismuth alloy, a standard alloy in the metals business.[78] In so being, it closely resembles a silver ingot but will not tarnish a deep black. If these were made for the tourist trade, they would be found in great frequency. They are not, partially because this ingot was hand punched. Identical punchmarks, as identified and measured using the SEM-EDS, have been found on at least one of the gold Parsons ingots, as noted in the "Ingots Under Study" section. The ingot is a forgery.

Case Studies

There are a number of ingots that have generated serious interest among collectors and to our group with regard to scientific study to determine authenticity. Among these are gold ingots reportedly made by Parsons & Co. of Colorado. Four different gold ingots have been found to date for this firm, all having the same or similar megascopic appearance. Opinions have been rendered in the past (on file at the American Numismatic Association in Colorado Springs, Colorado) on at least two of the ingots, and two others have surfaced unknown to writers of those opinions. Two of the ingots had jewelers' loops attached at different places on one end for suspension (probably a necklace.) For the purposes of this study, Parsons A is identified as the gold ingot in the Lilly Collection at the Smithsonian noted by John Ford as original in a letter to the ANA. Parsons B is the gold ingot recently found in a Daguerrian case with engraved plate adjacent stating that it is the first ingot made by Parsons, from the Edwards Huntington Metcalf Estate. Parsons C is the "fake" ingot described in a letter by John Ford to the ANA in the late 1950's. Parsons D is a gold ingot that just recently surfaced from an old collection.

Parsons & Co. gold ingot, Joseph Lilly collection, Smithsonian Institution: (Parsons A)

This ingot was examined on the same day as the Justh & Hunter ingot (J&H 1798). The piece has no serial or ingot number so we refer to it as Parsons A. Some researchers in the past have regarded it as genuine. The chemical analysis using SEM-EDS casts serious doubt on this. Data were obtained from two locations on the surface, using the same standards and corrections described above for the J&H ingot 1798. These show an average gold content of 877 Fine, average silver content 116 and an average copper content of 007 fine. The stamped purity, 18 ½ Carat, converts to 771 Fine in conventional assayers' terminology. The variance of this analysis is far too great. This piece is in need of a bullion analysis and Laser Ablation trace metal study. Although the SEM-EDS method can only yield an approximation of the purity, we believe that there is a chance this ingot may be too pure to be genuine.

John Parsons, the purported maker of these ingots, did not use conventional bullion or gold marking standards. As a former medical doctor, he was oper

77 p322
78 *Handbook of Chemistry and Physics*, 1970, edited by Robert Weast. Page D136

ating outside of industry accepted standards. The only proof from the historical record to date that Parsons might even have issued such a piece is from two sources. The first is a single article in the *Rocky Mountain News* published on June 27, 1861:

> *MORE PRIVATE COIN. Parsons & Co., of Hamilton, are preparing to begin the coinage of gold at that place. The issue will be quarter and half eagles of handsome and original design. We have seen facsimiles of the coins.*

The second source is from Hall's *History of Colorado*:

> *July 2oth* [1860] *Clark, Gruber & Co. opened a coinage mint, the only one we ever possessed, upon the spot and in the building now owned and used as an assay office by the Federal government…Only ten dollar gold pieces were struck. These coins were of pure gold taken from the neighboring mines, …On the reverses side the American eagle, encircled by "Clark, Gruber & Co." and beneath the date "1860." Some thousands of these coins were issued, but they are rare curiosities now, and worth to numismatists many times their face value. Other mints were established in the gold regions, one in Georgia Gulch, and the other in Terryall, in both of which the gold was coined into slugs taken from the ground. It contained more or less silver, but no alloys were used.*[79]

No specific mention was made of the $20 ingots, other than the crude reference to *slug* from Hall's work.[80] In further research on Parsons this year, we uncovered significant information:

1. All past information appears to be based on a crude card index of the *Rocky Mountain News* and a few other papers prepared by the WPA decades ago. This information has been only partially integrated into numismatic files. Research outside of this card file appears to be lacking.
2. Parsons was an extremely active miner, prospector and promoter in Colorado. He worked on more than a dozen different properties within the state for about 20 years.
3. The John Parsons obituary sheds no light on his business life, his sources of revenue, or potential historical importance.[81]
4. There is significant information on Hamilton and Terryall from the 1861 period that has not been published.
5. The only reference to the Parsons coins is from 1861, yet Parsons dated his pieces 1860. Did he make these in 1860 or was he just trying to copy Clark, Gruber & Co., having actually made the pieces in 1861?
6. John Parsons is not mentioned in *any* of the issues of the Terryall *Mining Record* on file at the Colorado Historical Society discussing local matters, nor does his name appear in published lists within the paper.[82] This is a significant anomaly. If he were issuing or minting coin, his name would be in the papers daily, if only as a gold dust buyer. Not a single gold dust buyer placed an ad in the *Mining Record* before August 10, 1861, probably because there were none there in the small mining camps that held a reported 300 miners. Additionally, not a single ad appears for an assayer in either the Denver or Terryall newspapers of

79 Hall, Frank; *History of Colorado*, volume 1 of 4, 1889, p255. The reference to Georgia Gulch is with respect to the Conway pieces.
80 The use of the term *slug* is significant. According to Adams in *Private Gold Coinage of California*, *slug* was first used by Moffat to indicate his $50 ingot. From page 54: "While many references to the Fifty Dollar octagonal piece as a coin have been made in recent years, still it was rarely so called in the pioneer days. The name of ingot, given to it in the Act authorizing its issue, clung to the piece through all the period it was made, although various other terms were applied to it in common parlance, such as…slug…The term slug originated with the Moffat & Co. and F. D. Kohler rectangular pieces." This is a clear indication of the use of the term slug as an ingot.
81 The obit was published in the *Denver Daily Times* January 28, 1881
82 There is no known complete run of this newspaper anywhere.

this period. The community appears to have been too small to support such a business. On August 10, 1861, three different Denver gold dust buyers advertised in the *Mining Record*, the same three as advertised in the *Rocky Mountain News* at the same time. This is no coincidence since the publisher of the two papers was William Byers. These 1861 Denver merchants were the bankers and gold dust buyers: Cass & Brother, Warren Hussey, and Clark, Gruber & Co. None were assayers. The latter boldly advertised, noting their coinage:

> ***Coin For Gold Dust***. *The native gold is coined as it is found alloyed with silver. The weight will be greater, but the value the same as the United States coin of like denominations. Clark, Gruber & Co.*[83]

Clearly, if Parsons was trying to compete with Clark, Gruber & Co., he would have advertised his coin and gold dust services. No such publicity has yet been found, but a more thorough records search is warranted.

7. Parsons was listed as a claim staker in early Territorial records in the Terryall, Hamilton, Buckskin Joe districts.
8. An advertisement for Daguerrian supplies was found in the *Mining Record* for a merchant at Terryall. This is unusual for a small mining camp in a remote location. This may have been the supplier of the case for the Parsons piece from the "Huntington" collection.
9. The Daguerrian case was inspected by Grant Romer of the Eastman House International Museum of Photography in Rochester, New York, who reported it as consistent with genuine similar pieces based on comparative study.
10. It has been reported that Parsons wrote a book on mining in Colorado. This is incorrect. William B. Parsons, not the same person, wrote a guide to the Kansas goldfields (Colorado) in 1859: *The New Gold Mines of Western Kansas: Being A Complete Description of the Newly Discovered Gold Mines*. Cincinnati, Ohio, 1859. No published work by John Parsons was located in a thorough search of the public record, including the Colorado School of Mines, Colorado Historical Society, and Denver Public Library collections. William Parsons' name is not found with John Parsons in any of the published claim indicies or material found on John Parsons, thus we assume he is unrelated.[84]

The above information leads us to consider the possibility that Parsons never issued the gold coins for circulation, but rather was "testing the waters."

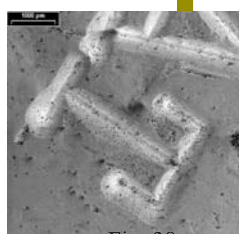


Fig. 38

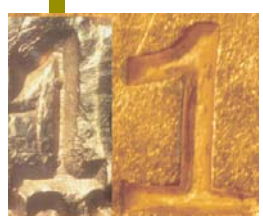


Fig. 39

At least three different sets of stamps were used to mark the various Parsons ingots. Parsons ingot D has punch marks identical to the fake tin Parsons ingot. Careful measurements were taken of the "T" in "Carat". This letter is very distinctive with unique serifs. Measurements with the SEM-EDS indicate a nearly exact match in punch size and specific characteristics.

We have reached no final conclusions concerning the subject of Parsons & Co. ingots, and the subject remains under study. Further detailed analytical testing of the Parsons D ingot is currently being done. Laser Ablation tests are scheduled to be performed on the ingot and on gold dust from Terryall and Alma placer gold. The results will form an important core of data for the future analytical study of the other Parsons ingots.

In summary, there has been no proof found that Parsons was ever active in the gold trade or assaying business other than as a prospector and miner. There is simply one lone newspaper article stating that he

83 *Rocky Mountain News* 6/29/1861 and subsequent issues. 8/10/1861 *Miners Record* and subsequent issues.
84 The possibility exists that such a book could exist in a private collection and be unknown to bibliographers of Colorado history.

came by the office of the *Rocky Mountain News* and showed an editor several "facsimiles" of coins he was minting or was reported to have made in July, 1861. He never advertised as a bullion or dust dealer or assayer, nor was there any mention of the $20 ingots. Further testing and research is necessary.

Authentic Historical Ingots

The following ingots were discussed at great length in *Coin World*. They are real beyond a shadow of a doubt.

Fig. 40

Kellogg & Hewston ingot No. 2425, (K&H 2425) Joseph Lilly Collection, Smithsonian Institution

Kellogg & Hewston were a successor assaying company to Kellogg & Humbert, who produced most of the ingots recovered with the S.S. *Central America* treasure. Kellogg & Humbert dissolved in 1858 and the business continued as Kellogg & Hewston until later, whereupon it became the San Francisco Assaying and Refining Co. until the business finally closed. This ingot was described in *Coin World* September 24, 2001.[85]

K&H 2425 shows all the standard features expected of a genuine assay ingot. The information appears in the exact order and style as it does on all 343 Kellogg & Humbert ingots recovered with the SSCA treasure. Assay chips are correctly cut from opposite corners of the piece. Since this piece was in the Lilly Collection well before the recovery of the *Central America* treasure, and it matches those pieces in style, it must be genuine.

San Francisco Assaying and Refining Co. ingot Joseph Lilly Collection, Smithsonian Institution

The San Francisco Assaying & Refining Co. was the successor to Kellogg & Hewston as described above. All the standard features are present on this ingot as well. The principle difference is that this piece is a silver bar, showing that the conventions hold for silver ingots as well as gold.

The punches are exactly the same size and style as those used on many SSCA ingots, although the microscopic detail has not been as well preserved. In fact, they may be the same punches passed down from company to successor company, but it is impossible to tell. This ingot was described in *Coin World*, September 24, 2001.

This specimen is stored with the study collections since it is not gold. Only the gold portions of the Lilly collection are on display. This is a genuine historical ingot.

Modern Ingots

Ingots will continue to be created until such time as there is no precious metals trade or mining. Modern ingots in America are made in various forms at every metals producing mine, every U. S. Mint, and all refineries. Very few are made for special events, while most are made for the bullion trade. Modern ingots are well illustrated in Nigel's *Industry Catalogue of Gold Bars Worldwide*, as mentioned previously.

Some modern ingots have apparently been made from California placer gold. Others are made from scrap gold and foreign gold coins. Several of these have been passed along as antique, though they have been engraved by a modern post-1950 mechanical engraving machine. They are not punched or stamped in the typical fashion, though a novice may never notice. These ingots are currently under study.

Conclusions

Authentic historical precious metal ingots form an integral part of the numismatic scene because of their direct tie to ores and minting of precious metal coins. Many real ingots are known to the numismatic community, though a number have also been shown to be fake. A thorough inventory of ingots held in institutional collections is needed to provide a source of further study.

The *SS Central America's* hoard of 532 gold ingots allows unmitigated study of real ingots and comparisons to questionable pieces. A thorough

85 "Disputed Smithsonian Bars Genuine" by Fred N. Holabird. The author disclaims any association with the title, solely a product of *Coin World's* editorial staff.

understanding of the historical setting, processes, and business practices of assayers, banks, mints and mines is necessary in further understanding the bullion industry, which was different than the gold dust industry at the beginning of the California Gold Rush.

Researchers and collectors need to keep an open mind when researching historical ingots. Certain outside influences affecting the assay and bullion business dictated changes in accepted methodology in ingot manufacture at the onset of the California Gold Rush. These influences continued to affect parts of the bullion trade for up to two decades after 1848.

Researchers should avoid jumping to conclusions based upon inadequate data. New technological methods have been developed over the past six years such that we can now identify the specific melt content and other features that a crook has used in the manufacture of some phony ingots.

Numismatists should be ready for a change in thinking. Invasive bullion analyses may be necessary as part of the authentication process. The results of these analyses include a modern "fingerprint" which should accompany the ingots. This documentation might provide assurance to prospective buyers or help determine the identity of stolen ingots. Certain risks are inherent when analyses occur. Likewise, risks were undertaken by the buyer at the time of purchase. As technology increases through time, so does our ability to uncover fakes. Collectors should be excited about the possibilities of the advanced analyses of precious metal ingots. They are, after all, the source of your coins.

Acknowledgements

The authors wish to thank the many individuals who have helped further our study. This has been an ongoing independent process for more than five years, and we expect it to continue development over the next half decade as time and budget allows. There is no outside funding mechanism, so all the work done to date has been paid for in-house or from occasional gifts. Special thanks to the following for their ongoing help, encouragement and assistance: Dr. Richard Dawson; Dr. Robert Chandler of the Wells Fargo Bank History Department; Dr. Paul Lechler, Dr. John McCormack, Dr. Jon Price, all of the Nevada Bureau of Mines and Geology and Mackay School of Mines, Dwight Manley and the California Gold Marketing Group; Monaco Financial Corporation; Douglas Mudd of the Smithsonian Numismatic Collection, Dr. Lambertus Van Zelst, Director of the Smithsonian Center for Materials Research and Education; Dr. Donald Kagin; Robert Rhue, JD., Larry Lee American Numismatic Association Museum Director.

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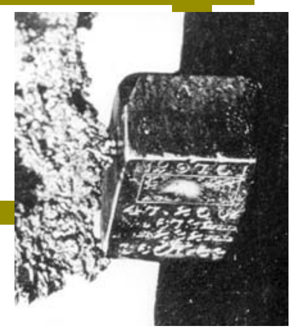
Supplemental Notes
Figure captions

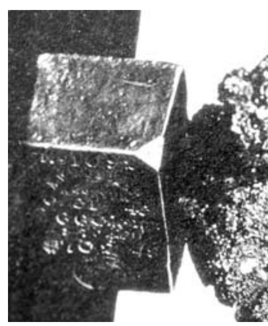
Figure	Description
1	SS *Central America* – recovery (Photo: Columbus-America Discovery Group)
2	SS *Central America* – gold ingots and coins (Photo: Columbus-America Discovery Group)
3	Garden of Gold, SS *Central America* (Photo: Columbus-America Discovery Group)
4	SS *Central America* discovery (Photo: Columbus-America Discovery Group)
5	Ingots as a medium of Specie Exchange – gold assay ingots from the SS *Central America* (Photo: Columbus-America Discovery Group)
6	Presentation ingot: Ruhling silver ingot (Courtesy of Mackay School of Mines, Nevada)
7	An example of Exhibition Ingots: Fricot gold nugget resting on three gold assayer's ingots produced by (from left) Kellog & Hewston, Hentsch & Berton, and A.P. Molitor. Displayed at the Paris 1867 Exposition, (Copy from Visher's California Views, 1870, from the Original Photograph by C.E. Watkins)
8	An example of Industrial Ingots: U.S. Assay silver ingots. Holabird Americana photo.
9	Ingot hand punch, Ophir mine, Virginia City, Nevada (Courtesy of Mackay School of Mines, Nevada)
10	Sampling of a few of the SS *Central America* gold ingots (Photo: Columbus-America Discovery Group)
11	Gold assayer's ingots from the SS *Central America* (Photo: Columbus-America Discovery Group)
12	Purity to be stated in fineness or parts per thousand. Published rules for ingots: Mining Scientific Press, Aug 31, 1861, p.2, col. 2
13	Assayer's chip from Justh & Hunter gold ingot (Photo: Columbus-America Discovery Group)

14 Gold dust advertisement from: *Guide to the Gold Mines*, 1861, published by the Rocky Mountain News.
15 Gold dust receipt. (Note transaction in ounces and pen nyweights)
16 Above, J.L. Moffat's listing in 1833 directory (From: Longworth's 1833 New York City Directory) and Below, Moffat's hallmark used on silver pieces crafted by him (From: *Wyler's Book of Old Silver*, 1937, p. 49)
17 Proofing from Fire Assay Bullion analysis, Flowery mine.
18 Bar graph showing comparison of original to fire assays – SS Central America Kellogg & Humbert gold ingots. Fineness increases along left axis. Bottom axis is indi vidual bar serial numbers. (Average variance .000 for the 56 data points). Original assays by Kellogg & Humbert, Assayers; New assays are by Hoover & Strong, Richmond, VA.
19 Graph showing variance in percent (.000 for 56 sam ples)
20 SEM-EDS instrument
21 SEM-EDS graph of a 1891 Carson City silver dollar coin. Note large silver peak(s) to left, and copper peak in middle of graph.
22 SEM photomicrograph showing uneven mixing texture in Justh & Hunter gold ingot number 4220, salvaged from the SS *Central America*
23 SEM-EDS photomicrograph of an example of unmixing due to density differences when ingot was formed by cooling from melt
24 LA-ICP-MS instrument and laboratory, being operated by Dr. Paul Lechler, Chief Geochemist, Nevada Bureau of Mines and Geology.
25 Electron microscope view of small laser ablation drill hole in quarter coin
26 5-micron diameter laser drill hole in quarter coin, center of '9' in the year 1998
27 45-micron diameter laser drill hole in quarter coin, cen ter of '9' in the year 1998
28 100-micron diameter laser drill hole in quarter coin, center of '9' in the year 1994
29 Fricot gold nugget resting on three gold assayer's ingots produced by (from left) Kellog & Hewston, Hentsch & Berton, and A.P. Molitor. Displayed at the Paris 1867 Exposition, (Copy from Visher's California Review from the Original Photograph of C.E. Watkins)
30 Fricot gold nugget resting on three gold assayer's ingots produced by (from left) Kellog & Hewston, Hentsch & Berton, and A.P. Molitor. Displayed at the Paris 1867 Exposition, (Original photograph courtesy of J. Silva)
31 Kellog & Hewston gold ingot supporting the Fricot nugget. Rotated for viewing ingot stamps. (Photo cour tesy of Wells Fargo Bank Historical Services)
32 Fake Wells Fargo silver ingot
33 Fake Wells Fargo silver ingot
34 Justh & Hunter gold ingot number 1798, a spurious for gery
35 Justh & Hunter Marysville Real ingot from the SS Central America (Photo: Columbus-America Discovery Group)
36 Important SEM-EDS backscatter scan, showing density differences between refined slver (999 fine) and coin silver (900 fine). This illustration is an important exam ple of the fallability involved, and the detection methodology now available when examining potential fake ingots.
37 SEM-EDS graph of Parson's "silver" ingot, showing it to be actually made of tin. Note large Tin peak on right, Bismuth peak on left
38 "T" strike on Parsons gold ingot
39 Comparison of numeral "1" strike on Parsons gold ingots.
40 Kellogg & Hewston Real gold ingot number 2425

PHOTO APPENDIX



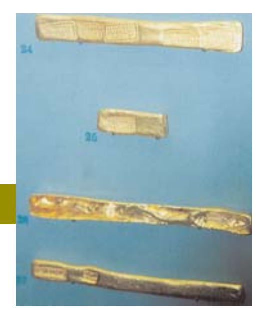
41 Hentsch & Berton gold ingot supporting the Fricot nugget. Rotated for viewing ingot stamps. (Photo courtesy of Wells Fargo Bank Historical Services)



42 A.P. Molitor gold ingot supporting the Fricot nugget. Rotated for viewing ingot stamps. (Photo courtesy of Wells Fargo Bank Historical Services)

43 Antique ingots

Bath lead ingot (ca. 50-100 AD)



Roman gold ingots (ca. 300-450 AD)

Roman silver ingot, Sicily (5th century BC)

Russian silver ingots (ca. 1400 AD)

Viking silver ingot and pieces (ca. 905 AD)

Postscript

Numismatists and collectors in general should be excited about the possiblilities of deciphering fakes within the ingot industry. Technological advances unavailable five years ago render the hobby much more protectable. Other collecting disciplines have not been so fortunate. As an example, religious artifacts are among the most highly collected artifacts worldwide. In a US News and World Report story published May 5, 2003, entitled “A Biblical Bazaar - Treasures, trinkets, and fakes mingle in Israel’s controversial antiquities market”, author Jeffery Sheler noted fakes have inundated this collecting discipline for more than a century “But clever fakes have deceived experts. Perhaps the most notorious incident occurred more than a century ago after the discovery of a ninth century B.C. Moabite tablet that loosely parallels events in the Bible’s 2 Kings. Within a few years, the antiquities market became flooded with fake Moabite inscriptions. The most prolific forger was a collector and dealer named Moshe Shapira, a Polish-born Jew who came to Palestine in 1855 and eventually converted to Christianity. Shapira sold some 1,700 “Moabite” inscriptions to the Berlin Museum, all manufactured by his team of workers. When his deceptions were exposed, Shapira committed suicide in 1884.”

The American Ingot Project

The authors are proposing a project to inventory antiquarian precious metal ingots and photographs of the same in American institutions. Additionally, the authors will seek the acquisition of analytical data on as many ingots as possible. This data is to include SEM-EDS, bullion fire assay and/or ICP trace element analysis with the ultimate goal of publishing the resultant data with color photographs.

The resultant publication will be an educational tool for educators, institutions, collectors and rarity specialists, marketable to the numismatic, mining, precious metal, and institutional markets.

A budget has been prepared and will be distributed to interested parties. The authors have proposed to form a non-profit corporation [501 C(3) IRS Code] for the project. The expected budget is about $375,000 spent over two years, including the publication of the resultant work. The non-profit will expect revenues from the sales of the book.

Please call 775-852-8822 or 775-829-9990 for more information.