The “Poor Man’s Mill”:
A Rich Vernacular Legacy

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Arrastras are ancient ore milling devices that could be cheaply built of local materials and operated with nearly any available source of power. Most were built and operated by small concerns in the American West. Those vernacular devices offer rich clues about cultural traditions, the adaptation of technology, and the niches carved out by small operators. In a broader comparative context, arrastras also provide insights into choices of milling technologies. That interpretive potential is illustrated with a small Italian mining operation in California.

Introduction
Arrastras are simple circular drag mills of ancient origin. They were popular throughout the Mediterranean region since Phoenician times and were introduced in the New World by the Spanish, following discoveries of plentiful gold and silver in Mexico and western South America. The term arrastre or arrastra translates as “dragging along the ground” in Spanish and is defined as “a crude machine formerly used for ore crushing.” Although some limited use of this simple technology occurred in the western United States before American annexation, it was not until the period immediately following the California Gold Rush that arrastras came into wider use.

Arrastras have significant research interest for several reasons. Their most obvious value springs from the fact that many were built in place with nothing more than a rough mental concept. While some prefabricated versions were made, most arrastras were hand-built vernacular devices. For that reason, they often survive in place and can be “read” as sensitive indicators of cultural traditions, technology transmission and adaptation, and the nature and scale of mining ventures. Site-built arrastras are the epitome of an appropriate technology, inseparably situated and necessarily understood in their cultural and physical settings.

Any effort to interpret the arrastra technology in the American gold and silver mining industry also must consider the niches arrastras filled and why. Arrastras played a persistent but marginal role in the American West, whereas they dominated the Mexican gold and silver mining industry. Those differences invite comparisons of the stamp milling and arrastra technologies as a way to gain access to the cultural, economic, and scientific reasons behind technology choices. Although stamp mills were favored by heavily capitalized American mining companies, arrastras were most often employed by small operators relegated to the fringes of the industry. Nevertheless, arrastras were used not only for prospecting but also for reprocessing stamp mill tailings and improving the recovery of gold in large industrial stamp mills. Their success in those latter roles has intriguing implications for theories of economic rationality and the evolution of global capitalism.

Both themes are explored as a way to situate the interpretation of arrastras in the American West. By way of illustration, recent investigations at Antonio Canone’s mine near Amador City, California, are used to explore the rich interpretive potential of mining sites that contain arrastra features.

A Primer on Arrastra Design and Operation
Despite a great deal of variability in design and materials, arrastras share certain essential features. They consist of a circular basin around which heavy drag stones are circulated to first crush ore and then amalgamate the gold and silver in the resulting pulp (Figure 1). The floors and drag stones were typically made of hard rock, although some machines manufactured in the 20th century had iron basins and drags. Most commonly, the perimeter walls were made of rock or wood; however, formed concrete and metal sidewalls were also used in some late-19th and early-20th-century examples. The milling basins typically ranged from 3 feet to more than 20 feet in diameter with depths commonly from 1 to 4 feet or more. The floor of the arrastra was sometimes dished (concave) to help keep the ore in the path of the rotating drag stones. Flooring stones were tightly packed, and interstices were usually chinked with clay or mortar to help...
prevent the loss of precious metal. Larger stones were generally preferred as a way to minimize the number of joints.

Drag stones were pulled around the basin by heavy timber or metal arms that pivoted on a central post or axle. The axle was usually held stationary by a heavy armature extending beyond the outer walls of the mill basin. Some arrastras featured central posts that were self-anchored by virtue of deep burial of the post base in the floor of the mill basin. Drag stones were secured to the rotating arms with chains or ropes attached to bolts secured on the top of the stones. Care was taken when hanging drag stones to ensure the leading edge would ride up on top of the ore. The orientation and proscribed arcs of the drags were selected to continuously move the pulp or “charge” into the path of following drags. Individual drag stones might weigh anywhere from 200 to 1,000 pounds or more depending on the size of the mill.

Hard stones such as granite, quartzite, diorite, and diabase were preferred for arrastra floors and drag stones because they lasted longer than softer rocks and thus entailed less maintenance. However, it was also important to choose rock that retained some “tooth” or roughness since stones that became too smooth were less effective. Drag stones and floors had to be replaced regularly. At the Commodore Mine in northern California, the state mineralogist reported that drag stones lasted a mere six weeks of steady use “and cost about $5 apiece. A new bottom costs $40, and lasts about six months.” Arrastra floors were periodically removed to recover the amalgamated gold and silver that collected in the flooring interstices. For that reason, floors are almost never preserved in archaeological examples of this milling technology.

The drive mechanisms for arrastras varied widely. The most rudimentary models transferred power directly to the central axle. Examples of such direct-drive systems include mills driven by animals that walked in a circle around the outer perimeter of the mill basin and horizontal waterwheels. Other power sources, including overshot and undershot waterwheels, steam and gasoline engines, and even electricity, usually transferred power to the axle through gears, belts, chains, cogged hurdy wheels, or other devices, taking advantage of mechanical reduction to achieve desired rotational speeds. An example of a belt-driven system powered by water is shown in Figure 2. It was used at the Georgia Mine near Independence, California, around 1896. Several mines in Siskiyou County, California, employed cogged wooden hurdy wheels driven by water. Those drive mechanisms had the advantage that they could be cheaply built and easily repaired. The remains of one example from Shackleford Creek below Mugginsville in Quartz Valley are shown in Figure 3. It was powered by an overshot waterwheel. The Commodore Mine, mentioned earlier, also used wooden hurdy wheels to power a double arrastra using a central undershot waterwheel.

Arrastras were more efficient than other ore-milling technologies because they could be employed for several phases of ore processing without transferring the
Figure 2. Belt-driven arrastra at Georgia Mine near Independence, California, ca. 1896. Courtesy of State Museum Resource Center, California State Parks, Sacramento.

Figure 3. The remains of an arrastra near Shackleford Creek in Siskiyou County, California, illustrating the use of a cogged wooden hurdy wheel. Courtesy of California History Section, California State Library, Sacramento.
batch. Both ore grinding and amalgamation could be conducted in such devices. The operation of an arrastra typically began with some initial break-in of the newly constructed machine, however. An article in an 1899 Engineering and Mining Journal states, “after an arrastra is built it should be run for several days on barren quartz or sand until the running is comparatively smooth, and the cracks in the floor have been well filled up.”

After the breaking-in period, an ore charge was placed in the basin, broken into small fist-sized chunks. Water was added to maintain the proper consistency for efficient grinding. The correct consistency was similar to thin mortar. After about eight hours of grinding, mercury was introduced and the rotation speed was slowed. The mercury was often sprinkled directly over the surface of the pulp by pressing it through cloth, breaking it into small globules. Periodically, the pulp was tested by panning to determine whether the mercury had taken up all the free gold in the charge. An oversupply of mercury ensured the recovery of all free gold but meant that some quicksilver was lost. As a result, arrastras could contain hazardous wastes.

Following successful amalgamation, the pulp was discharged through a scupper (outlet) in the wall of the arrastra. The amalgam was recovered from the pulp in a sluice, long tom, cradle, or by panning. Gold and silver were then recovered by heating the amalgam. Using a retort, mercury vapor was collected for reuse.

Arrastras could be built and operated with little capital, a fact that made them particularly attractive to independent miners who worked for themselves. When built of local materials, the chief investment was the labor involved in constructing and operating the mill and the cost of mercury and retorting equipment. Site-built arrastras were also readily customized to fit the scale and conditions of intended work. They could even be operated by a single miner working alone. Perhaps more significantly, arrastras were efficient gold savers. With those advantages, it is appropriate to look at how they were employed in North American hard-rock gold and silver mining.

Historical Trends and Economic Niches
Arrastras were first used in North American mines in the 1500s and were still employed as late as the 1940s. The earliest applications of the technology took place in the southwest during Spanish occupation of that region. Those activities, while historically significant, were limited when compared to the huge number of arrastras employed in the wake of the California Gold Rush of 1848. Hard rock mining was of course not the initial focus of most California argonauts. Placer gold held their attention at first because those deposits were easy to work and required only simple tools and little expertise. As the most promising placers were rapidly claimed, some miners began to concentrate on the quartz ledges and cemented gravels that were the source of the placer deposits.

Mining those hard rock deposits required greater experience and more elaborate equipment, both of which were in relatively short supply during the early 1850s. The large Mexican and Chilean mining contingent can probably be credited with the greatest initial success at quartz mining. Faced with discrimination and restrictive laws such as the Foreign Miner’s Tax of 1850, many Hispanic miners turned to hard rock mining, a pastime familiar in the places they originated. They made extensive use of arrastras, a technology of longstanding tradition in their culture. Many thousands of arrastras were probably used in that early period according to W. H. Storms, although no reliable data are available.

Others tried whatever hard-rock milling techniques they could purchase, fabricate, or piece together in the early 1850s. Some copied and adapted the arrastra technology, perhaps in part because imported equipment was initially hard to acquire. Small operators particularly liked arrastras because they could be developed on a shoestring. That technology transfer to other ethnic groups resulted in some novel adaptations. For example, J. Boot’s 1853 watercolor shows small pine trees in the arrastra basins, perhaps used to mix mercury into the crushed ore slurry (Figure 4).

Arrastras were also incorporated into milling operations that used other types of equipment. A great deal of experimentation occurred with milling machinery imported from northern Europe and the American southeast. The first stamp mill in California, reportedly developed in Amador City in 1851, employed stamps for crushing and arrastras for completing the amalgamation process. The practice of combining the two technologies continued throughout the late-19th century. By 1853 it is alleged that at least 20 “quartz companies were being ‘ floated’ in London alone” with 10 million dollars in capital. Others were presumably financed without foreign capital. Yet most of those early,
heavily capitalized quartz mills failed due to inexperience and the use of fancy machines that performed poorly. As a result, a general wave of bankruptcies ensued, and investment interest waned temporarily.

As hard-rock gold production recovered momentum in the late 1850s and 1860s, production strategies evolved dramatically. Smaller operators who made the most extensive use of arrastras were pushed to the fringes of the gold mining industry by large mechanized stamp-milling plants, built by heavily capitalized quartz-mining concerns. A burgeoning San Francisco foundry industry developed and aggressively marketed an “improved stamp mill” to the local industry. Venture capital also increased from eastern and English capitalists. Those large companies modeled their operations on other fabulously profitable industries, employing elaborate arrays of machinery and large crews of wage laborers.

As the late-19th-century mining engineer Almarin Paul observed, arrastras were

almost wholly superceded when our people became eager to earn money more rapidly, and grew ambitious to conduct matters on a grander scale. ... The English conceived the idea, so prevalent at the present time in California, that ponderous and expensive machinery, with its attendant expenses, would be correspondingly profitable. The fever ran high, they invested largely, and the result was ... failure in a great majority of the mining enterprises.16

It is difficult to know just how many arrastras were used in the American West during the late-19th and early-20th centuries because many were employed in small operations that often escaped general notice. The estimate mentioned earlier that thousands of arrastras were used in the early days of California mining appears generally reasonable, since some areas like Arrastra Canyon in Riverside County had more than 125 in just one district.17 Those small enterprises were often in remote areas, and many were never documented with a recorded claim. Archaeological surveys thus may be the only way to ascertain the full scope and character of arrastra use through time.

While arrastras associated with prospecting and other small-scale endeavors remain poorly documented, their use in larger milling operations is better known. An 1866 survey of portions of Mariposa and Tuolumne counties in California provides some of the earliest systematic insights into the specialized role arrastras came to play in large, heavily capitalized American mines.18 Only 2 out of 71 surveyed mills used arrastras for grinding, yet fully one-quarter of them (n=18) employed the ancient technology as amalgamation machines. Half of the mills that employed arrastras for amalgamation used them as the only device serving that function; the other half used the arrastras in conjunction with copper plates. In all, the surveyed mills used 570 stamps and 27 arrastras.

Figure 4. J. Boot watercolor of equine-powered arrastras in California, dated 1853. Small conifers in the mill basins were probably used to help sweep out the amalgamated slurry. Courtesy of Bancroft Library, University of California, Berkeley.
The number of stamp mills and arrastras employed in the larger milling operations of several western states was enumerated in the 7 January 1871 issue of the *Mining and Scientific Press* (Table 1). Only 3.7% of the milling machines in use at that time were reportedly arrastras. However, a note in that article mentions California had “several hundred, of which [only] 132 are reported” and that the number used in Arizona was an approximation. Based on the earlier survey, most of those arrastras were probably used for amalgamation. The nearly equal number of stamps and arrastras in Arizona implies the latter devices were likely used for both ore crushing and amalgamation.

By 1896, there were at least 119 arrastras in use in California, although that figure is again a nominal estimate that reflects only larger milling operations (Table 2). Their use had increased marginally, with arrastras by then employed in 30% of all gold milling operations in the state.20 Among those identified arrastras, 46% were water powered, 10% were powered by steam, 9% were powered by horses or mules, 1% was operated with a gasoline engine, and the motive power used for the rest was not specified in the annual report of the state mineralogist.

Greater use of arrastras in large industrial stamp mills at the turn of the century underscored their proven capabilities as good gold savers. In fact, the *Mining and Scientific Press* went so far as to state, “with free gold an arrastra will beat the best mill ever built, in results. Amalgamation is more satisfactorily accomplished in an arrastra than in the finest quartz mill.”22 Their reputation as gold savers is also highlighted by the fact that they were successfully used in a number of cases to reprocess tailings of less efficient gold-milling technologies.23 Figure 5 depicts one example where more than a half dozen arrastras were used to reprocess tailings from the 60-stamp Sierra Butte Mine in Yuba County, California, in 1891. In that kind of application, lower yields were balanced against substantially shorter processing times because crushing had already taken place.

Arrastras were used persistently into the 1930s, with some still in use in the late 1940s and 1950s.24 Anecdotal evidence suggests arrastras may have been used most heavily during periods of regional and national economic depression. That impression, however, is a working hypothesis that should be subject to scrutiny as inventory data become more widely available. Noteworthy economic depressions affected the western United States in the early 1870s, 1890s, and 1930s. During those periods, regional unemployment was high, and the arrastra technology provided a means to eke out an existence by mining marginal ore deposits not claimed by larger concerns or by reworking tailings produced by less efficient milling methods. The government’s decision to raise the official price of gold by more than 65% in January 1934 provided an added incentive to try mining during the Great Depression.

**Implications of Technology Choices**

Since the arrastra technology was widely known in the American mining industry and had many attractive
Table 2. Arrastras Reported in California in the Late-19th Century

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*One of these was powered by a gasoline engine.

characteristics, why was it relegated to the sidelines? Was that pattern replicated elsewhere? Answers to those questions have important implications for interpreting the social and economic contexts of arrastra use as well as for understanding the factors that influenced choices of technology. Those topics also inform understandings of the evolution of the capitalist world system.

It is often suggested that the main reason the stamp mill was favored over the arrastra had to do with the speed with which profits could be extracted from ore. As just one example, an 1899 mining journal states that arrastras were poor choices “where great quantities of ore are to be worked.” Yet, that perennial argument overlooks the simple fact that production quotas could be met with either technology by using an appropriate number of milling devices of the desired capacity. If technology choices were strictly rational, they should be based on the relative productivity of competing methods. It is thus instructive to compare the efficiency of the arrastra technology with stamping mills as a way to place technology choices in context.

Capitalism is often assumed to be a system where profits are maximized through efficient production. Yet a number of facts suggest productivity was actually not the primary reason stamp mills were chosen over arrastras in the late-19th century. Those production costs in the hard-rock mining industry can be broadly divided into investments in infrastructure (facilities,
equipment, water supply, timbering mine shafts, etc.) and operating costs (labor, energy, expendable supplies, etc.).

Turning first to the costs of basic infrastructure, the initial investment to build an arrastra was typically a fraction of the cost of setting up a stamp mill. Although some prefabricated arrastras were employed, arrastra construction generally avoided the high costs of acquiring and transporting heavy equipment. The cost of building two arrastras driven by a single waterwheel at the Commodore Mine in Siskiyou County, California, cost $700.\textsuperscript{26} That double mill had a five-ton per day capacity. However, the average for most arrastras was estimated by mining engineer C. M. Laizure at $300 or less per mill.\textsuperscript{27}

In contrast, a survey of 421 California active stamp mills in 1870 suggests the average cost of machinery in those mills ran more than $1,400 per stamp. Mining engineer Rossiter Raymond estimated the range was typically between $1,500 and $2,000 per stamp in the mid 1870s.\textsuperscript{28} The average capacity of the stamps in those mills was one and one-half tons per day, according to Raymond’s survey of 130 mills in 13 California counties. Those averages apparently did not include related infrastructure such as buildings, roads, and ditches, which would have been similar for any mining endeavor. Professor David Christy estimated the costs of getting a 20-stamp mill established in California in 1868 at about $50,000 with all necessary infrastructure included.\textsuperscript{29}

If the goal was to achieve comparable milling capacity, stamp mills were thus at least seven times more expensive to set up than arrastras. From the examples just discussed, it was possible to build a five-ton per day capacity with the arrastra technology for $700 (or less), while a comparable capacity would require more than three stamps, averaging $4,500 or more to install.

Figure 5. One of at least six arrastras used to reprocess tailings from the Sierra Butte Mine on the Yuba River in California, 1891. The direct-drive horizontal waterwheel is suspended on the outside of the mill basin. It could be operated by one man and a boy on a continuous basis according to the Mining and Scientific Press 55, no. 8 (22 Aug. 1891): 120. Courtesy Bancroft Library, University of California, Berkeley.
Those higher costs for stamp mills effectively limited their use to operations with heavy capitalization, and arrastras remained the most affordable choice for small operators who worked for themselves.

The per-ton costs to process ore in arrastras was also generally cheaper than in stamp mills, although actual operating costs were highly variable depending on the geological matrix, type of power, fluctuations in labor costs, and other factors. In 1892 the California state mineralogist observed, “the cost of milling in arrastras under proper conditions is 6 to 8 cents per ton; by stamps this would be 25 to 40 cents per ton.” 30 Those figures are probably understated. Laizure provided a more realistic estimate of the cost of using a double arrastra driven by waterpower. He states those costs “are estimated to vary from $1.25 to $2 a ton,” a figure likely predicated on the aforementioned Commodore Mine. 31 The Commodore used 30 miner’s inches of water to process a five-ton charge in the 1890s. By way of comparison, the 60-stamp mill at the Oneida Mine in Amador County, California, processed ore at a cost of $2.50 per ton in 1872; the 20-stamp mill at the Pittsburgh Mine in Nevada County processed ore at a cost of $2.25 per ton in 1873. 32

The cheaper operating costs of arrastras are also implied by their successful use in reprocessing the tailings of less efficient methods, already discussed. Their use for such low-grade ores suggests arrastras were not only efficient but also had the ability to capture precious metals lost in stamping operations. Nevertheless, period literature promoted the mistaken idea that arrastras were not “suitable for very low grade ores, as its operations are too slow to make such ores yield profit.” 33 That belief is perpetuated without critical reappraisal today. 34

Perhaps more significant than the lower costs of building and operating arrastras was their reputation as superior gold and silver savers. Gold recovery from late-19th-century stamp mills probably never surpassed 75% of the available metal, and some mining engineers such as Laizure and A. Paul claimed it was typically closer to one-third. 35 This was primarily due to two factors. First, the violence of the stamping method often led to “slimming” of ores and “flouring” of the mercury into such a fine powder that amalgamated gold and silver would not properly settle out. 36 As a result, the precious metals were washed away or otherwise discarded. Arrastras used a less violent method that recovered a higher proportion of the free gold. That is why they were used as an aid in the amalgamation process in large industrial stamp-milling operations as well as for reprocessing discarded stamp-mill tailings.

The second impediment to gold amalgamation was caused by the presence of sulphides, also called “sulphurets” in period literature. Many ores were coated with these substances, inhibiting proper amalgamation. Titus F. Cronise noted in 1868,

... when auriferous sulphurets are present, sufficiently rich in gold to make its extraction an object, they are frequently subjected to a further process of pulverization and amalgamation. This is effected by grinding them in a flow of water and mercury in an arrastra, chili mill, or in some of the many patent cast iron pans or grinding mills of recent invention. 37

Arrastras were able to remove some of the sulphides coating the gold and silver through abrasion, whereas the pulverizing action of stamps was generally ineffective. By brightening the surfaces of the metal particles, arrastras improved amalgamation and permitted more of the precious metal in the ore to be recovered. Other processes such as chlorination and treatment with cyanide eventually eclipsed the use of arrastras for such dirty ores.

Arrastras were thus generally much cheaper to build and operate than stamp mills and comparable or perhaps even superior gold savers in the days before stamp milling was augmented with other treatment processes. Their marginalization in the American mining industry during the late-19th century was thus not about productivity. It was more realistically about cultural preferences. Those preferences stand out when the American pattern is compared with the Mexican gold and silver mining industry of the same period. In 1886 it was reported that in Mexico “thousands are in use today, and no one can deny that the Mexicans know how to work ore as well as any metallurgists in the world.” 38 Those Mexican operations typically used arrastras for crushing and amalgamation, a pattern that apparently continued into the first decade of the 20th century. For example, a mill with more than a dozen mule-driven arrastras in Guanajuato, Mexico, is illustrated in a 7 March 1903 issue of the Mining and Scientific Press with the note that “there are no arrastra establishments operated in the United States on so large a scale.” 39 Two other mills in northwestern Mexico
had impressive arrays of arrastras that were powered by water during the first decade of the 20th century.\(^a\)

The American pattern resulted in large part from industry dominance by American investors of northern European extraction, as well as by the English. Stamp mills appealed to those capitalists for many reasons. First, stamp mills evolved from northern European precedents and were culturally familiar. Elaborate machinery was also esteemed, in part because it had proven so profitable in other industrial applications. Stamp mills symbolized the triumph of American technical ingenuity. As products of American industry, they were portrayed in the mining literature of the period as potent symbols of progress, speed, and modernity, regardless of their economic merits. That advertising succeeded splendidly.

In sharp contrast, the same literature is replete with disparaging references to arrastras, which were regularly called “primitive,” the “poor man’s mill,” “rude,” and even “slow and stupid.”\(^b\) Those terms conveyed the idea that arrastras were old, cumbersome, and outmoded, although grudging praise was sometimes interspersed in the very same sources. The strong association of arrastras with both native-born and immigrant Hispanic people meant that such devices, like those cultural groups, were the subjects of widespread discrimination and disdain in the American West. Hand-built arrastras became synonymous with marginality.

Modern cognitive science has shown that people respond to the way issues are framed, rather than to the way facts are presented.\(^c\) That finding points to the importance of understanding how products and technologies are manipulated as symbols. While arrastras were quite competitive with stamp mills, the language that influenced choices of milling technologies in American culture was dominated by terms that promoted stamp mills with glowing assignations while disparaging arrastras. That framing, not rational economic choices, appears largely responsible for the dominance of stamp mills and marginalization of arrastras in the American West. Nevertheless, the proven capabilities and advantages of the arrastra led to its continuing use in exploration, amalgamation, and reprocessing. In large, heavily capitalized mills, manufactured steel arrastras were sometimes employed, effectively transforming arrastras into modern machines on a par with other symbols of progress and industry.

**Design Evolution**

Arrastras were used by people culturally familiar with their design as well as others who learned about the technology by observation, word of mouth, or information provided in period literature. Hand-built examples can thus reveal much about tradition and innovation. Specific historical associations can shed light on the persistence of traditional designs, when innovations were adopted, by whom, and for what reasons. Some of the most obvious innovations are briefly considered before turning to a case study.

A fundamental innovation used in the American West between 1848 and the 1950s involves the types of motive power employed in the operation of arrastras. Animal power was the most common traditional form of energy used by Mediterranean peoples due to the general aridity of that region, although waterpower was also probably employed. In larger operations, water and steam power came to dominate American applications of the arrastra technology. Whether that pattern was equally prevalent in smaller mining enterprises is something archaeology is in a unique position to inform. Later in time, arrastras powered with gasoline engines and electrical motors were known, although they were probably the exception.

Another innovation that was adopted, mainly after the turn of the century, was the use of poured-concrete perimeter walls as well as floors made of stones set in concrete or mortar. At least two archaeological examples have been examined by the author in Calaveras County, California, and another was built in the late 1930s at the Kinder Mine on Willow Creek in Monterey County, California. The Kinder mill was built in 1937 and operated into the mid-1950s using steam power (Figure 6).\(^d\) The Calaveras examples include an unrecorded mine south of Indian Creek and site CAL-1065H just east of the town of Murphys.

A number of prefabricated steel machines based on the arrastra concept were also marketed in the late-19th century. At least 10 different brands of “pan” grinders and amalgamators of that sort were available by 1871. A. Paul later advertised another as an “Americanized Arrastra” (Figure 7).\(^e\) Paul’s design probably dates to the late-19th century. They were most widely used in the Comstock mines where huge arrays were installed to process ores with “sulphurets.”\(^f\) The earliest use of iron arrastras in gold mining may be one installed in 1864 at the Malvina Mine on Maxwell
Creek near Coulterville, California. The only discovered patent for an iron arrastra is one developed by Alexis Janin on 16 August 1892 for use in the amalgamation of silver ore.

Manufactured steel arrastras were not just a validation of the general utility of the technology; they also effectively placed it on the same footing as other “modern” industrial gold- and silver-milling methods such as stamp mills. Prefabricated arrastras eliminated one of the chief benefits of the technology—namely, that they could be cheaply made of local materials on site. That shortcoming was offset by the fact that such machines were portable, allowing reuse.

**Considering Arrastras in Context:**

**The Case of the Canone Mine**

Although the broad outlines of arrastra use in the American West have been sketched, major lacunae in that knowledge are indicated. Those gaps are an outgrowth of the fact that most arrastras were hand built by small operators who often left few records and were rarely noticed in period statistics. Archaeological research, when combined with those limited records, may thus significantly expand understandings of the niches carved out by such miners and how they fit into the industry at large. That interpretive potential is explored here, using as an example a small mining operation near Amador City, California.

The Canone Mine was determined eligible for the National Register of Historic Places for the design and

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**Figure 6.** A concrete arrastra at the Kinder Mine on Willow Creek in Monterey County, California. It was built in 1937 and continued limited operations into the mid-1950s using steam power. From the Ventura wilderness Society website [http://www.venturawild.org/news/fe01/kinder.html].

**Figure 7.** Almarin Paul’s manufactured steel arrastra. Courtesy of the Bancroft Library, University of California, Berkeley.
research value of its two surviving arrastra mills and its associated mining landscape. That finding was based on an investigation carried out for a highway realignment project subject to Section 106 of the National Historic Preservation Act. The mine was built and operated by Italian immigrants between 1882 and 1895. Recorded as CA-AMA-363/H, the mine is located in the western foothills of the Sierra Nevada Mountains.

The Canone Mine is situated about a mile west of “the richest part of the Mother Lode belt,” a 10-mile stretch in Amador County (Figure 8). Amador City is located just a mile upstream from the mine along the perennial Amador Creek. The creek comprised one of the very earliest placer discoveries in California, and the first stamp milling operation in the state was reportedly established in Amador City by 1851. The total output from mines near Amador City is estimated at more than 33 million dollars. That production was derived largely from the Keystone Mine, a venture that consolidated several adjoining claims in the town.

No hard rock mining was apparently attempted near the Canone Mine until Guiseppe Turre (later known as Torre) purchased the surrounding lands in 1880. By May 1882, Turre completed a ditch on the north side of Amador Creek using a water claim and the headworks of the old Milton Ditch sold to him by the prior landowner. The intake for the Milton Ditch was located just below several large-scale stamp mill sites in the town, a fact that was probably significant for the Canone Mine.

One arrastra was present on Turre’s property by 1882. Turre probably used proceeds from a $400 mortgage to develop three additional arrastras the following year. He then quickly deeded the mining rights on the north side of Amador Creek to another Italian immigrant named Antonio Canone for $3,400 in 1883. The

Figure 8. Mining claims in the Amador City vicinity, 1900. Map by author.
purchase price was financed by Turre. The deed specified that Canone was to receive the following:

All that certain water ditch which takes its waters from the Amador Creek, at about the southwestern limits of the Amador City town site, thence running down in a westerly side of said Amador Creek through the premises of the party of the first part (Guiseppe Turre), below the lower arrastra and known as the Turre Ditch with the privileges of about four hundred inches of water flowing in said Amador Creek, together with all flumes and aqueducts of said water ditch. Also four arrastras, with wheels and machinery therewith connected of all kinds and description with the privilege of erecting one or two more arrastras below said above described ditch, and on the land of the party of the first part, west of said Amador Creek and with the convenient space of land for working of said arrastras and taking out of the quarries the usual bolders [sic] and rocks necessary for said arrastras.\(^5\)

It is unclear why Turre sold his newly constructed milling equipment and ditch to another Italian immigrant. Amador County attracted many Italians who often sponsored others from their places of origin in a pattern of chain migration. The real reason, however, may have been that Turre deemed returns from the venture unsatisfactory. Whatever his motivation, Turre retained fee title to the land, developed a farm on the opposite side of the creek, and later perfected a non-mineral patent that encompassed the Canone Mine on 1 May 1884.\(^5\)

Insights into Canone’s life offer general clues about his mining operation. He was born in 1855 and emigrated from Italy in the early 1880s, perhaps attracted to the area because so many other Italians were already settled there. Canone was naturalized on 4 August 1886 and registered to vote the same day, but he remained illiterate and never married. The remains of two dwellings adjacent to his arrastras imply he lived at the mine. That practice would have deterred thieves and held down his living expenses.

Little is known about the mine from documentary sources, a fact probably quite common for minor operations of that kind.\(^5\) The county kept track of mining payrolls, but Canone’s operation is not listed in that ledger. That could imply he worked alone. More significantly, neither Turre nor Canone ever filed a quartz-mining claim. Whether that is a product of Canone’s illiteracy or an indication of the marginality of the mine is not completely certain. The latter scenario seems most likely, given the absence of any contiguous claims and the geology of the locality.

Despite that marginality, some limited returns are suggested. The scale of the mining carried out on the slopes above the two surviving arrastras suggests some values must have been returned to motivate that effort (Figure 9). It is also clear Canone experienced some

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Figure 9. Core area of the Canone mining complex. Map by author.
modest initial success because he retired his $3,400 loan to Turre within three years. That pattern apparently did not last. Although he continued to work the mine for more than a dozen years, it was eventually repossessed because Canone failed to repay a loan. As a result, the mine was sold back to Joe (Guiseppe) Torre at public auction on 9 July 1895 for a mere $60 to satisfy a judgment made against Canone in the Township 4 Justice Court. That low value implies the equipment present at the site had little residual value.

Canone’s declining financial circumstances strongly suggest the real source of the gold he recovered was his ditch. There are good reasons to believe tailings from the fabulously productive mines upstream contained appreciable quantities of discarded gold. First, inefficient recovery was characteristic of most early stamp milling activities. Second, ores from Amador City were known to contain “sulpherets,” a fact that initially impeded gold recovery. Finally, tailings in Amador Creek were later reprocessed in 1940 with a cyanide mill that recovered $5 of gold per ton. Yet, the significant effort Canone expended mining the slopes above his mills suggest he may not have realized the value contributed by those upstream materials. Eventually, losses of gold from upstream milling operations probably fell off as gold recovery processes were improved at the Keystone Mine. That seems to provide a good explanation for the precipitous decline in Canone’s fortunes, although other causes cannot be ruled out.

Archaeological remains of Canone’s mining complex include two relatively intact arrastras of remarkably similar layout and construction. Their uniformity of design suggests a clearly articulated mental plan. No other examples of arrastras built by Italians have been identified in published literature. However, the arrastra technology was widespread in the Mediterranean region and likely familiar to both Turre and Canone. These surviving examples provide information that should be useful for future comparative studies.

Each mill is located adjacent to a mined hillside along Amador Creek. The mill basins in both features measure 10 feet in internal diameter with 5-foot thick outer walls. The walls are faced with local metamorphic rocks and filled with earth and rubble. Both arrastras are quite substantial, and large stones were purposely selected for the walls. Figure 10 shows feature 2B prior to excavation. A plan and cross-section of that feature are provided in Figures 11 and 12. A trench placed across feature 2B revealed that the massive walls extend fully twice as deep
Figure 11. Plan of feature 2B with key features labeled. Drawing by author.

Figure 12. Cross-section of feature 2B showing stratigraphic sequence. Drawing by author.
as the floor of the mill basin and are surrounded by a 3-foot-wide channel, the full depth of the arrastra wall. Traces of the central axle survived, and several drag stones were left inside the mill basin, despite removal of the mill floor at the time it was abandoned. Regrettably, no evidence of the “wheels and machinery” mentioned in the mine deed survived to inform interpretation.

Canone’s arrastras were undoubtedly powered by water, based on the ample supply specified in the deed. However, the type of waterwheels used to power his arrastras was uncertain. The presence of a very large oak on the wall of feature 2B seemed to preclude a horizontal wheel, and an undershot wheel was not practical given the low head available. The only other feasible solution seemed to be an overshot waterwheel. That type of wheel could have been anchored to the large elevated rectangular terraces adjacent to both mill basins. Those terraces feature dry-laid rock walls of good workmanship with tailraces passing next to them. The available drop would have been sufficient for a wheel no larger than 8-foot diameter to operate over the tailrace with an axle supported on the top of the terrace. Drive belts or other devices would have been required to transfer power to the central axle and drag arms of the arrastras.

The terrace edges at features 2B and 2C contain no substantial stone reinforcement in the area where the axle for an overshot wheel would be expected. Instead, the main function of the terraces appears to have been as ramps that facilitated the transfer of ore into the mill basins. That use of the terraces as an active work space seems to be confirmed by the presence of a large drag stone blank left on the edge of the terrace closest to feature 2B. Bringing ore and drag stone blanks across the terrace would not have been practical if drive mechanisms also occupied that space.

Absent clear evidence that an overshot wheel was used, attention returned to verifying whether or not the oak on the wall of feature 2B was present at the time the feature was in use. That oak is an interior live oak (Quercus wislizeni) with a circumference at breast height of 12 feet, 5 inches. Mature trees of that species typically grow to 3 feet in diameter and live up to 200 years. Their growth is subject to extreme variability depending on edaphic conditions. The oak incorporated in the feature 2B arrastra is quite close to Amador Creek and had optimal growing conditions. A core was taken from the tree in an effort to confirm its precise age. That bore penetrated 18 inches, half of the tree’s nominal diameter, suggesting a minimal age of 96 years. The tree is likely marginally older than that because the trunk is irregular in shape, and the core did not hit the exact center of the tree. Even so, it appears quite likely the tree did not establish itself until after the mill was abandoned in 1895.

The channels surrounding both surviving arrastras at the Canone Mine lend significant support to the idea that these mills were powered with direct-drive horizontal waterwheels. The floor of the channel around feature 2B lacks evidence of compaction by draft animals, and animals are not mentioned in the mine deed. It is also striking that the channels around Canone’s arrastras closely resemble the configuration of the horizontal waterwheels shown in Figure 5. Like their counterparts at the Sierra Butte Mine, the channels around Canone’s mills are lined with rock walls on both sides. A concentration of machine-cut nails was also found near the outer edge of the channel surrounding feature 2B. Those nails are generally compatible with the known date of construction and could reflect either a wood lining installed to prevent scouring of the outer wall of the channel by water, or part of the wooden wheel left to rot in place.

Other aspects of the design of the arrastras at CA-AMA-363/H provide additional insight. Although the exact location of the scupper or outlet from the mill basin at feature 2B has not survived, the one at feature 2C is positioned close to the intersection of the tailrace and the channel around the arrastra. The mills are so uniform, it is likely the same design was replicated at feature 2B. The terrace at feature 2B is also interesting because a buried stone culvert passes under the elevated pad, providing a way to allow water to bypass that mill. The bypass implies the operation of the two mills could be synchronized, with a charge processed in one while the other was being reloaded. That mode of operation would have been particularly efficient for a single miner.

Soils from all three arrastras at CA-AMA-363/H were analyzed for residual concentrations of mercury and cyanide. Those results reveal mercury concentrations only marginally higher than background levels typical in soils of the region and cyanide levels equivalent to surrounding areas. Only one sample from a poorly
preserved arrastra at the far eastern end of the site (feature 2A) contained mercury in excess of the total threshold limit concentration of 20 mg/kg defined as hazardous by the state. Feature 2B produced less than 5 mg/kg and feature 2C produced 8.6 mg/kg. For comparison, background mercury is present in local soils in concentrations ranging from 0.10 to 0.17 mg/kg. Those findings suggest Canone used mercury frugally and recovered most of quicksilver he employed during amalgamation process.

The relatively well-preserved arrastra mills at CA-AMA-363/H are just one example of a small operation with clear associations, dating, and design details. Investigations at that site reveal some of the complexities entailed in interpreting the operations of such mills, which, although typically left in place, are often bereft of floors and drive mechanisms. Many other examples with verified associations and design details would be needed before it is possible to clarify larger patterns and answer basic questions such as whether or not certain configurations, materials, and modes of operation were characteristic of particular groups and periods.

The Canone Mine is an Italian version of an arrastra. Like other people of Mediterranean origin, the technology was culturally familiar, although it is uncertain if Turre had any direct mining experience before coming to America. The mills at CA-AMA-363/H are carefully planned and executed in a uniform pattern that suggests a strong traditional vernacular competence. Their layout took into account the need to site the mills and their waterwheels at elevations that took maximum advantage of the limited head available from a supply ditch. The buried stone culvert under the structure pad at feature 2B reflects intentional planning for synchronized use of water. Careful workmanship is evident through the site complex.

After relinquishing his claim to the mine on the Torre Ranch, Canone moved to Amador City, purchasing Lot 1 in Block 6 near the Bunker Hill Mine in 1900. He acquired two adjoining lots over the course of the following decade, living modestly and never marrying. Canone died intestate on 14 June 1925 of a self-inflicted gunshot wound. His three lots in Amador City and $462 in cash were distributed to his only surviving heir, Lena Caratto, a 21-year-old niece living in San Francisco.

Conclusions
While the arrastra technology was widely known and in many respects superior to other gold and silver milling approaches, its use was largely confined in the American West to smaller operations that often went unreported. That obscurity, combined with the fact that most arrastras were vernacular constructions often employed by those at the bottom of the socioeconomic ladder, underscores the potential contributions archaeology can make. Comparative studies will depend on the thoughtful accumulation of data from these often poorly documented resources. The Canone Mine offers an example of how future studies might seek to interpret this "poor man's" technology in a broad historic context comprising the intersection of technology, vernacular competence, social and economic factors, and environmental conditions.

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Notes
3. Almarin B. Paul claimed to have patented a metal arrastra in an article, “The Americanized Arrastra for Working Gold and Silver Ores,” Bancroft Library catalog no. F869.S3.7.P267, University of California, Berkeley, 1938. No corresponding patent has been discovered.
8. W. H. Storms, “How to Build an Arrastre,” Mining and Engineer-
ing journal (27 May 1911): 1054.
9. “Arrastra,” 799 (see n. 7).
10. California State Mining Bureau, Thirteenth Report of State Minera-
11. See Young, Western Mining (n. 1) for the earliest mining evidence in Arizona and New Mexico and Roger E. Kelly and Marsha C. S. Kelly, “Arrastras: Unique Western Historic Mining Sites,” Historical Archaeology 17, no. 1 (1983) for examples from the 1940s.
12. Storms, “How to Build,” 1055 (see n. 8).
13. Elisabeth L. Egenhoff, The Elephant as They Saw It: A Collection of Contemporary Pictures and Statements on Gold Mining in California (Sacramento: California Division of Mines and Geology, 1949), 116; and [Jesse D. Mason], History of Amador County, California (Oakland, Calif.: Thompson and West, 1881).
17. The Riverside arrastras are believed by Storms (see n. 8) to date to the early period of hard rock mining in California in the 1850s.
18. Auguste Rémond, Mining Statistics: No. 1. Tabular statement of the condition of the auriferous quartz mines and mills in that part of Mari-posa and Tuolumne counties lying between the Merced and Stanislaus rivers, August–November 1865, published by authority of the Legis-
lature of California, Geological Survey of California (Philadel-
20. Thirteenth Report (see n. 10).
21. Compiled from “Quartz Mills” (see n. 19) and the Thirteenth Report (see n. 10).
23. Kelly and Kelly cite several examples of tailings reprocessing operations that may have been conducted under contract with large, industrial mine operators in “Arrastras,” 87 (see n. 11). See also figure 5, an operation discussed in “The Arrastra,” Mining and Scientific Press 55, no. 8 (22 Aug. 1891): 120.
24. One example near Big Oak Flat in Tuolumne County, California, was still operating in 1948 according to Palmer C. Ashley, “Ancient Rastres,” Desert Magazine 34, no. 1 (1971): 16–17; the Golden Quartz or Kinder Mine in San Luis Obispo County, Cali-
ornia, still operated on a limited basis in the 1950s, according to the website of the Ventura Wilderness Society, Double Cone Quar-
25. “Arrastra,” 760 (see n. 7).
26. Eleventh Report, 315 (see n. 6).
27. Laizure, “Elementary Placer Mining,” 267–70 (see n. 5).
28. The Mining and Scientific Press (see n. 19) surveyed 421 California mines in November 1870; Rossiter W. Raymond provided an estimate of average erection costs for stamp mills of $1,500–$2,000 in Silver and gold: an account of the mining and metallurgical industry of the United States, with reference chiefly to the precious metals (New York: J. B. Ford and Co., 1873), 129.
29. David Christy, “How Shall Our Foreign Commerce Be Sus-
30. Eleventh Report, 316 (see n. 6).
31. Laizure, “Elementary Placer Mining,” 270 (see n. 5).
32. Costs for Oneida Mine are given by Henry Degroot, “The Mother Lode of California,” Overland Monthly and Out West Magazine 9, no. 5 (1872): 410; costs for the Pittsburgh Mine are given by Raymond, Silver and gold, 129 (see n. 28).
33. “Arrastra,” 760 (see n. 7).
34. Kelly and Kelly, “Arrastras,” 86 (see n. 11), state that “in order to return economic values, arrastras usually required relatively high grade ore with low capital and overhead investments.”
35. Almarin B. Paul, “Rebellious Gold Ores,” Bancroft Library cata-
log no. F869.S3.7.P267, University of California, Berkeley, 1938; and Laizure, “Elementary Placer Mining,” 266 (see n. 5).
38. “Working Gold and Silver Ores: Cheap Methods for Prospectors and Miners No. 1,” Mining and Scientific Press 52, no. 15 (10 Apr. 1886). This article is based on the notes of E. C. Van Blarcom who spent years in the Mexican mines.
40. Mark R. Lamb, “Hacienda Buburon, an Old Mexican Silver Mill,” Engineering and Mining Journal 86, no. 14 (1908): 663–64; and Frank H. Probert, “Primitive Mexican Crushing and Dress-
41. These terms were routinely applied in nearly all period descrip-
tions. Two typical examples include “Poor Man’s Mill,” (see n. 22); and “Arrastra—The Poor Man’s Mill,” Mining and Scientific Press and Pacific Electrical Review 70, no. 14 (6 Apr. 1895): 209.
42. See, for example, George Lakoff, Women, Fire, and Dangerous Things: What Categories Reveal about the Mind (Chicago: Univ. of Chicago Press, 1987); an excellent website, sponsored by the Cognitive Science Society, that provides sources and links to cognitive science and its findings about the way topics are framed with lan-
guage is available at CogWeb <http://cogweb.uchicago.edu/CogSci/>.
44. Rossiter W. Raymond describes two pans made by Knox and oth-
ers made by Horn, Booth and Company, Cox, Wheeler, Patton, Farrands, Hepburn and Peterson, Wheeler and Randall, and Varney in Mines and Mining in the Rocky Mountains, the Inland Basin, and the Pacific Slope (New York: J. B. Ford and Co., 1871); A. Paul’s “Americanized Arrastra” is advertised in a collection of his essays, reprinted in 1938, but originally dating to the late-
19th century (see n. 3).
46. Rémond, Mining Statistics, 4 (see n. 18).
48. The investigation is reported by Thad M. Van Bueren, “Drag-
stones and Stockraising: Results of Archaeological Test Excava-
tions at CA-AMA-363/H and -364/H in Amador County, Califor-


50. See n. 13.


52. Amador County, *Deeds W:450–452*, Amador County Archives, Jackson, Calif.


54. The following sources yielded no information on Canone’s mine: *Mining and Scientific Press; The Engineering and Mining Journal;* biennial reports of the state mineralogist; *Register of Mines and Minerals, Amador County, California* (California State Mining Bureau 1903); Amador County *Mining Claims, Index of Mining Claims, and Mine Labor*. Regrettably, no county assessment records, federal manuscript population census for 1890, or federal manuscript census of manufacturers and industries for 1890 have survived.


57. An article in the *Amador Ledger* (21 Nov. 1940) reported that Chester C. Torre was operating a cyanide plant to recover gold from tailings deposited in Amador Creek by the Keystone Mine some 70 years earlier. The tailings, mined using a hydraulic monitor, were being processed at a rate of one ton per hour with a recovery of $5.00/ton.


59. Substances are defined as “California hazardous” for handling and disposal purposes based on the *California Code of Regulations (CCR)*, Title 22, Division 4.5, Chapter 11, Article 3, § 66261.24. Test results mentioned here are derived from a Geocon Preliminary Site Investigation Report to Caltrans, dated 24 June 2002, California Dept. of Transportation, Stockton, Calif.

60. Purchased for $150 from Mrs. David Rettaglietta in 1900 (Amador County, *Deeds 19: 382*, Amador County Archives, Jackson, Calif.).


62. His death is recorded in the Catholic parish burial records of the Immaculate Conception Church in Sutter Creek, California. The distribution of his estate is listed in Amador County, *Decrees of Distribution 3: 124*, Amador County Archives, Jackson, Calif.