THE ANALYSIS AND CONSERVATION
OF THE BELLE FOOTWEAR ASSEMBLAGE

A Thesis

by

ANTHONY G. RANDOLPH JR.

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

December 2003

Major Subject: Anthropology
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ABSTRACT

The Analysis and Conservation of the

*Belle* Footwear Assemblage (December 2003)

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Nautical archaeology can be loosely defined as the study of the material remains of ships and their contents as a component of a broader cultural system. The oceans and lakes of the world are replete with shipwrecks from all eras, and these sites have become the premier source of data for the nautical archaeologist. The inter-relationship between vessel, cargo, and crew is expressed in the assemblages recovered from these sites, and analysis of these remains serves to fill in the expansive gaps between human behavior and the material culture that they leave behind.

The excavation of the French barque *Belle*, which had been part of La Salle’s ill-fated expedition to the Mississippi in 1684, yielded several hundred leather artifacts, predominantly in the form of shoes. This thesis first proposes to analyze the *Belle* footwear assemblage both as a representation of seventeenth century French culture and as a facet of La Salle’s final voyage.

The harsh environment of the sea floor, however, affects remains from the *Belle* site in myriad ways. Metal artifacts are transformed into non-descript conglomerations of marine growth and sediments called encrustations, while organic remnants are preserved via chemical reactions with metals, or by quick burial in anaerobic soils. Equilibrium established between artifact and its benthic
environment is disrupted upon recovery, and remains must be carefully treated to ensure long-term stability. This is the purview of the archaeological conservator. The role of the archaeological conservator is by no means limited to the stabilization of artifacts. They are also responsible for cleaning, documenting, and analyzing the objects that they treat.

The recent introduction of polymer passivation technologies, which relies heavily on silicon oils, provides archaeological conservators with a new option concerning the treatment of organic artifacts. This thesis also proposes to examine this new methodology, particularly focusing on the treatment of the leather objects recovered from Belle.
Dedicated to my mother and sister.

Their love and patience have made my life joyous.
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The completion of a master's degree represents the end of a small journey, and the beginning of an even larger one. The number of people who have fostered my love for nautical archaeology is beyond mention. I am sure that I have overlooked many, but those who come to mind are listed below. My pursuit of the discipline began as an undergraduate at the University of Pittsburgh, where anthropology professors Marc Berman, Kathleen Allen and Richard Scaglione first introduced me to the wonders of the past. My desire to pursue archaeology was solidified during field school at the University of Maryland, where John Seidel and Mark Leone presented an opportunity to relate to earlier generations in a tangible way.

My subsequent five-year tenure as a professional archaeologist at R. Christopher Goodwin and Associates was wonderful. While there I learned a great deal about life as well as archaeology. I made several lasting friendships during my employment, and would like to thank Christopher Goodwin, Christopher Polglase, Thomas Davis, Michael Hornum, Michael Simons, David S. Robinson, Jean-Bernard Pelletier and Adam Kane for their time and wisdom.

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professors in the Nautical Archaeology Department were all kind and generous men who took their roles as mentors seriously. I am a better person now than when I entered Texas A&M, and I would like to acknowledge Donny Hamilton, Wayne Smith, Cemal Pulak, Kevin Crisman, Shelly Wachsmann, Luis Felipe Viera del Castro and Helen DeWolf for their role in my improvement.

I have enjoyed friendships that have spanned many years. These people have served as confidants, advisors and stalwart comrades. More importantly, they have stood by me throughout my life, and have never turned away when I was in need. They are Arun Rath, Denis O'Connell, David Carroll, Chris and Dawn Betz, Christopher and Valerie Cook, and Kenneth and Katherine Craven. Thank you very much for all that you have done for me.

The great constant of my life has been my family. My mother, Rebecca Randolph, and my sister, Katherine Maria Randolph have been the cornerstone of my existence, and any accomplishment that I enjoy is also theirs. I would like to thank them for their love, patience and generosity; it has not been wasted.
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1. INTRODUCTION:

THE CULTURAL MILIEU OF FRANCE (1661-1684)

Excavation of the French barque, Belle, (1995-1997) produced a deluge of information concerning La Salle’s ill-fated expedition to the Texas coast and seventeenth-century French colonialism. After careful conservation and analysis, each of the two million artifacts recovered from Belle will contribute to the interpretation of this shipwreck site. Included in the collection were 350 leather artifacts, most of which were fragments of shoes or boots. An excellent representation of the overall assemblage, the leather footwear recovered from Belle relates to French history in two aspects. First and foremost these artifacts offer a glimpse into the daily existence of the French soldiers and colonists who ventured to the New World with La Salle in 1684. They also serve as silent reminders of the lives and skills of contemporary French craftsmen, in this case the cordwainer, or shoemaker.

Soldiers and craftsmen of that time lived in a world dominated by the French monarch, Louis XIV. Louis was determined to lead France toward international prominence, and this ambition was fueled by the sacrifices of the working class. Scholars, however, often look beyond the toil of the lower social classes, preferring instead to focus on the work of the king and his ministers. The

This thesis follows the style of American Neptune.
goal of this thesis is to place the French working class, which includes the crew of *Belle*, within the framework of Louis XIV’s France. This work represents an examination of the cultural milieu of France from 1661 to 1684 in order to set the historic background in which cordwainers and soldiers labored.

Special attention is given to Louis’ sweeping reformation of France, and effects that these changes had on the lower strata of the population. However, a complete summary of transformations that took place during those years is beyond the scope of this thesis. Only those aspects directly affecting the working class are discussed, including the reformation of French nobility, the economy, foreign policy, and colonization in North America. A review of the socio-political condition of France before the reign of Louis XIV is required to set the stage for the machinations of Louis XIV and his ministers.

France before Louis XIV (1614-1661)

Throughout history France has maintained the population and resource bases necessary for greatness. Despite these natural strengths, the French existed during the seventeenth century as a nation divided by war and poverty, without strong centralized leadership needed for success on the world stage. Hereditary rulers of France had little interest in governing their nation. Daily administration of the country was left to a series of stewards who acted in their stead. While these men
were focused on personal agendas, influential governors ruled French provinces with little concern for national priorities.¹

The plight of the French working class, however, had remained unchanged for twenty generations. France was mired in an agricultural economy based on a medieval feudal system, with 85% of the populace existing via subsistence farming.² Although the common man could generally feed himself and his family, the lack of a strong, diversified economy hindered national growth.³ Leadership within France between 1614 and 1661 had little concern for popular affairs, and a summary of their efforts will illustrate the condition of France at the time of Louis XIV’s ascension to power.

Coronated in the summer of 1614, Louis XIII immediately entrusted the stewardship of the country to his favorites at court, first the falconer Albert Duc de Luynes in 1613, and later the pious nobleman, Cardinal Armand John du Plessis de Richelieu in 1614.⁴ Richelieu displayed some prowess in leadership, but he was primarily concerned with persecuting French religious minorities and punishing protestant princes of Germany and Bavaria during the Thirty Years War (1618-1648).⁵

Upon the deaths of Richelieu and Louis XIII in 1642, the regency of France was officially passed to Louis' widow, Anne of Austria, in 1643. She subsequently requested that Cardinal Mazarin (Figure 1), a naturalized Italian nobleman, govern in her stead until the prince regent, Louis XIV, came of age.
Mazarin continued the work of his mentor Richelieu. More importantly, he became tutor and confidant to the young heir.\textsuperscript{6}

Under Mazarin, the influence of the French monarchy began to reach the provinces. Needing money to fill coffers that were depleted during the Thirty Years War, Mazarin heavily taxed provincial parliaments. This spurred a sporadic, and often violent, four-year civil uprising known historically as the Fronde (1648-1652). Suppression of this widespread unrest was a testament to Mazarin's brutal nature and political skill. His actions also served as an example to the young prince regent, reflecting the importance of central government and potential strength of the French monarchy. Although Louis XIV was coronated king of France in 1654, and married to the Infanta of Spain in 1660, he did not rule France until the death of his beloved Mazarin in 1661.\textsuperscript{7}

*Le Grand Siècle: Reforms and Abuses of Louis XIV*

*Manage your affairs yourself, sir, and raise no more premier ministers to where your bounties have placed me; I have discovered, by what I might have done against your service, how dangerous it is for a king to put his servants in such a position.*-Cardinal Mazarin, 1661\textsuperscript{8}

Louis XIV (Figure 2) was but twenty-three years old at the time of his ascension, but in his short life he had witnessed the rise of Spain, Portugal and England toward international prominence. He was also aware of the power of the
French provincial nobility and the value of a strong national leader who could bind France into an orderly, unified force. Most importantly, Louis believed in the latent greatness of his nation.

Louis, along with his loyal minister Jean-Baptiste Colbert (Figure 3), was determined to realize the potential of his dormant giant, regardless of its effect on his subjects. He spent exorbitant sums urging all facets of French culture toward international prominence, and forced thousands of subjects to serve in his armies. This personal obsession left no aspect of French society untouched; the most affected areas being the economy and France's foreign policy.⁹ His first priority, however, was to secure the loyalty of French provincial nobility.

The Court of Louis XIV

_The State is me._ -Louis XIV¹⁰

The fiercest opposition to a unified France came from the national parliament and the provincial nobility. According to the views of the French monarchy, these noblemen constantly inflamed the relationship between the monarch and his subjects. The Fronde, for example, was not viewed by the French aristocracy as a class riot, but as a protest against the influence of Louis XIV and his ideas of a unified nation. In light of these perceptions, it was clear that the king had to control these groups before France could be re-organized into a cohesive nation.¹¹
The goal of the crown was to entice the nobility with the grandeur and power of the central monarchy. The king himself would embody the national ideal of a glorious French commonwealth; he alone would represent a return to the golden age. This presentation of self was carefully crafted using fashion, ritual and perceived status; it was a call that few noblemen could refuse. The French writer, due De Saint-Simon, summarized Louis’ eventual control: *He* [Louis XIV] *loved above all splendor, magnificence, profusion. This taste he turned into a political maxim, and inspired his whole court to adopt it. It was to please him that one had to throw oneself into gaming, into clothes, into carriages...*

Louis began to fabricate this aura of personal greatness beginning with his coronation in 1654. His ministers immediately hired poets, historians and artists (Figure 4) to glorify every aspect of the monarchy, and no expense was spared for state sponsored events. Louis’ early extravagances were his most noteworthy. These include the expenditure of 84,000 *livres* on lace in 1668, and 14,000,000 *livres* on a diamond studded long coat in 1669. Such figures are even more astounding when one considers that the average French tradesman earned between 60 and 80 *livres* per annum in the latter half of the seventeenth century.

The scope of this royal propaganda grew along with Louis’ popularity. State sponsored festivals honoring the royal personage were held throughout France. These parties commemorated several culturally significant milestones, including the king’s birthday and important military victories. In an attempt to permanently broadcast his presence throughout the provinces, Louis commissioned twenty
large bronzes in 1684 that were to be placed in the squares of all French provincial capitals. The most lasting testament to this campaign, however, was the remodeling of Versailles in 1675.

Before Louis took control of the French monarchy in 1661, the French royal house moved from locale to locale throughout the year, much like medieval courts of centuries past. Winters were spent at the Louvre palace, while the more temperate months were spent between the smaller chateaus of Fontainebleau, Saint Germain and Versailles. The king decided in 1675 that the French sovereignty, which he considered the finest and most powerful in the world, was inadequately housed at the Louvre. Having always favored the small hunting chateau at Versailles, Louis decided to transform his small retreat into the showpiece of the French monarchy.

Early plans for remodeling Versailles were drawn in 1678 and an initial budget was set at two and a half million livres. Construction, which required an army of 36,000 workers, began early in 1679 and continued unabated until the project was completed in 1689. In keeping with Louis' vision of greatness, no expense was spared during construction. The project spanned eleven years, consumed over 60 million livres, and cost thousands of human lives.

Upon completion, Versailles (Figure 5) was truly the marvel of Europe. Royal architects created a compound that maintained 1350 bed rooms, over 500 acres of ornamental gardens (Figure 6), two chapels, and countless dining rooms. The associated staff, which included 14,000 permanent troops and 7,000 servants,
added to the grandeur of the estate. The imperial Roman theme of the décor and the countless images of the king constantly focused attention toward Louis and his vision of France.\textsuperscript{21}

The palace of Versailles was intended to serve as the political gateway to the monarchy. The enormous scope of the estate was intended to impress upon French nobility and foreign dignitaries alike the power and elegance of the king. Although considered by some to be garish and undignified, the palace was the most effective tool of Louis’ scheme to unify France’s nobility. French nobles flocked to Paris to join in the spectacle, and the apparent resources of the French state awed foreign diplomats.

This political campaign, which persisted until the French Revolution, culminated in the crown’s control of the vast majority of France’s 260,000 noblemen.\textsuperscript{22} In response to the state’s efforts, the royal house grew to enormous proportions under the reign of Louis XIV. His court routinely stood at over 10,000 members, while that of his grandfather, Henri IV, stood at 1,500 a century earlier. Although only the wealthiest 10% of the nobility could actually afford to stay at Versailles, this trend setting elite shaped the values and outlook of their peers.\textsuperscript{23}

Louis’ had succeeded in molding the nobility in his own image. His image, however, was not that of a kind and just leader. His machinations required much of his time, and his constant need for resources left the general population destitute from over-taxation. Lives of his subjects were meaningless, and the
thousands who died constructing Versailles were symptomatic of Louis' disdain for the common man. Unfortunately, newfound emphasis on opulence and fashion resulted in an increasingly decadent and neglectful noble class, and as a result, the welfare of the general populace began to suffer.

The change in the provincial nobility affected the social cohesion between peasant and landholder in two arenas. First, rural nobility began to spend an ever-increasing amount of time away from their lands. In doing so they became strangers to their tenants, and more importantly the tenantry could no longer rely on their protection. The working class had lost all recourse to law, and this behavior was positively reinforced by the state. Secondly, regional nobility began to increase taxes in order to pay for excesses that had become a necessity of their station. Money, traditionally saved for education or periods of scarcity, was now destined for the royal coffers. The working class was forced to survive with less, and any hope of upward mobility was quashed. The monarchy had intended to unify France, but it managed only to further divide it. The early portion of Louis' reign, however, was not spent entirely on restructuring the nobility. His drive to transform France into an international power also included diversification of the economy.
Colbert and French Economic Reforms: 1661-1684

Constantly reminded of the expenses required to achieve his nationalistic goals, Louis called for a rebuilding of the stagnant French economy. This task was assigned to financier Jean-Baptiste Colbert, who was appointed to Controller General of Finances in 1661. Colbert, a disciple of Mazarin and a trusted monarchist, effected significant change in the French economy between 1665 and his death in 1689. The economic success of Dutch and English industries and merchant fleets were the envy of Europe, and in response, Colbert’s early efforts were focused on stimulation of French industry and foreign trade. However, the re-organization of the archaic French tax system was his first concern.

The taille, or French head tax, was the primary source of income for the monarchy, and as a result it was the earliest tax to be revised. Financiers who governed the taille collection were corrupt and inefficient; less than half of the revenue collected actually arrived at the royal treasury. To illustrate, the crown received only 16 of the reported 56 million livres collected in 1660. In response, Colbert introduced order and accountability throughout the traditional tax structure.

Colbert first empowered the royal collection agents to police all aspects of the taille. These civil servants, who were constantly bullied by financiers and jeered by the working class, were now responsible for reporting any improprieties concerning the taille, including corruption and tax evasion. He also introduced
advanced bookkeeping and accounting procedures: specialists in regional financial centers carefully recorded all tax revenue. These efforts served the crown well, for in 1670 the taille yielded 24 million livres; a 50% increase from the previous decade.\(^\text{29}\) Although this first step helped to curb rampant corruption, Colbert continued to revise the taille by lifting exemptions enjoyed by the nobility and wealthy merchant class, or bourgeoisie. The working class, who had previously shouldered the burden of the head tax, now shared the responsibility with the rest of France.\(^\text{30}\) Colbert then shifted his attention to indirect taxes.

Indirect taxes, which included the aide (sales tax) and the gabelles (luxury taxes), were the plague of middle and lower classes. These tariffs, while not levied on necessities such as grain, were paid on luxuries that raised the quality of life for the whole of France.\(^\text{31}\) In response to dwindling royal finances, Colbert increased the yield of indirect taxes by raising existing taxes, creating additional ones, and contracting tax farmers. Tax farmers were individual businessmen who paid indirect tariffs of a region directly to the crown in exchange for the right to collect taxes from the general populace. In this way the crown was guaranteed a reliable, fixed income.\(^\text{32}\) State reforms were successful in realizing an increased tax yield for the crown, but neither Louis nor his finance minister was satisfied with those initial accomplishments.

French industry was in dire need of reform during the mid-seventeenth century. The goods that were produced, including wool, glass, tapestries and lace, were manufactured in small lots and were of inferior quality when compared to
the foreign competition. Items were sold regionally, but there was little demand for them either internationally or in the larger French population centers. French nobility and bourgeoisie, however, spent exorbitant sums on fineries imported from their European neighbors, and in doing so they consigned France's capital to the purses of foreign merchants. In an attempt to secure the loyalty of French and foreign consumers in Europe and the Levant, Colbert changed the face of French industry.

Industry in France had not progressed significantly since the thirteenth century. A portion of manufacturers adhered to ancient trade guild standards, but 40% of manufactured goods were produced by a poorly regulated cottage industry. Beginning in 1663, Colbert completely revised this system by limiting the power and growth of guilds and instituting stringent national standards regarding quality. He consolidated guild workshops into factories, and courted bourgeois investors with promises of royal titles. To support fledgling factories, the minister offered regional monopolies to businessmen who readily complied with state regulations and paid subsidies to those who struggled. By 1670, these measures had increased productivity and raised the quality of French goods. Enterprises that benefited the most were the wool and lace industries in Gascony and Provence, and textile and woolen industries in Paris and Languedoc.

To quench local needs for foreign fineries, Colbert imported foreign craftsmen to establish factories in France. He attracted specialists with royal loans and gifts, and once they had settled in France he forced them to train a
French workforce in their art. The newly introduced craftsmen included German gunsmiths, Venetian mirror makers and lace workers, and Dutch textile experts. For example, in 1665 Colbert enticed the Dutch textile specialist Van Robais to France with gifts and loans that totaled 100,000 livres. Robais quickly established a large textile mill in Abbeville that boasted an excellent product and a local workforce of 1,600.

Colbert’s efforts to rebuild the French economy were, from the state’s position, very successful. Tax reforms increased the yield of the taille from 16 to 24 million livres in five years. The concept of tax farming was profitable, with financiers engaging in bidding wars that raised an enormous sum from the populace. By 1681, indirect taxes had been secured under a single lease that yielded the crown 56,670,000 livres annually. The stimulation of industry succeeded on two fronts. New factories created thousands of new jobs for idle hands, and those hands could now pay the taille. In addition, regulations imposed on industry greatly increased the quality of manufactured goods, and the resulting French merchandise was in demand on all coasts. The fortune of the French monarchy, however, came at the expense of the French peasantry and middle class.

An affliction of the working class was a lack of representation within the government. Local parliaments were either rendered powerless or they answered to the king. With no regulations to protect the lower levels of society, state and bourgeois businessmen were free to abuse the populace for personal gain. Tax
reforms that benefited Louis and his court threatened the daily existence of the peasantry. Already hamstrung by grain tariffs imposed by absentee landlords, the rural workforce could not afford both the taille and their daily bread. Food riots, or entraves, were rampant during the seventeenth century. Entire regions revolted in 1662, 1675 and 1679 to prevent or ease famine.\textsuperscript{43} The aide and gabelles resulted in violent urban protests. Twelve uprisings occurred between 1661 and 1686, all reacting to over taxation.\textsuperscript{44} Rebirth of industry also dealt a severe blow to the working class. New factories that employed thousands of urban poor were infamous for oppressive working condition, criminally low wages, and 14 to 16 hour workdays.\textsuperscript{45} The impetus behind Colbert's ministrations was Louis XIV's voracious appetite for gloire, or greatness. As already noted, Louis' campaign for glorie was as expensive as it was ambitious, and his quest for military supremacy would demand even greater sacrifices from the French populace.
French Foreign Policy and the Dutch War

"Nothing brings a prince more prestige than great campaigns and striking demonstrations of his personal abilities" - Niccolo Machiavelli

The core of foreign policy during the seventeenth century was force. European nations vied with each other for a limited resource base, and the force that they could bring to bear, be it economic or military, frequently dictated the outcome of disagreements or open conflicts. In France, Louis XIV was firmly convinced that foreign policy was the essence of his royal function, particularly in war and the enlargement of his authority. French foreign policy between 1661 and 1684 was characterized by two salient happenings, the Dutch War (1672-1678) (Figure 7) and French colonial expansion in the West.

The traditional role of the French monarch was that of the warrior-king, and Louis XIV was eager to step into that role. An early interest in Machiavellian philosophy shaped his military policies; he felt that wars should be conducted with ruthless efficiency, discipline and overwhelming force. Louis' rationale for conquest, however, was vanity and greed, carelessly covered by a veil of perceived slights and concern for France's economic sovereignty. France's campaign against Holland from 1672 to 1678 was such a conflict.

Tensions between Holland and France had run high for centuries. Supremacy of the Dutch merchant fleet throughout the seventeenth century was long
perceived as a direct threat to French commercial interests. Colbert’s reformation of trade in the 1660’s brought France and Holland into direct competition with each other. Louis also chafed at Dutch involvement in a triple alliance with England and Sweden, thwarting the French attempt to annex the Spanish Netherlands in 1668. Holland was perceived as an arrogant nation that dealt with its neighbors in bad faith.

The true impetus behind the invasion, however, was Dutch military weakness. Their army was small, poorly trained, and they lacked the confidence necessary for success on land. Growth of the French navy, and Holland’s recent naval war with England, made a Dutch victory at sea uncertain at best. France was prepared for war in 1671. Minister Sebastien Vauban, who exclaimed there is no judge more equitable than cannons, encapsulated Frankish sentiments.

The Dutch War, as it came to be known, began on April 6, 1672. The French Army, which had swelled to 279,000 men by 1671, invaded the Dutch on three fronts, forcing them to sue for peace in early June. Despite the Dutch plea for mercy, conflict raged at sea and on land for seven additional years. French land tactics were focused on siege warfare, and they were extremely successful at taking city after city. The battle at sea, however, was viewed by most as a stalemate. France had won the war, but the gains did not justify the expenditure in human life.

Louis did not profit much from his victory. Territorially, France claimed a portion of the Rhineland in the northeast, and gained some control over the
heavily contested Spanish Netherlands. The venture was more effective commercially, for the Dutch economic infrastructure and merchant fleet suffered heavily. This left the bulk of the Mediterranean commerce to France, especially in the eastern Levant. The war, however, was undertaken as a conflict of gloire, and Louis, despite his victory, damaged his reputation at home and abroad. He was perceived as a dictator by much of Europe, and disdain that he held for allies and opponents alike sowed the seeds of jealousy and revenge among his royal peers.

The king and the nobility did not experience the true hardships of the Dutch War. Instead, soldiers and sailors alike suffered for the whims of the mighty. No longer comprised of equal parts foreign mercenary and Frenchman, the armed forces of Louis XIV consisted of French volunteers. Although rampant poverty made military service palatable to many, recruiters often resorted to brutality and deception to fill the king’s armies. The plight of the sailor was no better. Trained seamen and marines were a valuable commodity, and the royal recruiters impressed entire merchant crews into service; only fear of the lash kept them at their post. Work of the recruiters depopulated entire regions, which left many villages without breadwinners. This ruined the poorest families in regions such as La Rochelle, Paris and Marseille.

War was also an expensive endeavor. The enormous army massed for the Dutch War was difficult to fund, and Colbert had to increase the taille to supply his troops. The populace, which was already burdened with the excesses of
Versailles, almost collapsed under the increased demand. The army in Holland consumed 191 tons of bread daily, and the flow of grain towards the front often resulted in shortages in the provinces. Peasants stopped shipments of cereal crops from leaving the regions where it had been produced, and the deficit culminated in grain riots in 1675 and 1676. The war ended with the treaty of Nijmegan in 1678, and this brought a measure of stability back to the countryside. War, however, was not Louis’ only foreign concern. His colonies in the New World, particularly New France (Canada), were in disrepair, and required royal intervention to prevent further atrophy.

French Colonialism in the West

Before the reign of Louis XIV, French colonial presence in North America was of secondary importance to the French Monarchy. The colonies had fallen into disorder, and there was little incentive for Frenchmen to settle there. Motivated by the colonial success of his rivals, Louis XIV was determined to transform his ragged colonies into a model French state. The reform of New France serves as an excellent example of French colonial policy in the latter half of the seventeenth century.

In 1661, the colony of New France was in danger of collapse. A company of independent merchants, known as the Company of a Hundred Associates, had governed the colony for over 40 years. They threatened to ruin the enterprise in a
quest for profit. The colony drained the royal coffers instead of filling them, and their colonial militia had not subdued the native Iroquoians that threatened Montreal and Quebec. As a result the population was in severe decline. Death was common, and dangers represented by marauding Native Americans and inhospitable Canadian winters forced many early French colonists to return home. Of the Frenchmen that departed France before 1665, only 31% stayed in colonial service for more than five years.65 Determined to match the profitability of Dutch and English colonial holdings, the king charged Colbert in 1665 with resuscitation of his lands abroad.

Colbert’s quickly placed New France under royal control by naming Jean Talon intendant and governor in 1665. Talon encouraged colonial growth by forcing landholders to clear ground for cultivation, and he granted new land patents to servants who had faithfully served their indenture.66 Talon also requested aid against the Iroquois, and Colbert sent a force of 1,500 French regulars under the command of nobleman Seigneur de Tracy to push them away from Montreal. Once the colony was secure and reasonably self reliant, the government fortified their possession with capital and a much needed labor force.67

Royal recruiters in Paris, Marseilles, and La Rochelle supplied the colony with a new labor pool. They offered land grants, trading privileges and a substantial stipend of 130 livres to any able bodied man who was willing to settle in the New World for five years.68 Successful colonial merchants also provided
passage abroad, and the prospective settlers were able to negotiate shorter terms if they were skilled in a trade. This proposal was sufficient to entice many poor peasants and craftsmen to New France. Over 27,000 Frenchmen left for colonial service during Louis’ reign.⁶⁹

The funds needed to revitalize the holding were sent to Talon annually. He routinely received 200,000 livres per year to stimulate the coal, fishing, and beaver pelt industries that had declined due to government neglect.⁷⁰ Revitalized enterprises attained varying degrees of success over the next two decades, and the French government began to receive profit from its long dormant colony.

Despite periodic struggles with the harsh climate and discord with the Iroquois, life in New France gradually improved under Talon’s leadership. Although there were periods of difficulty, settlers were able to survive through a combination of farming, fishing and trade work. Furthermore, they were not required to pay taxes directly to the French crown, and their local tariffs were far less severe than those levied on their continental countrymen.⁷¹ Some inhabitants of New France successfully exploited the resources of the deep north.

Trappers and merchants garnered enormous profits from the abundant supply of beaver pelts in the North, and the constant search for trapping grounds inflated the borders of the small colony.⁷² This unchecked growth concerned Colbert; he did not want New France to expand beyond the grasp of Talon and the French state. The king, however, was eager to gain territory for France, and Colbert begrudgingly permitted expansion in 1660.⁷³ The prospect of exploration for the
king motivated several *bourgeois* entrepreneurs who were eager to establish their name in Paris. Among them was an ambitious young man from Rouen, Rene-Robert Cavelier *de la Salle*.

Colbert's reforms saved New France from ruin. Because of immigration, the population grew between two and five percent each year after 1665, and the birth rate also increased on account of improved living conditions. The capital that Colbert invested in colonial industries quickly paid dividends for the crown. Timber and fish from Montreal flooded into France, and the French government held a monopoly on the Canadian fur trade. Revitalization of New France would continue to pay dividends for the French crown well into the future; the colonial output from French Canada would rival the production of English North America by the first quarter of the eighteenth century.

Royal improvements to New France also benefited the French working class. Although there was an established social hierarchy in French Canada, distinction between classes was not nearly as severe as that of France. Upward mobility was possible in the colonies, and the average income of an established colonist exceeded the earnings of most continental Frenchmen. The fur trade was a lucrative endeavor for any soul hearty enough to endure the Canadian wilderness; many trappers left Canada with more capital than the merchants who had originally sponsored their passage.

News regarding the promise of Louis' northern holdings had reached continental France by 1660. Although prosperity in the new world was never
assured, the allure of profit and adventure enticed an ever-increasing flow of titleless French *bourgeoisie* to New France. In keeping with the ideals established by their regent and king, these young Frenchmen began to view this colonial option as an opportunity to earn capital while improving their social status regionally and within Versailles.\(^79\) It is for these reasons that Rene-Robert Cavelier Sieur de La Salle, son of a *bourgeois* clothier, departed La Rochelle, France for Montreal in the spring of 1666.\(^80\)

Over a period of 14 years, Rene-Robert Cavelier, historically know simply as La Salle, embarked on an ambitious series of treks through the wilds of North America. Primary accounts of these events represent an inexhaustible source of information regarding Native American populations, geography and seventeenth century European attitudes toward newness and colonial expansion. The following chapter will discuss La Salle’s contributions as an explorer by investigating his endeavors in New France and below. Particular attention will be paid to La Salle’s final voyage to Texas in 1684. Data regarding La Salle’s last journey, however, is not strictly relegated to recorded histories. Remains of his wrecked barque, *Belle*, were uncovered in 1995, and the last portion of this chapter will be dedicated to a review of the discovery and subsequent excavation of this vessel in 1996 and 1997.
2. A FRENCH COLONIAL LEGACY:

RENE-ROBERT CAVELIER-SIEUR DE LA SALLE

Discovery of *Belle* in 1995 rekindled interest in the storied endeavors of Rene-Robert Cavelier, Sieur de La Salle. This interest, however, is no longer interpreted via the schema of history or historiography; archaeology now dominates the landscape of La Salle’s past endeavors. Despite this fundamental shift, modern scholarship and primary source documentation that comprise Cavelier’s accomplishments remain as invaluable tools that can be used to fill the interstices between material culture and the anthropological interpretation of *Belle’s* remains. The following chapter represents a succinct history of La Salle’s efforts, forever linking the *Belle* footwear assemblage to historical events that resulted in their deposition in 1686.
France, La Salle, and Creation of an Empire

The seventeenth century was a period of unchecked colonial expansion and economic growth for several Western European powers. During the first half of that tumultuous century, Spain had solidified its hold on Mesoamerica and the greater part of the Caribbean. England maintained an ever-expanding colonial presence in North America and the Dutch trading empire had exploited half of the known world for power and profit. France had fallen woefully behind in the race for new territories, and the inadequate funds that she received from her holdings limited the king’s ability to effect change within Europe.

In recognition of France’s colonial inefficiency, Louis XIV slowly began to assert his might in order to establish a permanent presence in their North American protectorate of New France. This rededication resulted in an influx of new colonists and resources that encouraged the development of lucrative fur and fishing industries. As profits rose and probability of failure dropped, an increasing number of ambitious, educated Frenchmen left the relative safety of the continent for the promise and adventure of the Canadian wilderness. One such man, Rene-Robert Cavelier Sieur de la Salle, left an indelible mark on the history of the North America.

La Salle spent the final twenty-one years of his life in Canada, France and Texas, and in that span he became one of the most influential Frenchmen in North America. Despite his political acumen and shrewdness as a merchant, La Salle
reputation as an early North American explorer remains his most lasting gift to history and archaeology. Although his resume as a discoverer boasts five distinct journeys, three of these stand as his greatest legacy. The first exploration began with construction of Fort Frontenac at the northernmost extremity of Lake Ontario in 1673. This six-year adventure resulted in the first navigation of the Great Lakes. The second expedition began in 1682. In this instance La Salle journeyed from the southern shore of Lake Michigan, down the Illinois and Mississippi Rivers to the Gulf of Mexico. His tragic third voyage, which was an attempt to establish a French fortification at the mouth of the Mississippi, departed La Rochelle, France in 1684. The written histories of these expeditions have become lore and have contributed immeasurably to our modern understanding of North America’s colonial past.

The discovery and excavation of La Salle’s wrecked frigate Belle in 1995, however, has shed additional light onto this period of early America. Tangible reminders from Belle permit a privileged glimpse into the daily lives and hardships of La Salle and his fellow colonists, while also providing concrete evidence of France’s colonial aspirations. Using the accumulated scholarship regarding La Salle’s colonial explorations, this chapter will set the historic provenience for the Belle shipwreck site. This background will include accounts of La Salle explorations, and end with his final journey in 1684. The concluding portion will represent a review of the Belle excavation and her relevance to the events that preceded and followed her deposition in Matagorda Bay. In order to
gain perspective on the machinations of a mature La Salle, it is prudent to review his formative years in France and Canada.

The Early Life of Rene-Robert Cavelier (1643-1671)

The Cavelier surname was near the center of French society during the seventeenth century. Hailing from the commercial city of Rouen, two Cavelier brothers, Jean and Henri, had both become prominent bourgeois merchants and lay members. The older Henri Cavelier had become one of the original members of the Company of Hundred Associates, which was an assembly of merchants responsible for the French colonization of North America. Jean, through hard work and political wisdom, had become the master of Rouen’s cloth-merchant guild, the Confrerie du Notre Dame.\(^8^1\)

In the fall of 1643, lives of Jean Cavelier and his wife, Catherine Gest, were focused on the health and safety of their growing family. Catherine had blessed Jean with their first son, Jean Cavelier II, in 1637, and both awaited the coming of their second child later that year. Jean Cavelier II developed into a model adolescent. As first-born, he was encouraged to pursue the church as a profession, and as such he was preparing for life as a Jesuit Abbe in order of St. Sulpice. Expectations within the Cavelier family were that the next descendant would do the same.\(^8^2\)
The Caveliers’ second child was born on November 22, 1643. Christened Rene-Robert, this new son seemed destined to follow his older brother as a member of the clergy. Beginning his Jesuit education at an early age, La Salle displayed an exuberant personality and boundless energy. While under the tutelage of his masters in Rouen, he also exhibited a keen intellect with an obvious aptitude for science and mathematics. Having finished the curriculum at Rouen before the age of 15, and left for Paris shortly after to study further and enter the Jesuit order as a novitiate in the Society of Jesus in 1658.  

While in Paris, the young Cavelier entered the Jesuit school famed for natural science and mathematics, the College of Henry IV. Studying under the Jesuit name of Brother Ignacius, La Salle honed his abilities in philosophy, mathematics and navigation. Despite his success as a student, Brother Ignacius became increasingly stubborn, overbearing and irascible. His superiors viewed these traits as contradictory to Jesuit philosophies, and the resulting backlash prompted La Salle to withdraw from religious life in 1665. Unfortunately for La Salle, French law prohibited men who had taken religious vows from claiming inheritance. Finding himself without funds, La Salle considered life in New France as a way to change his financial condition.  

New France was an attractive option for La Salle for several reasons. His older brother and uncle resided in Montreal and Quebec respectively, and both offered to help him establish a base as a landed merchant. The lucrative beaver fur trade that surrounded the Great Lake region and the promise of dealing with
Native American populations also lured him to the colony. These conditions, and the lack of other potential options, prompted La Salle to leave La Rochelle, France for Montreal in 1666.\textsuperscript{85}

Upon his arrival, La Salle was immediately granted a tract of land on the St. Lawrence by the Brotherhood of St. Sulpice, of which his older brother Jean was a member. Naming his new holding St. Sulpice after his benefactors, La Salle immediately began clearing land and attracting settlers to his new holding. Consisting of 280 personal acres and a 133 acres of common land, his town became popular with colonists and became a success by 1668. La Salle need only wait to realize the fortune that awaited all shrewd land seizure.\textsuperscript{86} His desire for power and fame, however, demanded more than comfort and profit.

Born at a time when exploration was considered to be at the height of bravery and duty to country, La Salle (Figure 8) lusted for the recognition that stemmed from discovery.\textsuperscript{87} Convinced that the lakes and rivers of New France extended to the western edge of the continent, he desired to find a route using these waterways through North America to China. Selling his holdings at St. Sulpice for 1,800 livres of capital in January of 1669, La Salle embarked on a series of treks down the Ohio River in July of that year. After 20 months of exploration, La Salle was confident that the Ohio and its tributaries emptied into the Gulf of Mexico and not the mythical China Sea.\textsuperscript{88} He was determined to reach the outflow of these great rivers.
La Salle, Griffon and the Comte De Frontenac (1672-1681)

Upon his return from the Ohio River valley, La Salle ventured on a series of explorations in August of 1671 that took him from the Illinois to the Mississippi Rivers. Having reached as far south as the 36th degree of latitude, an exhausted La Salle returned to Canada without means to venture further south. As he arrived in Montreal in December of the following year, La Salle was confronted with a change of leadership in New France. The ambitious Louis de Baude, Le Comte de Frontenac, had replaced the previous intendant, Jean Talon. La Salle immediately recognized Frontenac as a possible ally and was determined to impress the new leader with bravado and his mastery of the local Iroquois populations.89

The Comte de Frontenac was an aggressive leader who was determined to impress Versailles by transforming a mission country into a crown colony.90 The first step toward this end was the subjugation of the Iroquois nations that threatened all French holdings south of Quebec City. To accomplish this, a fortification was to be constructed at the northern extremity of Lake Ontario by 1674. The French assumed that an armed presence on the lake would prevent Iroquois trading parties from penetrating south into northern New York and bartering beaver pelts with English or Dutch merchants, thereby forcing them to deal with the French as business partners instead of competitors.91
As envisioned by Frontenac, a meeting between the leadership of New France and select members of the Iroquois (Figure 9) was to precede any building in order to secure a window of safety for engineers and workmen to construct a stronghold. To guarantee Native American participation in the assembly, Frontenac required a Frenchman versed in Iroquois language and traditions; La Salle was logically chosen to fill this position. On July 12, 1673, the Comte de Frontenac and his entourage of 120 soldiers convened at the village of Katarokouy with over 200 Iroquois elders whom La Salle had convinced to attend. Impressed by the confidence and pomp of the French leadership, the assembled headmen approved the building of the fort. Construction began immediately after the agreement, and a primitive fort with four bastions was completed within the span of a week. La Salle spent the next year clearing land around the base and awaiting an opportunity to continue his adventures.

Despite completion of the newly named Fort Katarokouy, Frontenac still needed Royal approval for the venture. To this end, the Canadian intendant sent La Salle to Paris in the winter in 1674 to request additional funding to expand the small garrison and introduce his new assistant to Chief Minister Colbert and the Sun King himself. La Salle was granted a royal audience upon arrival at Versailles, and he so impressed the court with his wit and determination that he was granted governorship of the Katarokouy endeavor and funds to expand the base.
Upon his arrival in Quebec in October of 1675, La Salle busied himself with improvements to his fortification, which was renamed Fort Frontenac in honor of his new patron and ally. By September of 1677, the compound boasted a circumference of 360 fathoms and was defended with nine cannon and four expanded bastions. As governor of the new stronghold, La Salle was guaranteed a yearly profit of 20,000 *livres* from the regional traffic in furs. Despite this, he still desired, above all else, to follow the great rivers of America south toward the Gulf of Mexico.

Encouraged by his success at court two years previous, La Salle sailed for France in November of 1677 to petition the king for funding to explore the Mississippi River and her tributaries in order to claim the Mississippi valley for France. Asserting that this colonial addition would staunch English expansion west of the Mississippi River, Louis XIV granted La Salle all that he had hoped. He was given permission to "*work at the discovery of the western part of our said land in the New France, and for the execution of this enterprise, to build forts in places you deem necessary...upon the same terms and conditions as Fort Frontenac...*" The credibility that La Salle earned from this royal boon made solicitation of funds in France effortless. He departed La Rochelle with enough capital to build a large sailing vessel and man an extended venture down the Mississippi River. Joined by thirty men and two fellow adventurers, La Motte de Lussiere and Henri de Tonti, Rene-Robert Cavelier once again sailed from La Rochelle on July 12, 1678.
Having arrived at Fort Frontenac in early September, La Salle began to prepare for his journey to the Gulf of Mexico. By November of 1678 he had assembled three separate parties to accomplish his goal. The first was an advance party of fifteen men who were to join a friendly group of Native American from the Illinois tribe near the headwaters of the Mississippi River at Green Bay. While there they were to barter for buffalo hides that could be used as additional capital until the arrival of La Salle the following spring. The second group consisted of 16 colonists under the charge of La Motte de Lussiere. They were to travel to the western tip of Lake Ontario to construct a small fort and sailing vessel near the mouth of the Niagara River that would once again limit the passage of Native American traders to the south. The third party, which consisted of Tonti and La Salle, were to join La Motte in a matter of weeks with additional workers and supplies.99

The first group reached their goal near Green Bay with little trouble, and they immediately began to accumulate buffalo hides. The second party under command of La Motte de Lussiere was not as fortunate. Local Iroquois were not receptive to construction of a fort, and it was not until La Salle joined the group that the tribes warily consented to the project. Construction on both projects progressed throughout the winter, and the fort and vessel, now named Conti and Griffon respectively, were completed by mid-August of 1679. With a second fort and a new vessel at his command, La Salle was anxious to join his first party camped near the head of the Mississippi River.100
La Salle, Tonti and a Sulpician Friar named Hennepin boarded *Griffon* days after its completion and proceeded to sail her the length of Lakes Erie, Huron and Michigan where they encountered members of the advance party at the mouth of Green Bay a month later. Despite the daily challenge of survival on the frontier, the team had accumulated buffalo hides valued at over 12,000 livres. Pleased with their efforts, La Salle loaded the merchandise onto *Griffon* to be sent to Fort Conti for storage. Rene-Robert would await their return at the southern tip of Lake Michigan, and from there they would begin their intrepid descent down the Mississippi.¹⁰¹

While awaiting the return of his vessel, La Salle and his men constructed another stronghold, named Fort St. Joseph. The local Illinois tribe, however, did not welcome his presence, and they began to raid his meager supplies and undermine the confidence of his men. Convinced that he needed to separate his team from the Illinois saboteurs, Rene-Robert Cavelier left Fort St. Joseph for a new site on Lake Michigan in January of 1680. After an appropriate position had been chosen, he ordered construction of another garrison, named Fort Crevecoeur, and a vessel needed to navigate the waters of the Illinois and Mississippi Rivers.¹⁰²

The time spent at Crevecoeur was neither pleasant nor productive. Weather prevented the completion of the vessel, and La Salle became increasingly disconsolate as his concern for *Griffon* and her crew grew. After an agonizing six-month wait, he was forced in March of that year to consider the vessel lost.
Left with a demoralized band of colonists and a dwindling food supply, he had little choice but to return 1,500 miles back to Fort Frontenac. Leaving Tonti and a handful of colonists at Crevecoeur, La Salle and four others departed in March. After 51 days of toil and hardships, La Salle arrived penniless and weakened where his journey had begun.\textsuperscript{103}

To remedy his dire financial standing, La Salle turned to his patron, Louis de Baude. The Comte de Frontenac lent him funds to supply a small expedition and complete construction of the vessel left at Crevecoeur. Still determined to realize his goal, he and 25 men left to relieve Tonti in August of 1680. The trek back to his garrison on the southern shores of Lake Michigan was once again filled with hardship. Forced to deal with a raging battle between the Illinois and the Iroquois nations, La Salle was unable to locate his ally and second in command until May of the following year. He encountered Tonti convalescing near Green Bay. With the essence of his party once again intact, he once again returned to Fort Frontenac to renew his quest.\textsuperscript{104}
Descent Down the Mississippi River (1681-1683)

Despite the adversities of his failed attempt, La Salle was determined to complete his royal charge to discover the outflow of the Mississippi and claim the entire region for France and the glory of his king. The personal hardships experienced during those two torturous years encouraged La Salle to pursue his second trek differently from the first. The new expedition was to be led by him only, and the party would never be divided into several groups who, as previously witnessed, could desert on a whim. Trust was no longer a facet of La Salle’s personality.\(^{105}\)

The new party was to consist of 20 French colonists, Rene-Robert Cavelier, his older brother Abbe Jean Cavelier, Henri de Tonti, and a Franciscan Recollect, Father Zenobe Membre. These men were originally intended to ply the Illinois and Mississippi Rivers in a small sailing craft that lay half constructed at Fort Crevecoeur. La Salle spurned this unwieldy vessel in favor of swift and maneuverable birch bark canoes favored by Native Americans indigenous to the Great Lakes region. Supplies that could not be carried in the smaller craft were to be obtained from the multitudinous tribes that inhabited the Mississippi valley.\(^{106}\)

After traveling between Fort Frontenac and Fort St. Joseph recruiting expedition members, La Salle and his band left French territories near Lake Michigan on December 19, 1681. Initial progress was slow, as ice clogged even the central channels of the smaller rivers. The ice flows gradually subsided as the
party pushed southwest, and by the end of January, 1682 the caravan of canoes entered the Mississippi River with the promise of clear waters.\textsuperscript{107}

As weeks passed La Salle and his party encountered several Native American tribes unknown to the European world. Among these tribes were the Arkansas, Tensas, Natchez and Oumas. La Salle, with an extant knowledge of native languages and regional customs, was always viewed favorably. As a result, the Frenchmen exchanged trade goods for gifts of food, and were often entertained as dignitaries. These small triumphs suggested that this descent was to be as uneventful as the first was tragic.\textsuperscript{108}

There were signs that the journey was nearing conclusion by the fourth week of March. The river current had picked up, temperature and humidity had risen noticeably, and the water had a salty, brackish flavor. Shortly after, La Salle and his party wandered onto the expansive delta of the Mississippi River near the modern city of New Orleans, Louisiana. Confronted with three natural channels leading to the sea, La Salle finally consented to break up the party into three separate groups. Each would explore a route and would join the others at the outflow of the central tributary. Three days later the groups were reunited, symbolizing the fulfillment of La Salle’s long-standing obsession.\textsuperscript{109}

On April 9, 1682, La Salle and his party gathered to celebrate this auspicious occasion for God and Louis XIV. A speech, followed by shouts and several rounds of musket fire marked the event, followed by commemoration of a pillar inscribed “Louis the Great reigns 9\textsuperscript{th} of April, 1682-Robert Cavelier, with Lord
Tonti-ambassador, Zenobio Membre-Recollet, and 20 Frenchmen, first navigated this river from the country of Illinois, and passed through this mouth on the ninth of April, sixteen hundred and eighty-two. The vast territory was named Louisiana in honor of the new owner of the Mississippi Valley, Louis XIV of France.

After the land had been claimed for the French crown, there was little incentive to linger in the bayous of southern Louisiana. The trek back to the confines of New France took twice the expected time, as the party had to combat fever, a lack of provisions, and the contrary current of the Mississippi and her feeders. La Salle and his party finally arrived at Fort Crevecoeur in the winter of 1682, with the goal of rebuilding the fort and generating an income from the trade of beaver pelts to appease his creditors.111

After some deliberation, La Salle and Tondt concluded that a new fort should be constructed near Crevecoeur in a more defensible position. This garrison, named Fort St. Louis, was built on a nearby rocky peninsula, and it was there that La Salle decided to continue as a merchant. During these endeavors, news of his arrival spread throughout the colony. As was typical in a colonial society, his accomplishment was doubted instead of praised. La Salle, who had just completed one of the most important trips in North American colonial history, was destitute and a pariah. In addition to this, a change in the colonial leadership threatened to cost La Salle all that he had labored to accumulate.112
During his venture to the mouth of the Mississippi, La Salle’s ally and closest friend within the government of New France, Louis de Baude, had been replaced by the cruel and avaricious Le Febvre de la Barre. While La Salle was monitoring a burgeoning trading company to the west, La Barre stripped him of his holdings at Fort Frontenac, claiming that the younger Cavelier had failed to defend it as ordered by the kings’ patent. As winter approached in 1683 La Barre grew even more aggressive and he began to threaten his holdings at Fort St. Louis. These actions forced La Salle to again sail for France. While there he petitioned the king for the return of his property and permission for a new venture to establish a permanent French settlement near the mouth of the Mississippi.\textsuperscript{113}

The Final Voyage (1684-1687)

As La Salle landed at La Rochelle, France in January of 1684, he was faced with the most serious crises of his life. His holdings in New France had been wrongly seized and he was suffering under a crushing debt burden from his previous explorations. Once again faced with raising capital, La Salle first attempted to elicit funds from private investors in Paris and Rouen. Finding those avenues closed due to due his well-publicized business failures, La Salle was compelled to petition King Louis XIV for the funds needed to start a new colony.\textsuperscript{114}
He wished only to find the outflow of his river from the Gulf of Mexico, and establish a nearby stronghold from which he could control southern commerce unopposed. Understanding that the king would not sacrifice resources to start such a colony, he couched his true desires within a larger proposal that would be viewed favorably by Versailles. Borrowing from a plan developed by a disgruntled Spaniard called Penelosa, La Salle suggested that a garrison near the mouth of the Mississippi would serve as a safe haven for French merchant ships that were heavily predated upon by Spanish privateers. More importantly, this new colony would also serve as a starting point for eventual invasion of the Spanish colonial empire in Central and South America. Despite the improbability of either event coming to pass, La Salle felt that this was his only opportunity to interest Versailles in his Louisiana project.\textsuperscript{115}

In February of 1684 La Salle presented the court at Versailles with \textit{Memoire sur les Affaires de l’Amerique}, which petitioned the king to return his confiscated property in New France and grant him funds to proceed with the afore mentioned plan. Louis XIV, duly impressed by La Salle’s detailed and ambitious strategy, immediately granted him monies, vessels and soldiery to that end. Encouraged by news of La Salle’s royal backing, private investors reconsidered their earlier stance and extended additional loans.\textsuperscript{116} La Salle, with a flexibility and wit born from desperation, was bound for the Gulf of Mexico.

The grants from the king were indeed generous. La Salle received two ships for his command. The first, a 36 gun frigate called \textit{Joly}, was to be captained by a
French naval officer named Beaujeu. She was to be used as an escort that was to return to France upon their safe arrival in Louisiana. The second vessel, a small six-gun barque longue called Belle, was considered a gift that was to remain with La Salle for the duration of his life. The hiring of two other craft, a supply ketch called St. Françoise and the frigate, Aimable, bulked the tiny fleet. Ships intact, La Salle now had to fill them with men and supplies needed to establish a new colony.

A settlement located on the extreme frontier needed to be entirely self-sufficient. Accordingly, La Salle manned his vessels with craftsmen, farmers and builders as well as soldiers; women were encouraged to enroll in the expedition in order to ensure future generations of colonists. Persons of note that sailed with La Salle included Beaujeu, La Salle’s brother Abbe Jean Cavelier, and a Rouenese historian named Henri Joutel. Each participant joined the expedition for a variety of reasons, the most common of which were poverty, tax or legal problems, or a desire for adventure and upward mobility. Completely assembled, the entire population of the new colony was to include 280 souls.

The supplies taken aboard were as diverse as their human counterparts. Every aspect of life had to be maintained in the hold of four vessels, and as a result each boat was filled beyond capacity. Joly’s primary cargo was soldiers, ammunition and comestibles, while Belle was loaded with trade goods and the tool kits of various artisans. St Françoise carried food and cargo destined for sale in the
Caribbean, while *Aimable* hauled a representative assortment of the entire assemblage.119

Delayed by the stubborn and recalcitrant captain Beaujeu, La Salle’s fleet did not depart Rochefort, France until July 24th, 1684. Their progress was swift until Joly broke her bowsprit approximately 150 miles across the Bay of Biscay. Despite his dismay, La Salle and his vessels were forced to return to France for repairs. They did not depart again until the first of August.120

Determined to regain lost time, La Salle pushed his vessels beyond their capacity during the trans-Atlantic crossing by repeatedly refusing requests for rest and re-watering. This cruel work schedule, when coupled with the crowded, unsanitary conditions aboard seventeenth century vessels, resulted in wide spread illness among the crew. La Salle, who was listed among those suffering from fever, was forced to stop at the French colonial port of *Petit Goave* after a 59 day crossing. The stop on Hispaniola did not begin pleasantly. Two days after the faster *Joly* entered port, *Aimable* and *Belle* arrived with news that Spanish freebooters had seized La Salle’s ketch, *St. Françoise*. The expedition, just two months removed from France, was already dangerously low on supplies and riddled with illness and disease.121

The stay at *Petit Goave* promised to be an extended one. Colonists suffering from illnesses required time to recuperate and heal, while those who remained unaffected disappeared into the brothels and taverns that dominated the Haitian town. La Salle, like many of his charges, was ill and perilously close to death.
Fever that ravaged his respiratory system left him weak and unable to attend to the responsibilities of his station. Only because of the constant attention of Joutel and his brother Jean did La Salle slowly regain his wits and strength. After six weeks of recuperation, the vessels and crew were prepared to continue towards the Mississippi.\textsuperscript{122} Once asail, Beaujeu led \textit{Joly}, \textit{Belle} and \textit{Aimable} to the Cape of St. Antoine near the western tip of Cuba. From that point they awaited the arrival of fair winds from which to attempt a trans-gulf crossing. After one aborted attempt that resulted in a collision between \textit{Belle} and \textit{Aimable}, the group finally reached the southern shores of America on January 1\textsuperscript{st}, 1685.\textsuperscript{123}

Fearing the shoals and unpredictable currents of the coast, La Salle and Beaujeu proceeded with utmost care. Depths soundings were taken frequently, and advanced parties of soldiers were sent in longboats to search for an outlet of the Mississippi. After checking several possible bays and rivers, La Salle spotted a navigable channel that maintained similar characteristics to the river that he remembered. Confirming that the bay was at the expected latitude of 28 degrees, La Salle was convinced that he had found the Mississippi River. No one was aware, least of all La Salle, that the outflow of the great river lay 450 miles to the east, and that they were instead posturing at the gate of Matagorda Bay, Texas.\textsuperscript{124}

In order to escape the wind and pounding waves, all concerned were eager to sail the three vessels into the protected confines of the bay. A sand bar at the mouth, however, might prevent the vessels from reaching the much-needed succor of a protected harbor. Depth soundings indicated that \textit{Aimable} and \textit{Belle} (Figure
10) could pass the bar warding the entrance to the cove, while Joly, being the largest of the three, would not be able cross the bar due to the overburden in her holds.

Although waves and a leeward wind made the passage risky, Belle entered Matagorda Bay with little trouble. Aigron, who was the acting captain of Aimable, ignored channel markers established for Belle and promptly ground his vessel firmly on the shoals guarding the eastern edge of the Matagorda passage. Aimable, loaded with supplies vital to the success of the colony, was mercilessly pounded by wind and waves. A small salvage team was able to save some goods before nightfall, but the remainder was left at the mercy of the sea. By daybreak the hull of Aimable had been broken open, and the remaining cargo had been washed to sea. This accident, when coupled with the capture of St. François, resulted in the loss of half of La Salle’s precious provisions. Complicating matters, Captain Beaujeu was eager to depart for France. Risking injury to his vessel and crew, he unloaded the majority of the cargo that remained aboard Joly, which included ammunition and four cannon. On March 12th, 1685 Beaujeu bid La Salle good fortune and sailed for Rochefort, France.125

The months following Beaujeu’s departure were rife with hardships. The environment of the Texas coast was home to countless dangers; dozens of unwary colonists fell victim to alligators, rattlesnakes and poison plants. Furthermore, several forays into the surrounding wilderness had persuaded La Salle that he had
sailed past the mouth of the Mississippi. He was convinced that his goal now lay far to the east.\textsuperscript{126}

To complicate matters, the first two camps established by La Salle and the colonists had to be abandoned due to exposure to the elements and prying Spanish eyes. Desperate to establish a defensible stronghold, La Salle ordered the construction of a third fort five miles up Garacitas Creek. Completed after four months of constant effort, the new Fort St. Louis consisted of lodging apartments, storehouses and a church, all surrounded by palisades. By the end of October 1685, Rene-Robert Cavelier had provided what he could for those under his command. He was now compelled to re-discover the river that had to this point eluded him.

La Salle needed to find the Mississippi to fulfill his duty to his king and New France. Accompanied by 50 armed men and shadowed by \textit{Belle}, he began to probe St. Louis Bay for the outflow of the great river. This search, like most of La Salle's recent endeavors, turned quickly toward disaster. The pilot of \textit{Belle}, along with six sailors, disobeyed direct orders and decided to spend an evening on land. After their small fire died, marauding Native Americans surprised the sleeping men and slaughtered the entire group. Not willing to risk the loss of \textit{Belle} or her crew, La Salle commanded that she lower anchor in the secure confines of Matagorda Bay and await his return. After 4½ months of fruitless exploration, La Salle returned to Fort St. Louis in January of 1686 with eight of the original 50 men with which he originally ventured. Joutel, who had guarded
the small fort in Cavelier’s absence, greeted him with dire news; Belle had disappeared.\textsuperscript{127}

Four survivors from Belle returned to Fort St. Louis shortly after La Salle arrived. Apparently, the remaining soldiers aboard the small ship stayed anchored in the bay until all provisions had been exhausted. Desperate for supplies, the five remaining men decided to sail Belle toward the fort. A sudden storm swept the ship and her hapless crew onto a sand bar and stranded the vessel. The few that remained built a raft to escape, making several trips back to Belle to salvage what they could before she was beaten to kindling by the merciless waters of the Texas coast.\textsuperscript{128}

The additional stress of this tragedy threw La Salle into a prolonged illness that forced him to convalesce for eleven months. As he recovered, it became increasingly obvious that the 45 who remained at Fort St. Louis would not survive another year. As such, La Salle and 17 men left for the succor at French settlements on the Illinois River in mid-January of 1687. Those who accompanied him on this 800-mile journey included Joutel, his brother Abbé Jean Cavelier, the surgeon Liotot, a buccaneer called James Heins and the troublesome Pierre Duhaut. The few who remained at Fort St. Louis were to hold fast for aid from the north.\textsuperscript{129}

Passage through the marshlands of southern Texas steeled the party for the arduous trek to come. Rain had inundated the already swampy landscape, making travel slow. Food was scarce; the party encountered no game until a small bison
herd was spotted near the Navidad River four days into the journey. The burden of travel eased as January passed; the land became drier and La Salle was able to barter with the local Cenis population for necessities. By February 2nd they had crossed the Colorado River, which lay approximately 100 miles North of Matagorda.

February promised a continuation of steady progress. The flat expanses of the region were easily passed; only small rivers delayed their advance. La Salle’s lasting bond with the Cenis culture, which dominated south central Texas during the last quarter of the seventeenth century, also provided limited comfort. These favorable conditions urged the band toward the Illinois, and by March 12th they were approaching the Navasota River after eighty additional miles of travel.¹³⁰

Despite the auspicious start of their journey, some of La Salle’s party became increasingly unwilling to acquiesce to his will. Pierre Duhaut, Jean L’Archeveque, James Heins and the surgeon Lirotot consistently questioned their leader’s prowess, often dissenting on simple decisions such as routes and campsite locations. These grumblings, which first surfaced in early February of 1687, became progressively more difficult to ignore. As the Navasota River came into view it was clear that this dissention would either dissolve the party or result in violence.¹³¹

On March 14th the small party crossed the Navasota. Once safely across, La Salle sent a party of eight to search for a food cache that lay a mile from their chosen camp. The members of this group, which included the bulk of La Salle’s
foes, viewed this as an opportunity to wrest power from their leader and continue without him. Lead by Duhaut and Liotot, the conspirators lay in wait, ready to fall upon a searching La Salle. As expected, Rene-Robert’s concern for his missing party flowered into obsession, and he sent a second group, lead by his nephew Morenger, to search for them.\textsuperscript{132}

After a short hunt, the second party contacted the first. The meeting, however, was far from joyous. Angered by the delay, Moranger accused Duhaut of treason, which resulted in a violent argument between the two Frenchmen. Calming after several hours of dispute, both parties planned to rejoin their companions in the morning after an evening of much needed rest. Unbeknownst to Moranger, Liotot and Duhaut had conspired to destroy not only La Salle but his supporters as well. As a result, a treacherous Liotot murdered Moranger and two others while they slept.\textsuperscript{133}

La Salle’s patience was completely worn by the morning of March 19\textsuperscript{th}. Fearing a plot against his authority, he set out with a recollect priest and a native guide to find his missing men. After a brief search, they encountered Duhaut’s servant, Jean L’Archeveque, who beckoned them to join him near a copse of trees. Unaware of his deceit, La Salle moved closer, only to be shot dead by a hidden Duhaut. Satisfied with the death of their commander, the traitors turned to rejoin the remainder of the party.\textsuperscript{134}

The death of La Salle was followed by additional dissent and violence. One month after the assassinations, Duhaut was killed, and this prompted the group to
split one final time. One party, led by the historian Joutel, continued on for the Illinois and later Canada. The group of conspirators, however, melted into the mid-American plains. They were content to live their lives among native populations rather than face inquiries regarding their treachery near the Navasota River.\textsuperscript{135}

Of the 180 colonists that braved the unknown with La Salle, only 13 survived. The party lead by Joutel reached Canada and eventually France. Three of the six members of this group, which included La Salle’s brother Jean Cavelier, his nephew Colin Cavelier, and Recollect friar Anastasius Douay, penned accounts of their journey. Of the six men who deserted them after the murder of La Salle, only Jean L’Archeveque and Jacque Grollet ever saw Europe again. The fate of those left at Fort St. Louis was no better. An unfriendly Kawakawa tribe raided the fort, and all but five children were massacred. Those that survived were absorbed into the native population; Spanish nationals rescued them two years later and eventually returned them to France.\textsuperscript{136}

Information regarding La Salle’s fate and final voyage had long been limited to accounts of those who survived the ordeal. Despite numerous searches, neither Fort St. Louis, Belle nor Amiable were located by archaeologists, and it seemed as if La Salle and those who ventured with him were doomed to be lost in the faded annuls of history. Undaunted by previous failures, the Texas Historical Commission (THC) launched an underwater survey of Matagorda Bay in June of 1995 to search for La Salle’s lost vessels. Their investigation yielded several
magnetic anomalies that could represent shipwrecks, and after careful testing it became clear that one of them corresponded to La Salle’s missing Belle.

Excavation of Belle and the Re-Discovery of La Salle

Belle, once thought lost to the torment of the sea, had in fact lay hidden below the waters of Matagorda Bay. The process of identifying the vessel from the magnetic return of a magnetometer was the first step in an ongoing process to bring La Salle’s French colonial legacy to the forefront of historic archaeology.

THC nautical archaeologist J. Barto Arnold and three dive teams conducted preliminary testing at the anomaly site. Aided by the use of a propeller wash deflector, teams excavated several test units within the anomaly in order to obtain evidence regarding the date and condition of the shipwreck. Early work yielded non-diagnostic lead shot conglomerations and wood fragments. A second attempt, however, produced an early, dolphin embossed, cannon typical of the latter half of the seventeenth century. Additional finds, such as marked pewter plates and several intact staved casks, fortified the belief that they had uncovered one of La Salle’s ships. Convinced that they had uncovered a shipwreck of historical import, members of the THC immediately lobbied for a complete excavation of the site.

After a short period of debate, archaeologists determined that a through excavation of the shipwreck site would be impossible in the poor visibility of
Matagorda Bay. In response to this problem, a dry cofferdam was constructed around *Belle*. This enabled archaeologists to slowly excavate *Belle* as if she were found in a terrestrial setting; the data recovered during the six-month excavation exceeded the hopes of all involved in the project.

Protective sediments of Matagorda Bay preserved a majority of *Belle*’s hull below the waterline. The same anaerobic sediments that shielded ship timbers from microbial attack also preserved organic remains that do not commonly endure, including bone, leather and wool. As a result of these favorable conditions, the hull of *Belle* enclosed myriad artifacts from La Salle’s colonial expedition; dozens of artifact classes and material types were represented, including trade goods, apparel, and weaponry. Each of the recovered artifacts, if viewed as a component of a larger cultural system, offers a privileged glimpse into the French colonial conscience and La Salle’s final, brave endeavors.

Included in the overall assemblage was a collection of leather footwear. Like all artifact classes, the footwear recovered from *Belle* provides a unique link to past human behaviors and preferences. Hidden within this artifact class is information regarding the socio-economic status of those aboard *Belle*. Shoes, in particular, symbolize the hardships faced by colonists during the last great era of geographic expansion. Equally as important is how these items relate to seventeenth century France and the cordwainers, or shoemakers, who constructed them. Often overlooked by scholars, these craftsmen served as a stabilizing factor for a country rife with dissent and daily hardships. The following chapter will
examine the culture and precise science of seventeenth century European
cordwaining in an effort to relate the *Belle* assemblage to the vibrant participants
of the sub-culture that crafted them
3. THE GENTLE CRAFT:
CORDWAINING IN SEVENTEENTH CENTURY EUROPE

Archaeologists and historians have often overlooked the role of general craftsmen. As a part of the working middle class, they are not readily visible and rarely contribute to the cultural noise of early modern society. By providing a certain service or product, artisans enable the progress of society through honesty and continuity of tradition. Named for the fine Moorish shoemaking leather called *cordouan*, cordwainers (Figure 12) were among the best loved of these traditional craftsmen, and were among the more active of their ilk between the eighth and sixteenth centuries. Their popularity grew wildly, however, during the colonial expansion of the seventeenth and eighteenth centuries. The burgeoning upper class began to funnel their colonial wealth into art, food and apparel. That same prosperity also generated a new middle class, and the additional capital enjoyed by this stratum enabled the purchase goods considered luxuries to past generations. Demands of the newly prosperous included footwear, and as a result the cordwaining profession developed into a massive industry. The nineteenth-century English cordwainer, John Rees, theorized that there were over 2 ½ million practicing shoemakers in 1810. Paris and London maintained 50,000 each.\(^{138}\) As a result of this profound change, seventeenth century cordwainers were initiated into a working culture that differed greatly from that of their fathers. They alone would witness the golden age of their profession.
This chapter represents a synthesis of the salient factors of seventeenth-century European cordwaining. These elements include the materials and tools used to construct footwear, the time-honored process of shoemaking, and the history of footwear fashion during the seventeenth century. This discussion will begin, however, with a review of the shoemaking sub-culture, which was largely encompassed within the European guild system.

Cordwaining and European Life

Shoemakers enjoyed a visible and respected role in seventeenth-century European life. French and English playwrights of that era glorified their exploits in works such as Les Chaussiers des Anciens and A Shoomaker and a Gentleman. Frenchman Henri Michel Buch established a religious order of cordwainers in Paris that witnessed great popularity between 1645 and 1700. Their influence extended beyond the fashionable and the sacred. Several English public houses sported names such as Saint Hugh's Bones or Saint Crispin Arms, both of which were inspired by the patron saints of cordwainers.\textsuperscript{139}

Two factors contributed to their elevated position in seventeenth-century society. First, cordwainers were reputed to be the most literate of all craftsmen (Figure 13). Unburdened by an itinerant lifestyle common to most artisans, shoemakers enjoyed extensive leisure time that was often spent reading and discussing politics. As a result, they were famed as working class intellectuals;
most of the employed illiterate visited local cordwaining shops for information regarding local and foreign affairs. Practitioners of the gentle craft fomented popular revolts in all European countries.¹⁴⁰ French cordwainers, or Les cordonniers, were famed for just but firm actions during the French Revolution.

In a time when the Christian faith dominated all aspects of life, shoemakers maintained very close ties to the church. Plaques of their patron saints, St. Crispin and St. Hugh, were permanent fixtures in cordwaining stalls, and wealthy members of the profession contributed lavishly to the church and to charity. St. Crispin’s Day (October 25th) was a particularly festive occasion throughout Europe. That day witnessed a parade of garishly dressed cordwainers, all of whom were en route to a much-anticipated public feast.¹⁴¹ Despite a celebrated reputation within society, professional and personal lives of most shoemakers were dominated by the clannish craft guilds. Much like the Hindu caste system, guild status defined the prospects of each member, and the resultant structure of guild houses became synonymous with the shoemaking sub-culture.
Cordwaining Guilds

European shoemakers have been practicing their craft in hamlets and cities for two millennia. These artisans did not become a viable, culturally recognized entity until the twelfth century development of shoemaking guilds. The first of these organizations was established in Trier, Germany in 1104; these group dominated shoemaking throughout Europe by the turn of the thirteenth century.\textsuperscript{142} This system developed as a regional collective of employers and craftsmen who desired to establish firm standards for their trade. These values stipulated high standards of quality control, closely monitored production rates, and limited working hours. The guilds also used their associative might to ensure that contracts and debts were duly honored.\textsuperscript{143}

Guild members constantly endeavored to ensure the reputation of their organization. They aligned themselves closely with the church to legitimize their standing; all aligned themselves with fourth-century martyrs St. Crispin and St. Crispinian of Soissons (Figure 14), and St. Hugh of Canterbury. Trade guilds also sought recognition by the crown; they often agreed to low paying government contracts to earn and maintain favor of the ruling elite. Formal acknowledgment of government service was bestowed with a royal crest.\textsuperscript{144} The resultant marriage between church and state created powerful, lasting societies whose regional monopolies were rarely challenged.
The influence of guilds, however, was not limited to professional endeavors. Guild life dominated the existence of its members. Dedication to standards of moral conduct was as important as quality of work. This code of ethics followed guild members before their initial apprenticeship; no lad was apprenticed into a reputable society if he did not hail from a hardworking, virtuous family. To ensure continued fealty of their charges; guild elders organized and carefully monitored the social life of their members. Group functions, such religious and seasonal holidays, were authorized by the guilds and were celebrated using guild funds. Limits imposed by guild officials knew no bounds; even love was strictly monitored. Members were generally married from within their society, and these unions required consent of the ruling body.\textsuperscript{145} Personal freedoms could be earned, however, as members progressed through the guild hierarchy.

The internal framework of craft guilds was organized as a strict hierarchy. The premier position within each collective was the guild warden. This elected official was the public voice of the organization. He was responsible for addressing public officials, settling disputes between society members, adjudicating the frequent guild meetings, and collecting dues. They also upheld guild standards for quality and pricing, paid government duties on products, and reviewed applications for admission into the guild. His most solemn charge was to guard the guild chest, which held guild documents, funds, and other symbols of community life.\textsuperscript{146}
The bulk of guild members were master craftsmen (Figure 15). These members were considered learned artists and true experts of craft. Once initiated, master craftsmen maintained the privilege to practice cordwaining within their guilds' sphere of influence. Individual masters operated shops of their own, and employed a number of journeymen and apprentices. Attaining the title of master ensured community respect and financial stability.\textsuperscript{147}

Journeymen were trained day laborers who had recently graduated from their apprenticeship to a guild master. These individuals traveled between cordwaining shops, where they perfected their art and learned regional shoemaking variations and styles. These six to eight week stays also introduced fledgling shoemakers to different masters and guilds, impressing them with talent and humility. After six to nine years as a journeyman, a young man could petition a house for the coveted position of master and initiation into the guild. To receive this title, journeymen were required to present to the guild a book of his travels with approving letters of conduct from each master visited. More importantly, his skill was judged with a simple test, in which most cordwaining guilds expected applicants to complete four pairs of shoes of varying types in eight days. Once completed, the quality of these items was to be judged by four senior members of the chosen guild. If his conduct was exemplary, his quality of work sound, and his political ties secure, the journeyman could expect initiation into the guild, and a lifetime of prosperity for himself and his family.\textsuperscript{148}
The apprentice class represented the lowest rung within the guild system. Apprentices were young boys, usually between the ages of twelve and fourteen, who wished to become cordwainers. After gaining the acceptance of an established master, they labored unpaid for nine to twelve years, learning all of the basic stages of shoemaking. Their tenure was completed with the production of a masterpiece, which was a pair of shoes that exceeded the minimum standards of quality established by the local guild. Upon graduation, new journeymen were provided with a small fund and a set of cordwainers’ tools, and were sent to begin their trek as journeymen.149

Complexities and traditions that comprise seventeenth century cordwaining guilds are a testament to their longevity within European culture. Much like the organization of these societies, the fundamental art of shoemaking changed little between the fifteenth and mid-nineteenth centuries, and there are a handful of modern practitioners that still adhere to the procedures and standards of old. The following section will detail the time-honored cordwaining process, including the materials and tools that they employed, and the exact procedure followed to manufacture seventeenth-century shoes.
Cordwaining Procedures of the Seventeenth Century

Cordwainers, much like other craftsmen, jealously guarded the secrets of their trade. As a result, few historic cordwaining manuals exist. None remain from the seventeenth century. Continuity in the cordwaining tradition, however, permits the use of manual written in the sixteenth, eighteenth, and early nineteenth centuries. As such, information used in the following section was drawn from five basic sources. English master cordwainer, John F. Rees, compiled his knowledge in the work, *The Art and Mystery of a Cordwainer*, in 1811. French sociologist, M. de Garsault, recorded particulars of shoemaking in the French town of Metier in 1767, and this synthesis, titled *L’Art du Cordonnier*, remains the finest French source on historic shoemaking. The German scholar, P. N. Sprengel, also described the process of cordwaining in the work, *Handwerke in Tabellen*, in 1566. This manuscript is incomplete, however, and is of marginal utility. Contemporary Hungarian shoemaker, Laszlo Vass, has also recorded the time-honored procedure in his book, *Handmade shoes for Men*. Other ancient sources from Poland and Germany exist, but they have never been reproduced and are currently unavailable for study.

Master cordwainer D. A. Saguto of Williamsburg Virginia has also been an invaluable source of inspiration and data for this section. His kindness exemplifies the true spirit and generous heart of all shoemakers; the art that he practices has been forever known as the gentle craft for this reason.150
Cordwaining, as described by the above practitioners, is a highly skilled trade. The accumulated skills of a seventeenth-century cordwainer, however, did not begin with the synthesis of leather pieces into a finished product. He must have been fluent with the tools of his trade and a consummate judge of materials. A review of the cordwaining tradition would be incomplete without an evaluation of these three basic tenets.

Raw Materials

As with all handicrafts, the first step in cordwaining is the selection of raw materials. As such, finished seventeenth-century shoes are comprised of five basic materials, including leather, thread, wax, wood, and adhesives. These items can be separated into to categories based on how they were obtained by the cordwainer. The main material, leather, was obtained from a group of leather technicians/merchants called curriers. Peripheral materials, such as wax, thread, wood, and glue, were manufactured in-house or were purchased from a class of merchants called grinders.\textsuperscript{151}

A single type of wax was employed by seventeenth-century cordwainers. Cobbler's wax was added to stitching thread to hold the fibers fast and to ensure a watertight seal at each stitch. This material was fashioned using two different formulae. The first used a blend of three parts black pitch, and one part tree rosin. Fine oil was added to the mixture to reduce stiffness. The second type called for
equal parts resin, beeswax and paraffin. Once assembled, these elements were melted and thoroughly mixed in an earthenware vessel hung over a low fire. After completely blended, the mixture was plunged into chilled water and was kneaded until soft and ductile. Thread wax could be purchased from middlemen, but most shops fashioned the mixture in-house, varying the blends listed above according to personal preference.152

Two different types of thread were employed during the shoemaking process. Sewing thread, which was used to fasten the sole structure, was fashioned from 24 strands of coarsely spun green hemp. This material is used on the more robust portion of the shoe because it wears less than other threads and can absorb greater quantities of wax. Stitching thread, which was employed to stitch various upper components, was made of 12 strands of finely drawn linen or flax. This twine was more flexible than its hemp counterpart, and was easily drawn into the smaller holes of the shoe uppers.153

Shoemakers use wooden pegs fashioned from local deciduous species to fasten the heel to the sole structure. Western European shoemakers used straight-grained woods such as yellow oak or cherry, while eastern European craftsmen favored birch, hornbeam or birch. All of these woods were easily split with the grain, but are very difficult to shear against it. This provided the heel/sole junction with strength and some degree of flexibility.154

Adhesives were used for two purposes; to fix shoemaking elements in place before they were attached with more permanent means, and to fashion certain
types of heels. The adhesive was made from boiled and reduced collagen protein obtained from mammalian hides, or was fashioned from a blend of wheat flour, chestnuts and tuber starch. Once blended, the mixture was dried in thin leaves. Shoemakers then dissolved the sheets in water, as adhesive was needed.\textsuperscript{155}

Leather was the most important material used in shoemaking. In deference to this fact, the motto of cordwaining guilds was \textit{corio et arte}, with leather and skill. A range of leather types were used in the seventeenth century, and these were treated, or tanned, in a variety of manners. Waxed and blackened calfskin was the most popular for uppers, while soaked and beaten bull hide was preferred for the soles and heels. Cordwain, or alum-tawed goatskin, was used for fine footwear that was commonly seen adorning the feet of nobility.\textsuperscript{156} Leather manufacture in the seventeenth century was a lengthy, complicated process, with roots that date to the fourth century A.D. For a thorough review of seventeenth-century leather manufacture, please refer to chapter five of this thesis.

Few craftsmen relied on a wider array of tools than the cordwainer. Spartan tools sets were given to apprentices as they earned journeyman status; from that point onward these kit symbolized the craftsman’s status as a productive, upstanding member of society. The following section will examine the basic tools used by cordwainers in the seventeenth century; specific attention is paid to implements employed in the manufacture of style endemic to that time period.
Saint Hugh’s Bones: Cordwaining Implements of the Seventeenth Century

The tool assemblage of seventeenth-century cordwainers was commonly referred to as St. Hugh’s Bones, which stems from an eleventh-century German fable that claims that a set of shoemaker’s tools were fashioned from relics of that martyr. Components of these kits varied according to region and personal preference; long-practicing masters maintained extensive assemblages for the manufacture of dozens of footwear styles. Simple assemblages, however, could be purchased for a journeyman’s day wage. A functional kit contained at least two-dozen tools in the form of hammers, pincers, awls, bristles, knives, and wooden shoe forms, or lasts (Figure 16). The following section will review the implements in common use by all seventeenth-century cordwainers.

The cordwainers last (Figure 17) is the oldest implement directly attributable to cordwaining. Greek philosopher Plato first described these implements in the fourth century B.C., and the last has been the symbol of cordwaining since that time. Lasts, in function, are wooden foot forms used as a working surface onto which footwear elements are attached and formed. Cordwainers during the reign of Louis XIV did not fashion their own lasts. Specialists, called last makers, fashioned them from straight-grained hardwoods such as beech, hornbeam and oak. These templates were created for general foot sizes or were tailored specifically to the requirements of well-paying customers. Different lasts were also created for specific shoe styles.
The lasting hammer (Figure 18) was another standard cordwaining implement. Typical lasting hammers maintained a broad, flat head with a tapered down-turned tail. Fashioned from wrought iron and oak, these tools measured thirteen inches in length and weighed between 14 and 16 ounces. They were used for a variety of purposes, including hammering sole and heel leather, smoothing leather components while on the last, and inserting wooden pegs into the heel/sole structure.\textsuperscript{160}

A variety of pliers (Figure 19) were used during the shoemaking process. All of these tools resemble modern grasping pliers; variations of the form are expressed with different distal gripping platforms. Shoemaker's pliers, which maintain broad, grooved jaws, were used to remove nails from a lasted shoe. The squared area projecting from the side of these pliers were used to knock these tacks in place.\textsuperscript{161} Flat, bill-like gripping platforms and upturned handles are diagnostic of English shoehorn pliers. These were used to pull partially sewn upper onto the last, and for pulling newly made shoes onto the feet of customers. The final pliers type, commonly called cordwaining tongs, maintained a circular head and thin gripping platforms. These were used much like the English shoehorn pliers. Each of these pliers were between six and nine inches in length and were fashioned from either cast or wrought-iron.\textsuperscript{162}

Three types of awls (Figure 20) were employed by most seventeenth-century cordwainers. These instruments, which were composed of a sharpened, wrought iron spike attached wood or bone handles, were used to punch holes into the
various footwear elements. Stitching awls were used to perforate the seams of various upper components. These tools had thin, crescent-shaped blades. The different stitches employed by cordwainers required different nib curvatures; simple stitch types, such as the flesh-grained stitch, required a relatively flat blade. The butted seam whipstitch, on the other hand, required a severely curved, almost hooked extremity. Sole awls, which were used to puncture, thicker sole leathers, displayed a slightly more robust, slightly curved blade. The heel awl, used to pierce thick heel lifts of hardened leather, maintained a strait, wedge shaped blade with a large handle.\textsuperscript{163} On the shape and care of awls, Rees stated that the “awl should be well polished, and round [in cross-section] except at the very point, there it should be flat, that it may enter the leather with more ease; let the awl at all times be not quite as full as the thread that you are using.”\textsuperscript{164}

Boar bristles were other vital utensils of the cordwainer. These stiff hairs were used instead of copper needles because they were cheaper and were less likely to damage shoe components. Bristles were cut and fashioned much like a quill pen tip; skilled cordwainers sliced their bristle needles according to the stitch hole diameter and thread size of a particular seam.\textsuperscript{165}

A shoemaker’s chest also contained three types of knives. A half moon knife (Figure 21) maintained a large crescent-shape blade that was hafted at the midline. This tool was used to cut, or click, various shoe elements from a
prepared hide. On the contrary, trimming knives (Figure 22) were composed of razor-like blades with small handles. Both straight and angled blades were used; and they were used to trim unwanted leather from the edges of sewn seams.\textsuperscript{166}

Half-moon and trimming knives both measured six to seven inches in length, and were fashioned with steel blades and hardwood or bone handles. A third type of knife was comprised completely of bone. Fashioned from cracked femurs of large mammals, bone knives were used to flatten and smooth edges stressed by the tightly dawn stitches.\textsuperscript{167}

The relative simplicity of cordwaining tools and materials should not underscore the skill of early modern shoemakers. The more talented of cordwainers toiled for 15 years before achieving the rank of master, and their prowess and dedication to their art is undeniable. The shoemaking procedure that they labored to perfect is examined below.
Eight Stages of Seventeenth-Century Cordwaining

Cordwaining remained relatively unchanged between 1550 and 1856. Although styles changed and methods were refined, shoemakers of that time fashioned shoes of two basic types, cheap work and bespoken work. Cheap work referred to shoes manufactured for government contracts and general consumption. Footwear of this sort was made in general sizes and of inferior materials; shoes of this type were not distinguished as left or right.\textsuperscript{168}

To the contrary, bespoken work were shoes manufactured specifically for the feet of an individual, in which countless measurements were taken and patterns carefully adjusted. This type of work best displays the prowess of early modern shoemakers.\textsuperscript{169} As such, the few historic shoemakers who recorded their science described the bespoken process only. In doing so, they distilled the cordwaining process into eight basic steps. Each of these steps is reviewed in this section, highlighting procedures common to the seventeenth century. The nuances of this ageless science, however, stretch far beyond the scope of this work; the methodology outlined below represents a distilled précis of seventeenth century cordwaining. The first three steps were considered preparatory work, which began as the shoemaker took measurements from the feet of the patron.
Measurements

Clients requesting bespoken work were expected to spend one to two hours in the cordwaining workshop to have his or her feet properly measured. The master of the shop measured the length, width and height of the feet at prescribed intervals. Seventeenth-century shoemakers were well aware of the physiology of the foot and the dynamics of walking. They insisted on taking measurements while standing and sitting. Side elevations were then taken while a customer was standing on false heels, the height of which was determined by his/her preference. The shape of the foot was also examined by hand, so the cordwainer could account for minor deformations such a low arch or flat foot; many requested a foot imprint be made with ink. Once the basic measurements were taken, they were given to the last maker so a specialized last could be manufactured. At the same time the cordwainer tailored a style pattern to suit those specific measurements.¹⁷₀
Clicking

After the measurements were taken, the required shoe elements were clicked, or cut, from a single tanned cattle hide. Different areas of a hide were preferred for certain elements. Upper elements were always clicked from leather near the spine. Great care was taken here to ensure that both sets of uppers maintained similar qualities and had no visible scarring. Insoles and midsoles were cut from the neck, while treadsoles and heel lifts were taken from the rump. The welts and the toecap were then taken from the crest and belly. Shoemakers generally traced a faint outline of the pattern in chalk, and would then carefully remove the pieces using a straight-bladed trimming knife. Once cut, the pieces were soaked in water before of the next step.¹⁷¹

Closing

After components were cut from the leather blank, upper elements were stitched together in a process called closing. In closing, the cordwainer first perforated edges of the vamp and quarters; the type and placement of holes depended on the type of stitch to be employed. Stitch types typical of seventeenth-century bespoken work are all variants of the whip stitch; the most
common of which was the whip stitched butted seam. Most respectable
cordwainers employed between nine and twelve stitches per inch in this process.
Stitching began by joining the quarter pieces vertically at the heel. The vamp was
then joined to the quarter assembly, and if called for, the tongue. Closing was last
of the preliminary stages.\textsuperscript{172}

Lasting

The upper shell created in the closing stage was then shaped onto a shoe form
in a process called lasting. In this phase the stitched upper was stretched over the
last and insole using English shoehorn pliers or cordwaining tongs. The upper,
designed to extend one inch below the base of the last, was then carefully attached
to the wooden form with cordwaining tacks. Any flaws in the form, such as
wrinkles, were carefully removed using flat edge the lasting hammer. This
process continued until the upper assumed the shape envisioned by the artist.\textsuperscript{173}
Welting

The welt was a single strip of leather stitched to the upper where it curled beneath the last. A seventeenth-century development, the welt served as a platform for the attachment of midsole and treadsole, and also stabilized and weatherproofed the junction between upper and sole structure. Beginning at the heel, the welt was sewn to upper and insole using a double stitch that required two needles. Tacks used to fasten the upper were removed as the welt was sewn around the edge of the sole. Once firmly attached, the welt was smoothed using a dull bone knife. This was the most vital stage in shoemaking, the broad welting stitches served as the linchpin for the entire shoe structure.174 German cordwainers commonly exclaimed, small stitches do their job, broad stitches earn your bread.175
Soling

Seventeenth-century shoes commonly maintained three distinct soles, the insole, the midsole, and the treadsole. Fashioned from the same materials, these elements enhanced the durability of the shoes and extended the distance between foot and earth. The insole was secured to the upper structure during welting. The midsole and the treadsole, however, awaited attachment via the same welt. To begin, both midsole and treadsole were fixed in place with adhesive or small wooden pegs, and a small stitch channel was then cut in the base of the treadsole to prevent the threads from abrading. Stitch holes were punched through the welt/sole assembly, quality footwear of that era required between five and seven stitches per inch of welt seam. The soles were then firmly fixed using the same double stitch employed to attach the welt.\textsuperscript{176}
Heel Attachment

The widespread distribution of heeled shoes was a seventeenth century phenomenon, and three different types were employed by cordwainers of that era. The poorest shoes were fashioned with jump, or *peche*, heels (Figure 23). *Peche* heels were created by compressing leather scraps and hide glue in a book press; once stiffened, the resultant material was shaved to heel form. The second type was the stacked leather heel (Figure 24), which was fashioned from beaten leather disks, or lifts, cut from the rump of a treaded cattle hide. The third heel was shaped from leather-covered wood (Figure 25).177

Stacked leather heels, the most common variety used during the early modern period, were fixed to shoes with tapered hardwood pegs. To begin, the first heelpiece, or split lift, was fixed to the sole structure with small brass brads hammered into the center of the heel. The sole structure and split lift were then perforated and the lift stitched to the shoe body. The brads were then removed and their holes were expanded using a heel awl. Small pegs were then inserted in their place, from the sole extending downward. The four to five leather discs below the split lift were fastened in much the same manner. The final disc, or seat lift, was then attached to the rest of the heel using pegs that were set in circular pattern around the periphery of the element. Each of these was driven up toward
the sole from the base. In this way the heels were secured from both sides, and the seat lift was easily replaced if worn. Once the heel was attached, the heel was carefully trimmed to match the shape of the sole. Peché heels were attached in the same manner; the fabricated heel block simply replaced the four or five center lifts. The resultant peg pattern, with dowels set haphazardly in the center and neatly arranged around the base, was a defining characteristic of seventeenth century leather heels.

Leather covered wooden heels were affixed in a very different manner. Once the desired heel shape was fashioned, the piece was tacked to the sole structure using several brass pins. The heel was then covered with leather using adhesive.\textsuperscript{178}

Finishing

Bespoken shoes were not released to a customer until the work was perfect. Any wrinkles or divots were smoothed using a bone knife, and heels and uppers were protected using rich wax. Modern cordwainers can complete a pair of bespoken shoes in two days; this was matched by the finest journeymen shoemakers of seventeenth-century Europe, who had to fashion four pairs of varying types in eight days or less to become a master.\textsuperscript{179}

The process described above represents a distilled summary of the historic shoe-making process. The construction of different shoe styles, however,
required variations on the sequence described above. Cordwainers were expected
to master those deviations while touring the countryside as journeymen, and their
economic success as craftsmen hinged on their ability to provide the public with a
variety of footwear. The number styles available in the seventeenth century grew
wildly as the whim of monarchs and an influx of colonial wealth led to a
heightened interest in fashion. Shoes underwent a renaissance of meaning during
that century; men and women were judged by footwear they chose. The
following section examines shoe fashion in the latter half of the seventeenth
century, as it related both to royalty and the common man.

European Footwear Styles 1660-1700

Like other aspects of European popular culture, kings and wealthy courtiers
dictated fashion during the early modern period. A single man, however, dictated
style during the latter half of the seventeenth century. Louis XIV transformed
France into the focal point of western Europe; he used opulence and fashion to
fabricate an aura of greatness unrivaled by any except perhaps the Caesars.
Although his personal raiment was unmatched, wealthy courtiers and provincial
nobility of France adopted his choices in cut and materials to emulate him. The
entire French culture, along with most of Europe, became obsessed with fashion;
the lower classes followed royal examples according to their means. Louis XIV
particularly prized shoes; the term *shoes maketh the man* was coined during his
reign. The emphasis that he placed on shoes filtered slowly into consciousness the general populace, and an increased number of bourgeois footwear styles resulted.

For the common folk of Europe, the general trend in footwear was toward shoes of the latchet type (Figure 26). These were characterized by quarter pieces that maintain strap-like extensions, which are joined together with a variety of fastenings. Seventeenth-century latchets were generally of the open sided style, in which the foot was exposed between strap and sole structure. Variances on this form were manifested in toe shape and upper height. In general, a round toe form was favored throughout the seventeenth century. However, the square toe became increasingly popular between 1640 and 1700, and developed into the dominant shape during the eighteenth century. Shoes were also very low cut during this time; the pre-eminence of the riding boot faded as carriage transport became standard. The shoe colors of this time period ranged from fawn to dark black, the most common hue was a middle brown. Shoe form aside, the most striking developments in footwear fashion was the widespread adoption of heels and shape buckles.

Heels were originally attached to shoes in the thirteenth century to elevate the foot from the mire of the street and to provide horsemen with a better grip in stirrups. Not considered stylish, they did not become available until the beginning of the seventeenth century; the first documented evidence of heeled shoes sold for general consumption appeared in 1605. Louis XIV, however, transformed the
element into a symbol of elegance after 1660. Louis was a very short man, standing no higher than five feet four inches. He adopted the heel to make himself appear taller at court, and his whim became the standard in the latter half of the seventeenth century. Although the heels worn by Louis were between two and four inches in height, those favored by the general populace were rarely exceeded two inches.\textsuperscript{184}

Footwear from the beginning of the seventeenth century fastened with tie-laces (Figure 27). Tie-laced shoes employed hemp twine or leather thongs that were looped into latchet holes and tied in a bow at the front of the shoe. Despite their practicality, the garish dictates of post-1650 fashion called for a more stunning presentation. In response, continental shoemakers attached the chape buckle (Figure 28). The chape buckle was affixed to the shoe by means of a stud or anchor that was inserted into a hole pierced in the latchet. The other latchet strap, much longer than the first, was then threaded into the buckle, securing the shoe to the foot. These buckles were relatively expensive to purchase and were considered jewelry, much like a ring or necklace. They were transferred between pairs of shoes; members of the middle class could rarely afford more than a single pair. Women did not use buckles, however, because skirts ran to the toe and a buckle could not be seen.\textsuperscript{185}

Having reviewed trends in shoe fashion from 1650 to 1700, it is now possible to describe the footwear commonly worn during the time of La Salle, around 1680. The typical footwear worn by men was a low cut open sided latchet shoe.
It maintained a square toe, short tongue and one-inch heel; the color was middle brown and was fashioned completely from cattle hide. It was secured by means of a chape buckle. Much like those of men, footwear favored by women was also an open-sided latchet shoe. It maintained a tapered, but still square toe and a one to two inch heel. It was also middle brown in color and fastened with tie-laces.

Some of the footwear recovered from La Salle’s lost Belle matches the above description. Those shoes, however, tell a story that extends far beyond fashion. The first three chapters of this work represent an extensive historic background from which the Belle footwear may be viewed. The work of cordwainers and toil of colonists each impressed meaning onto the Belle assemblage. Furthermore, a single-minded monarch, who affected everything during his reign, dominated the society in which the colonist and cordwainer labored. He even dictated the style of shoes worn by common men. The following chapter utilizes the data accumulated in these pages to evoke meaning from the Belle footwear collection. Archaeology is valuable because it enables one to render human behavior from the apparent lifelessness of material culture.
4. AN ANALYSIS OF THE *BELLE* FOOTWEAR ASSEMBLAGE

The assortment of leather footwear recovered from La Salle’s wrecked *Belle* can be viewed from a number of perspectives. The simplest interpretation is one of function. Members of that colonial expedition chose to protect their feet from the perils that confront the unshod. Current theories in historical archaeology, however, encourage the examination of material culture as three-dimensional additions to historical events. In this way artifacts serve to explain or highlight aspects of past human behaviors.\(^{186}\) If observed from this standard, the footwear sub-assemblage from *Belle* opens countless pathways of meaning that further our understanding of French colonial history.

At first glance, the footwear collection from *Belle* appeared to be an unruly assortment of leather fragments. Closer examination, however, slowly revealed the components of shoes, including quarters, soles, heels and vamps. These artifacts, regardless of their aesthetic appeal or monetary value, contain a wealth of information concerning cultural phenomena such as the preferences of the French under classes, and cordwaining techniques during the reign of Louis XIV. On a more refined scale, the data mined from these artifacts can also address issues of class distinctions and use patterns among the colonists who sailed aboard *Belle*. 
The *Belle* footwear assemblage is composed of twenty-four separate proveniences that represent at least nine complete shoes. Most of these are comprised of either shoe components or fragments of these components. Despite the ravages of the past 316 years, all of these pieces display marks of manufacture, such as stitching holes, pattern marks and thread impressions. These clues can serve as evidence regarding the construction technique of seventeenth-century French cordwainers. The fragments also represent valuable examples of the stylistic preferences of the French lower classes, which comprised the bulk of La Salle’s crew.

Once purchased from shops at La Rochelle, these items underwent a transformation of meaning. Furthermore, the size and quality of each artifact offered clues as to the sex, age and relative wealth of the individual who purchased them. These observations define this study as an archaeological endeavor in which material culture is transformed into data used to tell a story, or, in this case, fill the interstices of one that has already been told.

The purpose of this chapter is to examine footwear recovered from *Belle* in order to supplement the historic record left by La Salle and those who joined him on his final enterprise. This raw data is then coupled with information garnered from primary source documentation and secondary scholarly works to enhance the historic record. To accomplish this, each artifact was evaluated using a set of criteria that will serve as a framework for this analysis.
These criteria were chosen because they highlight aspects of the assemblage that enable the archaeologist to expose the behaviors and preferences of the human beings who manufactured and used them. The information in these categories was compiled into a detailed catalog (appendix 1). A thorough description of these criteria must precede the analysis of the assemblage.

Criteria of the Belle Footwear Catalog

The Belle footwear catalog was developed to answer specific questions about seventeenth century French stylistic preferences, cordwaining techniques, sex and class distinctions, and footwear use patterns. Eleven separate categories were developed to help address these inquiries. The titles of these groupings are artifact record number, artifact identification, shoe components, construction techniques, fastener type, raw materials, tool marks, repairs, quality of manufacture, dimensions and use wear. The following section will describe each of these categories in detail.
Artifact Record Number

Over one million artifacts were recovered from the *Belle* excavation. In order to account for each find, the Texas State Historical Commission assigned every item or group of like items an artifact record number as they were recovered from the sediments of Matagorda Bay. These numbers, along with the preliminary field identification of each object or group of objects, were then entered into a database for easy access and class sorting. These labels have been retained as a part of this study for several reasons. To begin, it was the most accurate and convenient link between the footwear assemblage and the original excavation. This continuity between excavation and material culture also allows interested scholars to tie information from the footwear assemblage to other artifact classes recovered from *Belle*.

Some artifacts, however, were separated from their number designations either in the field or during conservation. In order to maintain consistency within this study, these artifacts were assigned new artifact record numbers. To prevent confusion with number designations given during the original excavation, these labels begin with the number 500. Furthermore, the term provenience will be substituted for artifact record number for the remainder of this work for continuity and expediency.
Artifact Identification

Each artifact within the footwear assemblage is related in some way to leather shoes. The purpose of the artifact identification category is to provide the observer with a concise but accurate description of the artifact or artifacts that share a common provenience. In some cases this identification is limited to the component itself, such as peche heel or welt fragment. In other instances the element(s) are diagnostic and they permit a more detailed description.

It is important to recognize that more than one shoe element may comprise a single artifact designation. Information listed under the artifact identification category assimilates all of the elements within a given provenience to form the broadest possible description. Therefore, a number with six separate components of a single shoe will be interpreted as a whole for the purpose of this category. For example, provenience 7449 is composed of 11 upper fragments and two sole fragments. The diagnostic shape of the vamp and sole fragments depicts a round-toed shoe, while the presence of two latchet straps fragments indicate a latchet attachment form. Therefore, the description offered in the artifact identification field for that provenience is that of a round toed, latchet-type shoe.
Shoe Components

As discussed in the previous chapter, shoes dating to the last quarter of the seventeenth century are comprised of several different components. As is the case with most archaeological finds, the footwear recovered from Belle were incomplete. The shoe components category was designed to highlight the shoe elements that were present within each provenience.

To maintain an orderly framework from which to view these parts, the shoe component category was divided into four sub-categories. These distinctions were designed to highlight the main structural elements of footwear, to include the uppers, soles, and the heel. Components within the upper category are the quarters, toecap, tongue and the vamp, while those within the sole sub-category are the sock, insole, midsole and treadsole. The heel sub-category describes types of heels and their means of attachment to the sole. The only component not covered within these categories is the welt. This leather attachment, however, is thoroughly covered in the construction techniques category.
Construction Techniques

Pre-industrial manufacture of shoes is a complex, multi-staged operation. Hidden within this operation, there are two techniques that highlight the regional and personal preferences of French cordwainers. The construction technique category deals specifically with these diagnostic methods. They are welting and upper stitching. Both of these techniques are considered diagnostic because the master cordwainer alone manufactures welts and punches the holes needed for stitching. In that way they accurately embody the vision of the craftsman and the preferences of the consumer.

Welting, as previously described, is the manner in which soles are attached to uppers. There are several variations of welts used to accomplish this, and it is these variations that mark differences between region and individual cordwainers. Concurrently, the manners in which upper components are stitched together differ greatly between shops. Data for this portion of the category was obtained from the position of the stitch holes on the upper fragments.
Fastening

Means by which seventeenth-century shoes are secured to the foot seems to be a trivial sidebar within the study of footwear. These phenomena, which will be called fastening for the purpose of this study, offer a great deal of insight about people who wore them. An analysis of the different shoe fastenings within the *Belle* assemblage can indicate shoe quality. More importantly, they efficiently express individual concerns of fashion and status.

I describe only artifacts that display elements diagnostic of different fastening techniques are described within the fastening category. This description includes the type of fasteners used and the data that supports each judgment.

Materials

Materials used to construct leather shoes are, by nature, limited. The material category of the *Belle* footwear database was designed to permit easy access to this information. To facilitate this, the materials category was divided into five subcategories, to include upper, soles, heel, stitching and welt. Data under each grouping only lists materials present at the time of analysis.
Tool Marks

The tool marks category is the least rigid category in the Belle Footwear database. There are two grouping within this category, to include makers’ marks and tool marks. The tool mark sub-category was created to highlight attributes of the Belle footwear that are associated with shoemaking shortcuts. Cordwainers, much like other craftsman, cut corners to increase their productivity and their profit margin. These shortcuts were never visible to the consumer. They become apparent, however, when the shoes are disassembled during conservation or recovered as a collection of associated parts. Shortcuts such as these serve as indicators of quality, and they also evidence the innate resourcefulness of seventeenth century craftsmen.

Makers’ marks are uncommon in the Belle footwear assemblage, and they were placed within this category for the sake of convenience. Their rarity, however, does not underscore their value to the archaeologist. Makers’ marks are the only means of locating the origin of craftwork and materials, and as such contribute immensely to the overall analysis.
Repairs

Two of the *Belle* shoes display evidence of being repaired during their use-life. Although rare, these alterations indicated that the wearers could not replace their footwear due to poverty or lack of opportunity. It also indicates the components of shoes that are most commonly stressed during use. Repairs are evidenced by the presence of two sets fastener holes surrounding the replaced piece.

Quality of Manufacture

Seventeenth-century craftsmen, much like their modern counterparts, adhere to established standards of craftsmanship. Cordwainers during the age of Louis XIV adhered to an unwritten code of quality that dictated the price of their wares and who would be interested in purchasing them. This code, as described by Master Cordwainer D. A. Saguto from the Colonial Williamsburg Foundation, is founded on leather quality and the number of stitches per inch (SPI) on sewn seams. Visible seams, which are those shared by upper components, should maintain between nine and twelve seams per inch. Those that fasten hidden seams, which fall between the soles and on the attachment welt, should maintain at least five stitches per inch. The quality of leather used by shoemakers was determined by the standards of the regional leather merchants. The criteria used
to judge shoe leather differed depending its use. Excellent sole leather was tough, coarse-grained bull hide with a thick corium layer. Upper leathers, on the other hand, were finer grained with a great deal of luster and flexibility. Leathers that displayed higher qualities were more expensive and were used on more elaborate, valuable shoes.

In order to simplify this evaluation, the quality of manufacture category was divided into three sub-groups. The first, which was called the stitches per inch (SPI) of visible seams, incorporates the average number of stitch holes per inch of seam. In order to produce a more valid assessment, three separate measurements were taken from different seams, and this number was averaged and rounded up to the nearest whole number. Artifacts with less than three inches of intact seam were evaluated based on those that were available. The second sub-group, which was called the stitches per inch of hidden seams, followed the same guidelines.

A qualitative assessment of quality was required for the Belle leathers because no concrete standards exist for the excellence of shoe leathers used in seventeenth-century France. In order to provide a numeric value for a qualitative judgment, the leather objects were given a score of one to ten. Sole leathers were evaluated for relative thickness and durability. A quarter inch was used as the standard for thickness, and those artifacts that met this were given a mark of seven and a half out of ten. Upper leathers were evaluated based on grain density and suppleness. Those that displayed a tight papillary layer and some flexibility were given a score of seven and a half out of ten.
Leathers that fell below expected levels were given lower scores, while the marks of those that exceeded expectation were higher. The proveniences that maintained both sole and upper leathers were averaged to produce one score. Although differential preservation within the assemblage can obviously mislead the analyst, the overall scores from this evaluation should provide supporting evidence for the quality of the shoes recovered from Belle.

Dimensions

All artifacts within the footwear assemblage were measured using a metric caliper. The sizes provided for each provenience were recorded in centimeters and are accurate to one hundredth of a centimeter. Although it is customary for historical archaeologists to measure in the same units used by the craftsman (in the case of cordwainers it is the English system), modern scholarship dictates that material culture be measured in the Metric system in order to facilitate comparisons with other collections.

As is the case with most archaeological finds, few artifacts are recovered intact. Fragments without finished edges were measured at their widest points. Complete shoes or shoe components, however, were measured according to their function. For example, dimensions recorded for complete soles were length from heel to toe, width at the toe, and width at the center of the heel. Intact heels were evaluated for height, width and length.
Use Wear

Objects that are used daily display distinct patterns of wear that are directly related to the function of that object. As expected, shoes from La Salle’s expedition exhibit patterns common to the heavily used footwear. In order to maintain consistency within this category, Belle footwear was examined for three types of use wear. The first was abrasion at the base of the heel and treadsole. The second is friction imprints of toes or the foot on the toecap and insole. The third is scaring and/or chafing from buckles or laces surrounding the fastener attachment holes. Assuming that all of the recovered footwear was frequently worn, the presence or absence of wear in these three diagnostic areas is an excellent indication of how the Belle shoes were used.
Data Base Management

The categories described about were assimilated into a catalog/database using the program called FileMakerPro 5.5. This software package, which was released by FileMaker Corporation in June of 2001, enables the user to combine photo documentation within a fully functional database. Scholars wishing to access the Belle footwear data can utilize this fluid program to sort and cull information as needed.

The collection of data and the development of an assemblage catalog are the first steps toward a comprehensive analysis. This information must be used in conjunction with historic evidence to answer questions about past human behaviors. The remainder of this chapter is dedicated to extracting meaning from the Belle footwear data and the historic record.
An Analysis

Despite the wealth of data mined from the *Belle* footwear, no valuable inferences can be made without an extensive amount of supporting research. This study will incorporate the analysis protocols of Dutch footwear specialist Olaf Goubitz, historic data from the first three chapters of this work, and the *Belle* footwear catalog to address inquiries focused on two themes. The first of these involves seventeenth century cordwaining, and the notion of footwear as a commodity with an assigned value. The questions asked from this perspective include: What styles were represented within the assemblage? How was the *Belle* footwear constructed? What was the quality of the *Belle* footwear assemblage?

The second topic combines the results from the first theme with French colonial history and primary accounts from the *Belle* voyage in order to examine the use-life of the *Belle* footwear. Inquiries within this theme include: What was the status of those who wore the *Belle* shoes? What was their age and gender? Why were they left aboard *Belle*?
What Shoe Styles Were Represented in the Belle Footwear Assemblage?

The seventeenth century witnessed several shifts in shoe fashion. Heels became fashionable when Louis XIV adopted them to present a more imposing presence. The number of forms available for public consumption also increased as fashion became more important to the middle and lower classes. As such, one would expect to encounter several different styles of footwear in the assemblage due to the variety of people who sailed aboard Belle.

Style, however, is a difficult characteristic to evaluate from archaeological remains. Artifacts, including the shoes from Belle, are recovered as fragments of the whole. Diagnostic components can be over or under represented due to differential preservation, which forces the analyst to assess the assemblage using the broadest possible criteria. This evaluation will consider four separate characteristics to determine style; these are fastening forms, toe shape, quarter structure and heels.

Seventeen of the twenty-four proveniences that comprise the Belle assemblage (seventy-one percent) maintained features diagnostic of one or more of these style elements (Table 1), and six and these (thirty-five percent) retained all four of the style elements. Artifacts 500 and 501 represent square-toed, latchet type shoes that fasten with a buckle (Figure 29). Artifact 6075 is a round-toed, latchet type shoe with tie-laces (Figure 30), while shoe 6060 represent a round-toed latchet type shoe with tie-laces and open sides (Figure 31). Proveniences 7449 and 58
represent a round-toed, latchet type shoes that fastens with a buckle (Figure 32). Artifacts 5851 and 5954 also represent incomplete latchet type shoes. The remaining nine proveniences display single elements of form. Four of these artifacts are heels, and the other five are vamp or sole fragments indicative of square-toed shoes.

The Belle shoes that retain more than one diagnostic element are variations of the latchet form. This simple style is characterized by quarter pieces with strap-like extensions that are joined with buckles or tie-laced on the distal face of the instep. In this way these extensions serve to secure the shoe to the wearer's foot. This form was common throughout the latter half of the seventeenth century, and was typically worn by the middle and lower classes.\(^{190}\) The style most indicative of overall assemblage is a square-toed, latchet type shoe with short heels and buckle fastenings. Variations on this theme, such as rounded toes, tie-laces and open sides, can be attributed to the growing availability of styles at that time and personal preference.

Despite their simple form, shoes of the seventeenth century French commoners are still marvels of early modern craftsmanship. Extreme care went into their construction; the mere survival of these goods is a testament to the skill of the cordwainers who fashioned them. The following section will examine the techniques used to create the Belle footwear.
How Were the *Belle* Shoes Constructed?

As noted in chapter three, the fundamentals of shoe construction differed little between 1500 and 1820. Despite this, three subtle changes did occur during the seventeenth century, and these are the nuances that define the *Belle* shoes as unique creations of their era. Although these techniques were not invented during the seventeenth century, their widespread employment did not occur until after 1625. Two of these developments are the emergence of the welt, and the employment of the butted seam with whip stitching. Pervasive use of the heel was also a new addition to the cordwainer's quiver; the manner in which these heels were attached was defined in the seventeenth century.¹⁹¹

Welts are leather strips that serve as a fastening medium between uppers and the sole structure (Figure 33). The type of welt used was defined by the complexity of the shoe and the individual preferences of the cordwainer. Evidence from the *Belle* shipwreck indicates that all shoes were fashioned using two types of welts. The heel region was fastened using a curled tension welt. This welt, which was the most common type used to fix the upper to the sole, was employed because it pulled the rear of the shoe towards the instep of the foot. This secured the rear of the shoe, which suffered the most abuse. The remainder of the upper/sole seam was attached using a folded welt. The least complex of all welts, this folded band of leather served as an attachment point for both upper and
sole. The welt stitching extended through every sole piece, which further strengthened the seam.

All of the shoes recovered from Belle shoes were of welted construction. Only twelve of the proveniences (50%), however, maintained evidence of specific welt types, and all of these utilized the curled tension welt and/or the folded welt (Table 2). Both of these styles were present on proveniences 500, 5854 and 6060. Artifacts 501 and 11736 maintained evidence of curled tension welts alone. While there was direct indication of folded welts within seven other proveniences, including artifacts 5447, 5811, 6059, 6075, 7012, 10,263 and 11,300.

Shoe uppers, which typically include a vamp and two rear quarters, have been stitched together using a variety of techniques. Seventeenth-century cordwainers preferred the use of the whipstitch between butted seams (Figure 34). To complete this stitch, a series of holes were made between the cut edge of the leather piece and the grain, or papillary, layer. Thusly perforated, the two cut edges were butted together and stitched inside out in a continuous, circular pattern. Once the assembled uppers were turned out, this stitch type produced a watertight seal that did not expose the flax thread to damage from abrasion. 192

After observing the stitching holes on the upper components of the Belle assemblage, it is clear that this type of stitch enjoyed great popularity among French cordwainers in the latter half of the seventeenth century. Ten proveniences (42%) from that shipwreck contained upper fragments with stitch
holes (Table 2). All of these artifacts maintain butted seams that were whip stitched.

Heels were medieval inventions designed to protect the sole from wear and keep the bulk of the shoe from the dirt and grime of the street. The adoption of the heel by French aristocracy of the seventeenth century turned clever necessity into a statement of fashion, and this spurred widespread adoption of the heel throughout continental Europe. Cordwainers, however, needed to find an efficient means of fixing heels to bare soles, and this phenomenon became a point of variance within the trade. Most attached either stacked leather or *peche* heels to the soles using tapered hardwood pegs. It is the pattern in which these pegs were employed, however, that separates one cordwainer from the next.

Ten *Belle* proveniences (42%) contained heels (Table 2). Eight of these, including artifacts 500, 5811, 6050, 6075, 7012, 11,398, 11,617, and 11,685, were attached using the same basic pattern. Between one and eight pegs were set in circular pattern around the periphery of the heel. Each of these was driven up toward the sole from the base. Six to eight additional pegs were then set haphazardly into the center, each driven from the soles down toward the base. In this way the heels were secured from both sides. Two others proveniences, artifacts 6060 and 13,959 respectively, were fixed with six to eight pegs around the periphery only. All of these were driven upward.

A clear pattern emerges from this data. The *Belle* shoes were constructed using a limited number of techniques, all of which reached their height of
popularity in the latter half of the seventeenth century. The shoes purchased by those aboard *Belle* were fashioned with folded and curled tension welts, butted and whip stitched seams, and heels pegged in a predictable pattern.

The widespread occurrence of these factors can be attributed to two possible scenarios. It is conceivable that all of the shoes were purchased from the shop of the same master cordwainer, or, it is more likely that La Salle or one of his agents contracted with this shop to provide footwear for his expedition. It is also possible that footwear designed for the under classes, which is commonly known as “cheap work”, was manufactured by all cordwainers with the same specifications.\(^{193}\) This remains a possibility because all of the evaluated techniques were, while effective, among the least time consuming to employ.

Although it has been established what these artifacts looked like and how they were constructed, what is not clear is their value as merchandise. All commodities, including footwear, are made with a certain clientele in mind. Were these items cheaply made, or did they represent the standards of the day? The following section will evaluate the quality of the *Belle* shoes in order to determine if they were indeed designed for a specific market.
Of What Quality Was the *Belle* Footwear?

All manufactured goods, regardless of the era, were designed and manufactured to different standards of quality, and the shoes recovered from La Salle’s shipwreck were no different. The most efficient way to establish the relative quality of commodities is to evaluate them using the standards of the craftsmen who created them. Fortunately, seventeenth-century cordwainers followed set criteria that established minimum standards of quality. As noted earlier in this chapter, seventeenth-century shoemakers were bound by guidelines that dictated a certain number of stitches per inch of sewn seam. Visible seams (Figure 35) required between nine and twelve stitches per inch, while hidden seam required five. Leather quality was also a measure of good shoes. The use of well-tanned and curried leather components would naturally result in a better product. Finally, the type of heel employed also denoted quality. Jump, or *peche*, heels were fixed to cheaply manufactured shoes, while wooden or stacked leather heels were typical of well made footwear.

It is difficult to appraise the quality of leather from archaeological remains. The Belle leathers, which had been used extensively before their deposition, were exposed to microbial attack and the abrasive sediments of Matagorda Bay. As previously described, a set of simple criteria was established to provide a numeric value for quality.
Twenty-two of the 24 total proveniences (91%) were evaluated for leather quality (Table 3). Of these only provenience 11,398 received a score of seven and a half or higher. The remaining scores ranged from three to seven, and the average leather quality score for the entire assemblage was five and three quarters. This indicates that the leather used was of lower than average quality. There is support for this claim, however, in another aspect of the collection. The right rear quarter piece recovered from provenience 6075 bears the crescent-shaped stamp mark of the Dutch or German word *eslet* on the grain side (Figure 36). This term is commonly used in Germanic languages to mean bad or of low quality, and it is likely that this stamp represents a tanners’ mark used to denote the quality of the specific hide.\(^{196}\) It can be inferred that the cordwainer who made that particular shoe used inferior leather that was imported from Holland or Germany. This is in keeping with the low score obtained from the leather evaluation, and it is reasonable to assume that the leather from the *Belle* assemblage was of inferior quality.

The stitch standard is a useful means of determining the relative quality of shoes. Although the 10% shrinkage of waterlogged leather due to swelling could alter the number of stitches per inch, the totals for each specimen will supply additional proof of the quality of craftsmanship used to create the *Belle* footwear.

Twelve of the 24 proveniences (50%) contained intact visible seams (Table 3). Five of these shoes (42%) were constructed within the range established for quality footwear; each artifact maintained an average of nine stitches per inch of
visible seam. The other seven proveniences were fastened using between five and eight stitches per inch, and the average for the entire assemblage was eight and six tenths stitches per inch. Therefore, the visible seams of the assemblage were not stitched to the minimum standards of quality used by seventeenth century-cordwainers.

Seventeen of the 24 proveniences (71%) contained intact hidden seams (Table 3). Ten of these artifacts (59%) were constructed within the range established for quality footwear. The seven proveniences that fell below the standard were sewn with three or four stitches, and the average for the entire assemblage was 4.9 stitches per inch. Therefore, the majority of the Belle shoes met the minimum standards for the stitches per inch of hidden seams.

The type of heels used by cordwainers can also be used as an indicator of quality. Cordwainers lowered the cost and the quality of their wares by affixing jump, or peche, heels to their shoes instead of heels fashioned from stacked leather or wood. Ten of the 24 footwear proveniences (42%) contained some form of heel (Table 3). Six of these were peche heels (60%), and three others were made from stacked leather (30%). The final heel was comprised of leather-covered wood. The predominance of peche heels within the footwear assemblage suggests that the majority of footwear recovered from Belle was manufactured with lower quality heels.

Review of the three criteria discussed above indicates that the average shoe recovered from Belle did not meet the minimum standards of value set by historic
cordwainers. Only artifacts 7449 and 6060 met all of the established benchmarks; the remainder fell short in one or more of the examined criteria.

What Was the Social Status of Those Who Wore the Belle Shoes?

The most fundamental of all archaeological theories states that quality and grandeur generally denote high social status; kings donned the finest apparel that his subjects could provide, while those of lesser importance wore what was available for general consumption. The poor quality of the Belle footwear assemblage would therefore indicate that the people who purchased and used those items were of limited means and low social status.

The majority of La Salle’s crew matched this description. They hailed from the lowest strata of French society; historic accounts of his final voyage make note of the wretched circumstances from which the colonists were drawn. The historian Joutel depicted this in his relation of La Salle’s Texas misadventure. “Only a few [men] were able to do anything at all... As I mentioned, these men were beggars who had been taken [from La Rochelle, France] by force or deceit. In a way, it was like Noah’s Ark where there were all sorts of animals... The soldiers had been recruited by the lowest ranking officers of the Navy, who received a half pistolle for each man, by whatever means possible.” It is therefore likely that the shoes recovered from Belle were worn not by La Salle or his allies, but by the colonists referred to above.
Unscrupulous recruiters described by Joutel constantly plagued the French lower classes. These men, who worked throughout France, enticed perspective colonists with monetary offers earmarked for the acquisition of items needed to start a life abroad; this included shoes, clothing and other necessities. Port cities like La Rochelle were littered with merchants and craftsmen who catered to clients in need of inexpensive goods.\textsuperscript{199} It is likely that the Belle shoes were made specifically for perspective colonists and were purchased from such merchants.\textsuperscript{200}

Aside from questions of status, footwear from La Salle’s shipwreck can provide additional information about those who purchased them. The relative size of the footwear can serve as an indicator of the age and gender of their owners. The following section will examine the sole length of the Belle shoes in order to determine the age and/or gender the their owners.

What Was the Age and Gender of Those Who Wore the Belle Shoes?

People of all types joined La Salle on his quest for the Mississippi River. Two of La Salle’s soldiers, Pierre and Jean-Baptiste Talon, described the personnel who sailed with Cavelier during an interrogation by French officials in 1698. “About 300 [people joined La Salle], among whom there were three Religious of the Order of St. Francis and two priests, one of whom was the said Sieur de la Salle’s brother, some children, and nine women.”\textsuperscript{201} Due to this variety, the most interesting dilemma faced by the author was attributing the
recovered footwear to people of specific ages and genders. There are few reliable means, however, to differentiate between these factors using footwear as the only evidence.

Shoe style cannot be used as a reliable indicator of age or gender concerning the lower classes. European archaeologists have established that, beginning in the late middle ages through the early modern period, there was no distinction in the style of shoe worn by lower class men, women and children. Women preferred narrow toed footwear with tie-laces, but very little else distinguished them.\textsuperscript{202} The paucity of children’s shoes recovered from terrestrial archaeology sites indicates that young people from the lower strata for society went barefoot during the warmer months, and wore cheap, disposable footwear during the winter.\textsuperscript{203}

Shoe size, however, can serve as an indicator of age and gender. The most reliable measure of shoe size is the length the treadsole (Figure 37). This, however, is an inherently flawed criterion; size will not allow one to differentiate between the shoe of an adult woman and that of an adolescent man. Dutch scholar Olaf Goubitz, however, calculated that larger treadsoles, which are those above 25 centimeters in length, can be safely attributed to an adult male.\textsuperscript{204} The following analysis will focus on the length of soles recovered from \textit{Belle} to determine if adult men, or women, adolescents and children wore them.

Six of 24 proveniences (25\%) maintained complete soles. Five of those exceeded the minimum 25 centimeter length, and the average for the six extant pieces was 25.75 centimeters. These figures fall safely within the sole lengths
calculated by Olaf Goubitz for adult men. The single provenience that fell below this length, artifact 5854, was 24.3 centimeters in length. It is likely, but not certain, that this shoe was made for an adult male. Although the sample size used in this analysis is small, it is likely that all of the shoes recovered from Belle had been intended for adult men.

Much like other aspects of apparel, footwear was of considerable value to La Salle’s colonists. It protected their feet from the elements, injury and the bites and stings of new world pests. Despite this, these precious commodities were left aboard Belle. The possible reasons for their presence aboard the doomed ship will be examined in the following section.

Why Were the Shoes Left Aboard Belle?

At the time of Belle’s demise in January of 1686, a majority of the colonists were without adequate apparel. Linen intended for trade had been fashioned into shirts that quickly deteriorated in the damp of southern Texas, and surviving settlers often recycled the clothes of the dead.\textsuperscript{205} Clothing was also fashioned from dressed deer and bison hides bartered from the local Cenis population.\textsuperscript{206} Despite this endless need for apparel, several shoes were recovered during the Belle excavation. There are several rationales for this, the most plausible of which is that they were badly worn and were no longer serviceable as shoes.
To determine the use-value of these items to the colonists, one must assess the condition of the footwear at the time of burial. To address this phenomenon, the degree of use-wear on each shoe or footwear element was examined, because it is logical to suppose that items with light or moderate use-wear were serviceable at the time of Belle’s sinking. The following section will examine the physical traces of use on the Belle shoes to determine their worth as apparel at the instance of deposition.

Criteria used to evaluate condition must be strictly defined, so as to not confuse use-wear with post-depositional damage. For the purpose of this exercise, harm that would not result in discard is limited to light and/or moderate use-wear. This includes abrasive wear on the heel and sole, friction imprints from toes or feet on the insole and the interior of the toe cap, and the erosion of latchet attachment holes due to tie-laces and chape buckles. In contrast, artifacts that were discarded or awaiting repair should display heavy wear. This includes abrasion holes in soles, and disjointed or torn seams between upper components. A preponderance of one type should indicate the disposition of the shoe assemblage.

Fourteen of 24 proveniences (58%) maintained evidence of use-wear. Of these, 12 showed signs of light or moderate use (Table 5). Six artifact groups displayed worn soles or heels, six evidenced friction imprints on the insole and toecaps, and three showed wear due to the use or attachment of fasteners. The
two proveniences that maintained heavy wear exhibited exploded seams that necessitated the replacement of an upper element.

The predominance of shoes that displayed minimal wear indicates that the shoes were intact and wearable at the time of Belle's demise. There are few reasons why intact footwear would be left within the moored vessel. One possible rationale is that they belonged to the small crew of sailors who manned the ship as she trailed La Salle's search party between late October and November of 1685.²⁰⁷ Sailors often stowed their shoes to work, for the leather heels and soles were too slick on wet decks.²⁰⁸ It is possible that these shoes were taken off during the final hours of Belle's existence to complete a task and were then forgotten in a melee of activity that culminated in the loss of Belle and the death of several colonists.

It is also plausible that the shoes were being stored in the presumed safety of the ships' hold. It is known that La Salle and his allies stored great quantities of personal equipment aboard the vessel, and that the final efforts of Belle's crew was spent salvaging the belongings of their leader.²⁰⁹ It is possible that the general colonist stored valuables in much the same manner. These items, unlike the possessions of La Salle, were simply never claimed.
particular interests of the analyst. It is vital that Belle footwear be preserved so
The questions that can be asked of this data depend entirely on the curatorial and
Despite the widened scope of this study; it is by no means comprehensive.
we now know what it was like to walk in their shoes for the briefest of instants.
more fulfilling life abroad. This study has offered a glimpse into their daily life;
impressive. Motivated by desperation or coercion, these people left France for a
have been few studies conducted about the plight of seventeenth-century French
The analysis also provides information about a lost class of people. These
the Belle footwear symbolizes a form of folk art
the Belle footwear symbolizes a form of folk art
characterize works of the lowest quality, they were still fashioned with far more
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of academic attention, often at the expense of a working populace that formed the
modern period. Simultaneous between the Great nations of Europe Gained the majority
largely overlooked the contributions of the common citizen during the early
seventeenth-century Cornewhite. Historians and archaeologists alike have
historical record from two different perspectives. The first of these concerns
from Belle. Since notwithstanding, analysis of these finds has supplemented the
The footwear assemblage represents but a fraction of the artifacts recovered

Conclusion
evens that culminated in the artifacts removed from the hull of Belle.

conservation procedures. The first step in this evaluation is to review the chain of

profession from ancient technology through to the application of modern

archaeological conservation of ancient artifacts. However, must be evaluated as a

this work focuses on the conservation of leather artifacts for this reason. The

new scholars can ask different questions of this assembly. The second half of
5. FROM CRAFTSMAN TO CONSERVATOR: 
THE PATH OF ARCHAEOLOGICAL LEATHER

Manipulation of organic complexes to create useful products is a cornerstone of social evolution, and as such, treated hides and skins have been utilized in myriad aspects by human culture for the breadth of their genetic existence. Egyptian and Babylonian leather practices were thoroughly documented as early as 2000 B.C., and Roman leatherworkers pioneered hide tanning procedures that became ritual until the latter half of the nineteenth century. Leather technology has therefore grown with humanity, and the versatility and strength of hide products has led to their pervasive use throughout recorded time. This long-established practicality has resulted in an archaeological record replete with leather remnants from past ages, and it has fallen to the archaeological conservator to preserve these treasures for the future.

Much like other leather assemblages recovered from archaeological contexts, the leather shoe collection recovered from the seventeenth-century French barque Belle is a product of a succession of processes that resulted in the artifacts excavated from the floor of Matagorda Bay in 1996 and 1997. The purpose of this chapter is to detail the facets of leather composition, production and deterioration in order to provide a working framework for the archaeological conservator to draw upon. This will include inquiries into hide histology and biochemistry, vegetal tanning procedures, and leather deterioration in a marine
environment. Special attention will be focused on the composition and historic procedures that produced the Belle leathers, which were the techniques of continental Europe between 1650 and 1700. Any discussion regarding leather composition, however, must begin with a description of the nature and chemistry of untreated hides.

The Histology of Vertebrate Hides

Often considered to be the simple covering of a more complex living system, skins and hides are in fact multifaceted organs that serve a series of vital functions, such as the regulation of body temperature, protection, and the excretion of waste. It also houses a wide range of sensory apparati, to include chemical, thermal and touch receptors. This diversity of function is made possible by a complex layering of tissues that includes two main strata. These are the outer epidermis and the central dermis.²¹¹ Although leather is composed strictly of the dermis, all layers will be reviewed because it is the interaction between the two that creates a material suitable for treatment and use.
The Epidermis

The epidermis is the outermost layer of mammalian skin. Being much thinner than the underlying dermis, the epidermis is composed of several dense layers of epidermal cells in various stages of growth and decay. The lowest layer represents the youngest cells, and as the bodies age they develop characteristics that define them in terms of strata within the epidermal layer. In general, cells become increasingly keratinized with age. This implies that they develop an increasing number of keratin bundles while at the same time losing the ability to produce melanin (the common mammalian skin pigment protein). Dead, highly keratinized cells are eventually shed as individuals or thin sheets, only to be replaced by cells from below. This transitional process creates a multi-layered epidermal stratum that maintains tougher, keratinized cells on the exterior, a clear, partially keratinized middle layer, and a protected inner stratum that maintains pigment producing granules and surrounds projecting hair follicles. Specific strata within the epidermal layer include the corneum, lucidum, and the malpighii, or basal layer. Hair filaments and follicles also originate in the epidermal level.
Epidermal Histology

The corneum represents the highly keratinized layer of epidermal cells found on the outer-most surface of the epidermis. These cells form an outer protective layer that serves to defend the living interior from physical trauma. The cells have lost their nuclear structure and they appear flat and grotesque when magnified. These bodies are gradually sloughed off and are replaced by others from the layer below.\textsuperscript{213}

The lucidum is a less distinct layer of cellular growth beneath the corneum. These cells are in the process of developing keratin bundles but are not yet physiologically inert as are those in the corneum. As these epidermal cells degenerate they produce a fatty oil that contributes to the flexibility of the epidermis while rendering this layer translucent.\textsuperscript{214}

The stratum malpighii, or basal layer, is the innermost layer of the epidermis. This layer produces all epidermal cells while at the same time generating Melanin granules. Melanin is the pigment that determines the color of the skin and hair of the animal while at the same time protecting the living layer of the epidermis and dermis from ultraviolet light. The base of stratum malpighii is composed of the basement membrane. This membrane forms the epidermis/dermis junction and it is composed of developing epidermal basal cells. This coating sends small tendrils of cell membrane into the papillary layer of the dermis to ensure a strong adhesion between the epidermis and the dermis. The basement membrane of the
stratum malpighii also houses the root of the hair follicles that extend into of the papillary strata below and out of the epidermis.\textsuperscript{215}

Histology of Hair Filaments and Follicles

Hair is considered to be epidermal structures because basal cells formed in the stratum malpighii comprise the outer sheath of the hair follicle. The majority of the functioning hair mechanism, however, extends proximally into the papillary layer of the dermis.

Hair mechanisms are composed of an integrated system of glands, muscle, nerve and protein fibers and can be separated into two distinct parts; the hair and the hair follicle. Hair is the keratinized filament that extends out of the epidermis. This is composed of two central components, the shaft and the bulb. The shaft portion of the hair filament extends proximally toward the base of the follicle to form an expanded circular knob referred to as the bulb. The bulb forms the anchor of the hair and receives blood flow from a single capillary.\textsuperscript{216}

Hair filaments are formed from a tapered column that is composed of three separate layers of keratin. The innermost core, or medulla, is formed of columnar shaped keratin fibers and cells that stimulate hair growth. The surrounding cortex is comprised of keratin and a group of more loosely defined cells. The outermost layer, which is referred to as the cuticle, is made of the same cells that are found in the stratum malpighii of the epidermis.\textsuperscript{217}
The second section is known as the follicle, which is the sac-like structure in which the hair resides. It is again composed of three distinct layers. The outermost stratum is comprised of longitudinally directed and very elastic fibers comprised of the protein collagen, while the dense, central layer is composed of a tightly wound spool of collagen. The inner lining of the follicle is formed of a single layer of epidermal cells that originated in the stratum malpighii of the epidermis.\textsuperscript{218}

Two glands accompany each hair mechanism. The sebaceous gland is found at the base of the hair follicle. It is composed of a special group of epidermal cells, much akin to the bodies found in the stratum lucidum. This gland secretes oil that surrounds the shaft of the hair and the outer layer of the epidermis. This oil serves to lubricate the hair and creates a water resistant barrier on the epidermis that aids in temperature regulation. The sudoriferous gland, or sweat gland, is composed of similar cells that secrete salts and water onto the outer epidermis via the hair follicle. This aids in temperature regulation.\textsuperscript{219}

The final component of a single hair is the erector-pilli muscle. This consists of a single, non-striated muscle fiber that surrounds the bulbous base of the hair follicle. This fiber is able to contract around this bulb, either stimulating secretions from the sebaceous gland or causing the hair to bristle, or stand on end.\textsuperscript{220}

Although the epidermis is not maintained as a part of the finished leather, it is germane to this discussion because the structure affects the appearance and
properties of the final product. Distribution of hair, sebaceous glands and oil content within the epidermis determines the grain pattern of the leather as well as the overall quality of a specific specimen. The grain pattern of finished leather is formed by the junction of the papillary layer of the dermis and the basement membrane of the epidermis. It reflects the original attachment of the epidermal structures. It is this lustrous, water resistant layer that holds the greatest aesthetic appeal to leather workers and users. Beneath the epidermis lays the dermis, which is the hide component from which leather is fashioned.

Dermis

The dermal layer comprises the main body of the skin and is the structure from which finished leather is derived. The dermis itself is composed of two non-distinct strata, which are the papillary layer and the corium. Although there are several biological components of each layer, seventy five percent of both layers are comprised of an interconnecting network of fiber bundles composed predominantly of the protein collagen. Hides of all vertebrates, from sharks to elephants, are comprised of this protein; and it is for this reason that leather may be created from their skins.
The Structure and Formation of Collagen

Protein collagen is a simple polymer that is recombined three times to form the basic building block of the dermal layer, the collagen bundle. The development sequence that results in the formation of the bundle, however, originates with the chemical precursor of collagen, tropocollagen. Tropocollagen is a protein that is manufactured by cells called fibroblasts. Fibroblast bodies are spindle shaped cells that are irregularly spaced in the interstices of the collagen fiber network. These cells, which are common components of all mammalian connective tissues, migrate throughout the intercellular matrix, producing tropocollagen as needed for the creation of collagen.\(^{223}\)

Tropocollagen itself is composed of three linear, un-branching amino acid chains that utilize a minimum of 1000 amino groups each and maintain a molecular weight of at least 300,000.\(^{224}\) The individual chains utilize twenty different amino acids, the most common of which are glycine (30%), proline (10%) and hydroxyproline (10%). The spatial shape of proline and hydroxyproline give each collagen chain a helical twist. Each of the chains that comprise the tropocollagen molecule is joined to their neighbors by hydrogen bonds that form between adjacent carboxyl and amino groups. This creates a distinct three chain right-handed helical molecule with a rod-like appearance.\(^{225}\)

Tropocollagen is then chemically aligned outside of the fibroblast to form the smallest building block of collagen, the fibril. Collagen fibrils are elliptical in
cross section, appear striated if magnified and are of indeterminate length. The striations of each strand, which appear as regularly spaced white and black bands, are due to the varying density of tropocollagen molecules.\textsuperscript{226} Fibrils are soft and very flexible, even when dry. They display great tensile strength and are very resistant to pulling and twisting.\textsuperscript{227}

An accumulation of collagen fibrils is then vertically woven into a longer collagen chain via highly polar regions at each end of the fibril. These elongated collagen polymers are called fibers, and they form the basic unit of the collagen bundle. Collagen bundles are formed by the horizontal alignment of fibers by means of a series of peptide bonds, forming a bundle of collagen that maintains a twist that resembles a right-handed helix. Although individual fibers are not elastic, the angle of the helical weave within the larger fiber bundle permits stretching much like a spring, offering increasing resistance as the force exerted on the bundle becomes greater. Interweaving of these bundles forms the bulk of the dermal matrix, which is pliant, elastic and strong.\textsuperscript{228} Alignment of these bundles, however, changes within the dermis.
Dermal Histology

As previously mentioned, the dermis is composed of two layers, the papillary layer and the corium. The papillary layer is comprised almost exclusively of large collagen bundles that are arranged at ninety-degree angles to each other and are very densely packed. This assembly creates a compact, watertight layer that serves to protect the underlying corium from physical damage. Flexibility of the papillary layer is achieved by a small number of fibers composed of the protein elastin interspersed throughout the stratum. Density of the collagen fibers within the papillary layer drops proximally until it merges with the corium layer below.229

The papillary layer is of vital importance to leather manufacture and use, as it comprises the outer surface, or grain layer, of leather products. The grain layer is vital because it imparts the pleasing, burnished surface to the outside of the product while at the same time providing a strong, flexible and water resistant backing for the corium below.230

The corium composes the bulk of the dermis and it is comprised of an unending web of collagen bundles, collagen producing fibroblast cells, blood capillaries and the surrounding ground substance liquid. These components are interwoven to form a complex network of fibers on which the most important characteristics of leather are founded. Specific arrangement of these components, however, is dependent on species and location on the hide. In all instances,
however, the general weave is oblique to the base of the corium. It is this angle, when coupled with the unique properties of collagen, which provides the toughness and tensile strength inherent to all leathers.  

The entire dermal network is immersed in a electrolyte-enriched fluid known as the ground substance. This fluid serves as a lubricant for the sliding collagen bundles, and also provides an amniotic matrix needed to repair damage to the dermal layer. The corium ends abruptly at the hypodermis, or flesh layer of the organism.

Untreated hide, as examined above, would serve human needs almost as well as tanned leather. The use-life of the object, however, would be very short, as the hide would quickly decay and become dry, weak and brittle. Introduction of tanning not only increased the use-life of hide objects, but also enhanced the toughness, tensile strength and flexibility of the material.
The Procedure and Efficacy of Hide Treatments
in Seventeenth Century Europe

It became apparent to early man that untreated hides were of limited function. Through experimentation that began with ancestral hominids, techniques developed to prolong the use-life of hide products. This testing culminated in the development of vegetal tanning techniques by the Egyptians and Babylonians around 2000 B.C., thus producing true leather that varies little from what is currently used today.233 Leather treatment procedures of seventeenth-century Europe had not changed appreciably from those early, defining attempts. Pre-industrial hide treatments were labor-intensive, time-consuming efforts that often required several years to produce a finished product. Two different craftsmen, the tanner and the currier, were required to create usable leather, each altering the hide in unique ways to fit the needs of the leather workers.234 This section will detail the standardized European hide treatment procedures in terms of the work of these two craftsmen, followed by a scientific evaluation of the method's chemistry and efficacy.
Tanning in Seventeenth-Century Europe

The tanner was a fixture in all pre-industrial European villages. Located a safe distance from the center of town, tanneries were the site of a multi-stepped manufacturing procedure that turned freshly flayed or salted hides into basic leather. Tanning regimen can be divided into three distinct sections for the purpose of this discussion; these include hide preparation, tanning, and post-tanning treatments.  

The hide preparation step began after the tanner received the raw or salted hides from a local skinner. He would then remove all remaining blood, dung, and curing salts by washing them in a swiftly flowing stream. This process was accelerated by pounding the soaking hides with a mallet or by treading them under foot.  

Unwanted hair and epidermis was removed and the corium fibers separated in a process called liming. During the liming step the revived hides were de-haired through several baths in alkaline liquor prepared from wood ash, lime, water and urine or stale beer. Hides were then left in the mixture until the hair root and epidermis had putrefied. Once the hair was loosened, the hide was splayed over a wooden frame and both sides were carefully scraped with a blunt, double handled, tanners knife to remove the hair and excess fat that was liberated during the process. This procedure was repeated until the hair complex was completely removed and the skin structure was free of unwanted fats and oils. This
procedure, which could take up to one month, not only removed the epidermis and hair, but also separated the collagen fibers of the corium so as to better receive the tanning liquor.\textsuperscript{237}

The next procedure, which was called bating, was undertaken to produce a softer, more flexible hide medium. This was initiated by immersing the skins in an underground bath composed of dog or bird dung and water for several weeks. This mixture created a rich, enzymatic soup that dissolved, or hydrolyzed, any unbound proteins trapped within the dermis. Upon completion of this step, the hides were again washed and scraped to remove the protein-rich precipitate that had accumulated during the soaking. This sequence required a minimum of six months to accomplish.\textsuperscript{238}

The actual tanning process began by immersing the freshly prepared skins in underground tubs that contained a weak tanning solution composed of oak bark and water. The skins were constantly agitated to assure a uniform exposure. This step acclimated the collagen proteins in the hide to tannins and introduced a uniform color to the grain layer of the hide. This took no longer than one day.\textsuperscript{239} The hides then underwent a relatively rapid immersion in a succession of tanks called suspenders, each containing tanning liquor of increasing strength. This step required another month, and it served to acclimate the collagen to a longer immersion in a potent, freshly made tanning liquor.\textsuperscript{240}

Hides were then transferred to larger tubs, called layerers, for the remainder of the tanning process. Each hide was laid flat within these pits with six inches of
tanning material such as ground oak bark, wood, leaves and twigs between each skin. Once filled, the pit was capped with 12 inches of tanning materials and topped with fresh water. Hides were kept in these layering vats for between 12 and 18 months; the time required varied according to hide thickness and the potency of the tanning liquor.  

Once sufficiently tanned, the leather was removed, stretched and dried in a dark barn. The drying step required precision and a consistent temperature and humidity, for if the leather dried too quickly it would crack, while too slow a process would encourage mold growth. Once dried, the leather was graded by a member of the local tanning guild and sold to another group of craftsmen, curriers. 

Currying Leather in Seventeenth-Century Europe

Beginning with the early medieval period, currying, or the finishing of dried vegetable-tanned leather into a material appropriate for fine leather goods, was a trade distinct from that of the tanner. As such, curriers were responsible for a series of different techniques; each catering to the specific craftsmen who utilized the finished leather, such as the glover, boot maker and cordwainer. The currying procedure examined below reflects the needs of the pre-industrial cordwainer for shoe upper materials. The standard currying process can be divided into three basic steps: scouring, splitting, and stuffing.
The currying process commenced with the scouring stage, which began immediately after the dried hides, or crust leather, had been purchased from the tanner. During scouring, the stiff skins were first softened by several immersions in running water. They were then softened with repeated blows from large wooden curriers’ mallets. Both leather surfaces were then scrubbed clean using stone blocks or stiff brushes.\textsuperscript{245}

The splitting of a hide followed scouring, in which the corium portion of the leather was pared to a thickness required by the contracting craftsmen. To perform this exacting exercise, a hide was stretched over a vertical bench and shaved with a specialized curriers knife. A curriers knife was a long two-handled knife with a single cutting edge. The right handle of the tool represented on extension of this edge, while the left handle was attached at a ninety-degree angle to the blade, facing away from the currier. This design, which had lingered since ancient Rome, enabled a craftsman to shave a hide to exacting proportions with little risk to the currier or the expensive raw material.\textsuperscript{246}

Once pared, the hides were again washed and dried in preparation for the stuffing step. Stuffing involved application of dubbin to the leather, which was a mixture of tallow and fish oils. This substance was applied in order to preserve the flexibility and pleasing luster of the finished product. Once the master currier had finished the product, it was sold to leather merchants based on quality defined by grain density, finish, color and flexibility.\textsuperscript{247}
Although tanners and curriers of the seventeenth century had mastered leather making in all aspects, the chemical foundation of their treatments have were obscured. The conservator, however, must be concerned with the efficacy and action of past treatments in order to confront the problems that effect ancient leather assemblages in the modern setting.

An Appraisal of Seventeenth-Century Hide Treatments

The tanning procedure examined above had been utilized to transform untreated hides into finished leather for more than two millennia. Until very recently, however, it has remained unclear as to how that end was achieved. The following analysis will examine the three central benefits of tanning in relation to the time-honored tanning procedure reviewed above.

The first benefit of tanning is that is raises the shrinkage temperature of mammalian skin. The hydrogen bonds formed between the collagen chains of the collagen bundles of un-tanned hides will rupture at 65° Celsius, thus causing warping and shrinkage of the collagen matrix and eventually the entire object. Vegetal tanning introduced large molecules called tannins that cross-link with collagen molecules. This reaction occurs because the unbound hydroxyl group on the tannin molecule forms hydrogen bonds with electronegative centers on the carbonyl and amino groups of the protein chain. This condensation reaction eliminates weakly bound water molecules while at the same time more closely
binding collagen bundles. In doing so, the union between tannins and collagen protein molecules is strengthened. Furthermore, the hydrophobic areas of the tannin/collagen unit are drawn together by Van der Waal forces. This again releases weakly bound water molecules and further enhances the bond between the two substances. These two bonds serve to form a more stable collagen/tannin interaction that requires greater heat energy to deform and break down the protein structure. This, in turn, serves to raise the temperature of shrinkage from 65 to 85° Celsius.\textsuperscript{248}

The second problem with the use of natural skins is their susceptibility to attack by microorganisms. Tanning reduces the likelihood of microbial attack by removing water-soluble proteins and fats during the tanning process. The odorous mixture created by the addition of bird and dog droppings during the bating steps of the process selectively metabolize all unbound proteins and biological matter trapped within the matrix of the hide, thus eliminating the food supply of any marauding microbes.\textsuperscript{249}

Rapid water loss is the third failing of un-treated hides. As raw skins are used, they gradually lose bound and unbound water through evaporation. This creates a chemical imbalance within the matrix of the skin. The addition of vegetal tannins balances the hide chemically by removing water and replacing it with a tannin molecule that cannot be lost by evaporation. Bound tannins can be removed with prolonged washes; even so, most archaeological leather is still tanned when recovered from the ground.\textsuperscript{250}
The loss of water also disrupts the fiber structure of skin. Usually, the collagen fiber bundles that were surrounded with the water-based ground substance would collapse when the water was lost, resulting in an immediate reduction in flexibility and torsion strength. This is prevented during the tanning process by replacing water with tannin molecules. This substitution fills the interstitial gaps between corium fiber bundles, which results in a retention of flexibility for an extended period of time.²⁵¹

Freshly tanned leather is a resilient, durable substance that can maintain a viable use-life for several decades if well treated. Despite this, all media will eventually decay if left to the mercy of time and the elements. The deterioration of archaeological leather deposited in a waterlogged environment occurs due to a set of circumstances unique to the material type and the benthic environment of the sea floor. The following section will investigate the causes of leather deterioration in a waterlogged setting in order to prepare the archaeological conservator for conservation problems specific to collections from wet sites.
The Deterioration of Archaeological Leather
in a Marine Environment

Factors that contribute to the deterioration of leather in a marine environment are poorly understood at best. The majority of data regarding this topic has focused specifically of the degradation of collagen chains. It is therefore necessary that leather deterioration be viewed from the viewpoint of the material scientist and not the conservator.

From the perspective of material science, leather can be defined as a protein polymer infused with complex tannins. Leather therefore reacts and deteriorates much like any complex natural protein; and the factor that most contribute to the breakdown of collagen that has been subjected to long-term marine exposure is the hydrolysis of the collagen chains.\textsuperscript{252}
Hydrolysis

The operational definition of hydrolysis is the breakdown of collagen due to the re-hydration of the amino acid chains that had been originally assembled through the loss of water.\textsuperscript{253} This damage directly affects the protein chains of corium fibers by breaking peptide bonds between amino acids in the triple helical structure of individual corium fibers. This results in mechanical weakening of the fiber structure that is promoted from one fiber to the next.\textsuperscript{254} The end result is a protein body that is soluble in water. This reduces the leather object to small free-floating peptide chains or amino acids that cannot be reconstituted.\textsuperscript{255} Causes of hydrolysis are numerous, and include acidification by metal or other reactive compounds and bacterial attack.

Oxidation of collagen in marine environments can be directly attributed to the breakdown of metal salts trapped within the matrix of the leather. For example, sulfur dioxide, which is a common compound created as a bacterial metabolite, reacts with free oxygen in the presence of ferrous or ferric ions to produce sulfur trioxide. This in turn reacts with water to form sulfuric acid. The hydrogen ions from the acid then attack peptide links of collagen molecules, breaking them into smaller polymer chains or simple amino acids.\textsuperscript{256} The same basic reaction occurs when ferric chloride blooms react with water to form hydrochloric acid, or sulfur combines with oxygen to produce sulfuric acid.\textsuperscript{257} Copper and chromium salts will also cause oxidation in the presence of hydrogen peroxide.\textsuperscript{258}
Digestive enzymes of some marine bacteria also hydrolyze leather structure in the same manner. Although poorly understood, digestive secretions from a large percentage of marine bacteria can cleave peptide bonds between individual amino acids and collagen chains alike. This can only occur in the presence of oxygen and it is for this reason that leather is preserved only in anaerobic environments. Despite quick burial in sea sediments, most leather experiences a limited exposure to oxygen, which results in some degree of bacterial attack. Leather hydrolysis, regardless of its source, will always be the central conservation problem faced by the conservator.

Effects of Hydrolysis on Historic Leathers

Leather that has undergone any degree of structural weakening due to hydrolysis will display a series of characteristics that begin with a loss of coherency in the collagen weave of corium. Fibers from degraded leather appear loose and flaccid, with very little structural strength. This damage, when coupled with the loss of oils and tannins from within the matrix, results in severe warping and swelling while in the sea. This problem becomes more acute after recovery, as the loss of the replacing water will result in severe shrinkage and further warping if it is not replaced with a consolidant during conservation.

Hydrothermal stability of leather is also compromised by fiber damage due to hydrolysis. The weakening of collagen leads to a relatively low temperature of
denaturation, which represents the temperature at which the collagen fibers break down completely and become gelatinized. Gelatinized leathers appear as flat, none-distinct objects with no defined collagen fiber structure. The temperature of denaturation is especially vital when considering archaeological leather recovered from tropical climates or wet leather that has been stored in a high temperature environment.\textsuperscript{261} While these factors by no means comprise all of the conservation problems encountered with marine leather, they do encompass the most common conservation problem that stems from deposition in a marine environment.

Archaeological leather, which can be simply defined as tanned collagen, arises from a series of treatments and conditions that pose unique problems to a conservator. For this reason, a thorough understanding of the path of marine archaeological leather is vital for proper assessment and treatment of the material. As knowledge of archaeological leathers has increased, conservation therapies that have arisen to stabilize collagen products have become more refined. The following chapter analyzes the leather conservation procedures developed during recent decades in order to evaluate the current state of leather treatments around the globe.
6. THE CONSERVATION OF LEATHER FROM MARINE CONTEXTS

Nautical archaeology can be loosely defined as the study of the material remains of ships and their contents as a component of a broader cultural system.\textsuperscript{262} The oceans and lakes of the world are replete with shipwrecks from all eras, and these sites have become the premier source of data for the nautical archaeologist. The inter-relationship between the vessel, cargo, and crew is expressed in the assemblages recovered from these sites, and the analysis of such remains serve to fill in the expansive gaps between human behavior and material culture that is left behind.\textsuperscript{263}

The harsh environment of the sea floor, however, affects remains from these sites in various ways. Metal artifacts are transformed into non-descript conglomerations of marine growth and sediments called encrustations, while organic remnants are preserved via chemical reactions with metallic salts, or by quick burial in an-aerobic soils. Equilibrium established between an object and its benthic environment is disrupted upon recovery, and the artifacts, if neglected, will rapidly deteriorate into warped, non-descript waste. To avoid this, remains must be carefully treated to ensure their long-term survival as museum specimens or diagnostic examples. These treatments are the purview of an archaeological
conservator, and it is for this reason that conservation and nautical archaeology are forever wed.\textsuperscript{264}

Archaeological conservators have myriad treatment options available to them. Metal objects can be preserved or even remade through the use of electrolysis and casting procedures. Organic materials, long thought to be unfortunate casualties of nautical excavations, can now be treated and stabilized with various bulking agents and or polymers. The role of an archaeological conservator, however, is by no means limited to treatment and stabilization of artifacts. They are also responsible for cleaning, documentation, and analysis of objects that they treat. The intimate link that develops between conservator and assemblage always results in a wealth of new data that was not evident during the field excavation. In this way the conservator serves not only as a technician but also as a laboratory archaeologist.

Leather artifacts are a component of many marine assemblages, and conservation of wet leather has long been a source of contention within the archaeological conservation community. Techniques that have been utilized on wet leather are diverse; each individual conservator or organization employs different methods to treat and store leather artifacts. The purpose of this chapter is to survey the trajectory of wet leather conservation over the past thirty years by examining the salient cleaning, consolidation, and storage procedures in use over the past three decades. Archaeological conservators are bound by a professional code that defines ethical treatment of all materials. The more pertinent ethics, as
defined by the International Institute for Conservation (IIC), are reviewed in appendix 1 of this work.265

Sediments, Salts and Stains:
The Cleaning of Archaeological Leather

Upon removal from an archaeological matrix, leather artifacts are commonly tainted with sediments and salts, both soluble and insoluble. Cleaning of leather artifacts burdened with the above problems is required for several reasons. Bulky concretions or heavy sediment build up are removed to reveal diagnostic structures hidden below. Other elements must be detached due to their deleterious effects on the objects themselves. Regardless of the rationale, all cleaning procedures should be undertaken with extreme care; it is sometime advisable to leave stubborn concretions in place rather than risk damage to an artifact during removal. The first step in cleaning any artifact recovered from a marine setting is removal of soluble salts.
Desalination: Removal of Water Soluble Salts

The sea abounds with ions such as sodium (Na⁺), potassium (K⁺) and chlorine (Cl⁻). These elements can combine to form a simple salt when ions pairs reach a critical concentration in water; the most common of these salts are sodium or potassium chloride. Once a leather artifact is removed from the sea, ions trapped in the collagen fiber matrix crystallize as water evaporates. This can affect leather in two ways. First, the salt can precipitate on the surface of the leather, which obscures diagnostic details. Second, the expanding body of salt crystals can disrupt the delicate structure of the leather itself, causing irreparable physical trauma throughout the body of the artifact.

The favored procedure for removal of soluble salts from leather objects differs from other material types. Although archaeological leather is often brittle and delicate, it is prudent to desalinate leather with several small baths of de-ionized water. The small bath size limits the amount of water and ions available to hydrolyze the already weakened collagen fibers of the artifact. Also, the lack of enclosed cellular bodies within the matrix of tanned leather does not necessitate the use of graded desalination baths required for wood and other organic materials. Testing discarded rinse water with a conductivity meter can monitor progress in the desalination step. Leather artifacts that contain less than ten parts per million of soluble salts are considered to be acceptably desalinated.
Sediment Removal

Adhering sediment should be removed immediately following desalination. This often serves to reveal details originally hidden, such as stitch holes or makers' marks. It also permits a conservator to make a more accurate assessment of disposition of the artifact. Sediment removal, however, should be undertaken with extreme care.

If possible, sediments should be removed with soft brushes. This limits abrasion to the exposed surfaces, which can weaken the artifact and result in loss of data. Furthermore, running water should never be applied directly to archaeological leather, as it may result in physical damage. Hidden areas can be cleaned using wooden or metal tools such as tongue depressors, dental picks or cotton swabs. A non-ionic surfactant, such as Lissapol-N, can be applied to the surface of the object to loosen stubborn soils before removal. Mechanical cleaning with a hand-operated ultrasonic transducer (a Branson Sonic Twenty kHz sonic cleaner is the most commonly used) can also break bonds between soils and collagen fibers of the corium. Despite limited utility, this method does not remove sediments from hidden areas and can damage the structure of leather objects in an advanced stage of hydrolysis.
Removal of Insoluble Salts

Removal or stabilization of insoluble salts is the most difficult and time-consuming aspect of the cleaning process. These salts, which are commonly manifested by bulky calcium carbonate concretions or metal salt stains and encrustations, can be removed mechanically or with the application of chemicals. Elimination of these elements, however, should be undertaken only if the chosen procedure does not place the integrity of the object at risk. Some insoluble salts, such as calcium carbonate, are stable after excavation, and should not be removed unless the concretion or stain obscures data.

Iron corrosion compounds are the most commonly encountered partially or completely insoluble salt found on archaeological leather. These include ferrous hydroxide (Fe(OH)$_2$), ferrous chloride (FeCl$_2$), ferric oxide (Fe$_2$O$_3$), ferrous sulfide (FeS), and cuprous chloride (CuCl). The majority of these stains or concretions occurs incidentally on leather, resulting either from corrosion of the metal component on a composite artifact, or from a “bleed” created by deterioration of a nearby metal source. These corrosion products are unstable, and should be removed with judicious application of chemicals solutions in order to prevent further chemical and/or structural damage to collagen fibers of leather.\textsuperscript{273}

Most iron oxides can be removed with a five percent solution of oxalic acid in de-ionized water. This requires repeated baths over the course of three to four
days and should be carefully monitored throughout the process. The treated artifact then requires prolonged rinsing to remove any lingering acid solution trapped within the leather. This treatment is effective, but time consuming.\textsuperscript{274}

Other solutions that maintain a similar efficacy include a three percent solution of orthophosphoric or ascorbic acid in de-ionized water with the two percent addition of a surfactant or chelating agent. The surfactant serves to loosen bulky concretions and shorten the treatment time.\textsuperscript{275} A three percent solution of citric acid, phosphoric acid or ammonium citrate will also suffice, if applied in short, closely monitored baths of no more than two hours.\textsuperscript{276}

The most useful chelating agent for archaeological leather, however, is disodium EDTA (the disodium salt of ethylene diamine tetra-acetic acid). A five percent solution of disodium EDTA can remove ferric (Fe\textsuperscript{3}\textsuperscript{+}), cuprous (Cu\textsuperscript{2}\textsuperscript{+}), nickel (Ni), lead (Pb\textsuperscript{2}\textsuperscript{-}), zinc (Zn), ferrous (Fe\textsuperscript{2}\textsuperscript{+}), manganese (Mn), and calcium (Ca) salts sequentially by forming water soluble complexes with the undesirable metal ions. The disodium EDTA procedure must be carefully monitored, and artifacts should be thoroughly rinsed before further treatment is initiated.\textsuperscript{277}

There are several aspects that should be considered, however, when using strongly acidic or basic solutions on deteriorated leather. These chemicals promote the creation of ions that, much like the free associated ions of seawater, can result in the hydrolysis of collagen fibers.\textsuperscript{278} Furthermore, iron salts also react favorably with any unbound tannins within the corium to form the darkly colored but stable compound, ferrous tannate. Subsequent removal of the ferrous
tannate molecules greatly reduces any benefit that remained from the original
tanning of the artifact and aggressive use of acids reduces the shrinkage
temperature of leather objects for this reason.\textsuperscript{279} For these reasons chemicals
should be used in low concentrations and carefully monitored.

Aside from elimination of potential corrosive agents, removal of insoluble
salts benefits leather artifacts is two ways. Metal salts, specifically ferrous
compounds, tend to darken collagen and impart archaeological leathers with a
dark hue. Therefore, collagenous materials display a lighter, more realistic
leather-like color after cleaning. In addition, metal salts can also infuse into the
porous matrix of the corium and bind with collagen fibers. The relatively large
size of metal salt complexes do not permit fibers to slide against each other and as
a result flexibility is reduced or completely lost. Consequently, leather artifacts
also display a greater range of flexibility after cleaning treatments.\textsuperscript{280} The
cleaning procedure is the first of several steps required for stabilization of marine
leathers. The following step, referred to as consolidation, should be complete
before an artifact can be displayed or curated.
Consolidation of Wet Archaeological Leather

Removal of salts, sediments and stains is the first of many steps required to stabilize and successfully conserve archaeological leather. After cleaning, a conservator is faced with a second set of conservation problems. As previously discussed, most leather artifacts recovered from marine contexts are in an advanced stage of hydrolysis. The physical structure must be strengthened if the object is to survive and maintain its value as a diagnostic specimen. That portion of the process, referred to as consolidation is the most heavily debated aspect of leather conservation. In this vein, two basic techniques have dominated leather conservation for three decades. These are polyethylene glycol or glycerol infusions used in conjunction with freeze-drying; or a period of controlled drying followed by the application of humectant mixtures in the form of dressings or baths.
Freeze-Drying Archaeological Leather

Freeze-drying has long been a technique utilized by archaeological conservators. First used on archaeological leather in the early 1970's, the method has been slowly refined over the course of three decades. Schools of conservation that currently utilize freeze-drying strive to stabilize and consolidate leather without sacrificing the natural softness and flexibility. Despite a degree of uncertainty, the method has proven to produce leather of a realistic color and texture, while also providing the bulking required to offset damage from hydrolysis. It also generates a dehydrated end product without the use of organic solvents. Despite some variation, the procedure for freeze-drying archaeological leather can be distilled to three basic steps, to include consolidant impregnation, freezing, and freeze-drying.
Consolidant Impregnation

Introduction of a consolidant into an artifact is the first stage of freeze-drying. These agents serve a dual purpose within the collagen matrix of leather goods. First, consolidants fill interstitial gaps that resulted from hydrolysis within an artifact; thereby strengthening it. Second, the presence of this substance prevents formation of large ice crystals during the freezing stages to follow, which could, if allowed to form, damage the internal structure and diagnostic details of the artifact.

All proponents of freeze-drying adhere to a simple procedure of impregnation that requires an immersion bath in a consolidant at ambient pressure for between four days and six weeks. This allows the bulking agent to gradually spread throughout the collagen matrix of the leather without risk of damage from a vacuum. While the method for introducing consolidant is universal, the conservation community is split as to the most efficacious bulking agent for archaeological leather.

Two basic materials, polyethylene glycol (PEG) and glycerol, are currently favored for consolidation of archaeological leather. Both of these compounds offer unique benefits and drawbacks, and each institute or school of conservation uses them independently or in tandem to conserve leather. PEG has been used for the longest period of time and will be discussed first.
Polyethylene glycol has been a tool of the archaeological conservator for four decades. Many in the leather conservation community prefer the use of PEG in conjunction with freeze-drying because it produces a lighter, more realistic color and is less prone to shrinkage than glycerol.\textsuperscript{286} Several molecular weights are utilized, to include PEG 400, 540, 600 and 1500. The larger molecular weights are used to consolidate severely hydrolyzed examples, while the lower molecular weights penetrate easier and offer a greater degree of flexibility.\textsuperscript{287} PEG is also applied in different concentrations depending on the amount of bulking required for the specific object. All reviewed procedures utilized PEG in percentages ranging from 15 to 33% in solution with de-ionized water.\textsuperscript{288}

Glycerol, or propane 1,2,3 triol, has been used with increasing frequency and with excellent results. Glycerol tends to be far less hygroscopic than PEG, and acts as a more efficient consolidant at lower percentages and molecular weights. Hide artifacts pre-treated with glycerol also display a more realistic texture and flexibility when compared to PEG-treated objects.\textsuperscript{289} The concentration of glycerol used during pre-treatment varies from 15 to 30% in solution with de-ionized water.\textsuperscript{290}

In an attempt to combine the benefits of both bulking agents, the conservation institute at the Vitenskapsmuseum in the Netherlands pre-treats leather with an aqueous solution that contains 7.5% glycerol and 7.5% PEG 400. This amalgam has resulted in leather with an excellent balance of aesthetic appeal and structural stability.\textsuperscript{291}
Freezing

Once the pre-treatment step is complete, the artifact is frozen in order to acclimate it to the stresses of freeze-drying. This can be achieved via two basic methods. Most institutions advocate freezing the object to between −20 to −30°Celsius in an insulated box filled with solid carbon dioxide, or dry ice.292 Another simple but effective method is to seal an artifact in a polypropylene bag and place it in a domestic chest freezer until completely frozen.293

Freeze-Drying

After an item has been frozen, it is then placed in a vacuum freeze-drier that maintains a constant temperature set between −18 and −30°Celsius.294 A vacuum of no more than 150 milliTorr is then applied to the sealed chamber, prompting the small ice crystals to sublimate and gather around the exposed condenser coils of the apparatus. An object is considered to be completely dehydrated when no crystals appear on the condenser coils or the weight of the object remains constant for several days.295 The time required for freeze drying step varies between two days and four weeks, depending on the temperature within the chamber and the size of the artifact being treated.296 After completion of the treatment, an artifact is gradually acclimatized to the temperature and relative humidity of the storage facility or museum in which it will reside.
Post-Treatment Techniques

A few post-treatment techniques have been applied to freeze-dried leather in order to enhance appearance or repair pre- and post-depositional damage. The resin Acryloid B-72 has been used to repair rents or holes in leather objects, and the acrylic monomer, polymethyl acrylate, has also been utilized to further consolidate badly hydrolyzed or worn areas. Microcrystalline wax polish can also be applied with a lint free cloth or brush to promote a more realistic, soft sheen on the grain layer. Despite the apparent utility of freeze-drying leather goods, several sharp criticisms of the technique have evolved as previously treated leather assemblages have come under closer scrutiny.

Evaluation of Freeze-Drying Methodologies

Despite continued efforts of the conservation community, there are no perfect conservation treatments available for archaeological leather. Opponents of freeze-drying cite numerous post-treatment problems that afflict artifacts conserved in the recent past. These critiques can be divided into two categories that include pre-treatment consolidants and the freeze-drying mechanism itself.

The two pre-treatment consolidants that are most commonly used are the previously mentioned polyethylene glycol and glycerol. Both have been recently attacked by numerous schools of conservation, catalyzing a debate as to whether
freeze-drying still has a place in archaeological conservation. The early result of this debate has rendered PEG as the most controversial consolidant in use today.

To begin, PEG is a hygroscopic compound that tends to release trapped moisture, or sweat, at a relative humidity of 60% or above.\textsuperscript{299} Despite the best intentions of curatorial facilities world wide, very few can boast an interior environment that is that rigorously controlled all of the time. Furthermore, if treatment calls for a solution that contains less than 20% PEG, the mixture is too dilute and results in a dry, warped end product with very little structural stability.\textsuperscript{300}

In addition, lower molecular weight PEG compounds, such as PEG 400, 540, and 600, are components of many car antifreezes and do not fully freeze at \(-30^\circ\) Celsius. This results in an artifact that is not fully dehydrated during the freeze drying process, which frequently leads to additional sweating or mold growth shortly after the treatment is complete. PEG infused leather goods also tend to change color as the relative humidity of the storage facility rises and falls.\textsuperscript{301}

Despite several inherent flaws, glycerol has immerged as the preferred consolidant by default. The main drawback observed with glycerol-infused artifacts is that the compound tends to migrate to the surface of leather objects as the freezing step is taking place. This often leads to partially consolidated objects that warp and shrink as much as 15% during treatment. Glycerol is also a dense compound, and the leather tends to retain more of it than is needed. This results in a heavy artifact that may not be able to support its own weight.\textsuperscript{302} Furthermore,
Glycerol is more sensitive to fluctuations in humidity than PEG, and often weeps under balmy conditions. Even if the above drawbacks could be overcome, problems with freeze-drying are not limited to the vagaries of pre-treatment consolidants.

The technique of freeze-drying is, by nature, an unforgiving treatment. There is no way to monitor the quality of the treated leather during the procedure. Once an artifact has been placed in the sealed chamber of the freeze-drying apparatus, the process must be completed before the leather can be critically evaluated. Any problems that occur during that time cannot be remedied and the end result often reflects this lack of control.\textsuperscript{303} In addition, by removing all or most of the moisture from the artifact, “successfully” freeze-dried leather goods lack cohesion within the matrix of the leather fibers. This results in stiff artifacts that shed corium fibers when handled. Furthermore, freeze-dried leathers cannot be reshaped effectively after treatment and are rarely reconstructable for this reason.\textsuperscript{304}

Despite the above criticisms, freeze-drying remains as one of the better options available to modern leather conservators. It is a relatively cheap considering both material and labor costs, and is flexible enough to permit procedural changes as conservators become more experienced with nuances of archaeological leather. Artifacts in poor condition can undergo freeze-drying, and shrinkage is often held to between 5 and 10%. Like most techniques employed by archaeological conservators, freeze-drying is efficacious under certain
circumstances, but is inadvisable in others. Additional research is required to establish a clearly defined role for the freeze-drying of archaeological leather. Regardless of the promise of the technique, many conservation laboratories advocate the use of controlled dehydration and leather dressings or baths as the most effective and least invasive leather conservation methodology.

Use of Dressings and Baths as a Conservation Methodology for Archaeological Leather

Conservators of leather book bindings first introduced the use of dressings or baths during the late 1950’s. The early dressings varied according to the personal preference of the conservators, and very little attention was paid to long-term stability of objects being treated or the environment in which the collections were stored. The archaeological conservation community adopted leather dressing in the late 1960’s as the predominant methodology for the conservation for both wet and dry archaeological leathers. The first universally accepted archaeological leather dressing was developed at the British Museum of Archaeology in 1972, and the British Museum Leather Dressing (BMLD) became the standard leather dressing treatment for the next 25 years. Since that time, countless different dressings and baths have been developed to treat wet leathers, and there are several established conservation laboratories that still advocate their use over freeze-drying.
Current proponents of leather dressings espouse a conservation philosophy that focuses not on consolidation but on establishing oil, moisture and acidity levels that are conducive to the long-term stability of archaeological leathers.\textsuperscript{306} As such, effective leather dressings contain specific components or pre-treatment steps that address problems arising in those areas. The action of leather dressings is best understood in terms of these individual ingredients. The following section will examine various compounds employed in leather dressings and how they satisfy the above criteria. This will be followed by a review of several dressings, their application procedures, and an evaluation of their role in archaeological conservation.

Oil Content and Leather Lubricants

All leathers, both historic and modern, must maintain an oil, or lubricant content in the range of 4.8 to 11.8\% by volume in order to remain stable.\textsuperscript{307} This stability can be attributed to three interrelated factors. To begin, certain oils prevent the collagen fibers from adhering to each other as the leather ages. They also permit individual fibers to slide against each other when leather is stressed, thereby preserving or even enhancing flexibility. Oils reduce water absorption as well, which provides a degree of water resistance.\textsuperscript{308} Various lubricants are, for this reason, an ever-present component of leather dressings.
The more common lubricants used in leather dressings are anhydrous lanolin, neats-foot oil, castor oil and cedarwood oil. These are all natural oils or waxes. Lanolin and neats-foot oil are mammalian byproducts. Lanolin is wax that is extracted from sheep wool, while the former is rendered from the femurs and hooves of cattle. In contrast, castor and cedarwood oils are vegetable based. These substances are used in leather dressings because they share certain chemical characteristics that benefit historic leathers. Most importantly, all of the materials maintain a high percentage of saturated fatty acids. Saturated fatty acids are chemically stable, and this extends their use-life and prolongs their efficacy as a lubricant. These compounds also maintain two distinct polar regions. The negative pole is attracted to the numerous positive regions of the collagen helix. This leaves the positive pole exposed to repel water from the interior of the collagen matrix. Glycerol is the only synthetic lubricant in common use, and it is used only on artifacts that are in poor condition.
Acidity Levels and Chemical Buffers

Historic leather must also maintain pH between 5 and 7 in order to remain stable. As mentioned previously, acids degrade collagen proteins of leather in the presence of water. If left untreated, acidic leather goods will deteriorate at an ever-increasing rate, and this deterioration will cause the pH level to fall below that at the time of excavation. It is therefore imperative that artifacts treated with dressings be buffered against predation from acids before the collagen environment is completely destroyed. The compounds that commonly promote the deterioration of archaeological leather are sulfuric (H₂SO₄) and hydrochloric (HCl) acids, and both are present in wet archaeological leather in varying proportions. These compounds arise from the byproducts of enzymatic attack by microorganisms or from contamination resulting from the decay of nearby metals.

The acidic character of archaeological leather can be buffered or neutralized via a variety of techniques. A pre-treatment method espoused by many English leather specialists requires a series of thirty-minute immersions in a solution of 4% ammonium hydroxide (NH₄OH) in de-ionized water until the pH of the artifact has risen to an acceptable level. This serves to stabilize leather by neutralizing acids trapped within the artifact. Despite its utility, this treatment must be reapplied every two to four years as the pH within the leather will begin to fall again as the artifact is exposed to air pollutants. More commonly, a buffer
is used as a component of the leather dressing itself. The best buffer available for this purpose is imidazole, which is preferred for several reasons. It can be joined with other components without the presence of water, and it also acts as a humectant that draws water away from the already hydrolyzed areas of the artifact. Furthermore, imidazole reacts with copper and iron salts to form neutral compounds that no longer contribute to acidification of leather. Finally, imidazole acts as an anti-histamine that repels attack from insects.\textsuperscript{314}

Moisture Content

The appropriate moisture content of archaeological leather that has undergone significant hydrolysis has been determined to be 4\% or less by weight.\textsuperscript{315} Well preserved archaeological leather that has undergone little or no hydrolysis, however, can maintain a moisture content as high as 12\% and remain stable.\textsuperscript{316} The choice is therefore subjective as to the desired concentration. Most conservators prefer to limit or eliminate possible conservation problems as opposed to managing them, and the current treatments advocate the elimination of water instead of closely monitoring its presence.

Most water can be removed from desalinated archaeological leather with a dehydration step that precedes the actual dressing application. Several different solvents are used, and emphasis of this step is placed on restricting use of organic solvents to accomplish this. Controlled air-drying is generally undertaken to
remove at least 50% of the existing water.\textsuperscript{317} Artifacts are then bathed in neatsfoot oil, methylated spirits or white spirits to drive most of the remaining water out of the leather. These compounds are considered to be gentler than organic solvents, and they do not remove beneficial tanning stuffs from leather as do prolonged baths in acetone or ethanol. Several short baths in ethanol, diethyl ether or hexane will remove any lingering water.\textsuperscript{318}

Once dehydrated, there are several components that can be added to leather dressings to ensure that water does not creep back into the matrix of the leather. The most common of these components is beeswax. Beeswax is an organic substance that serves as a physical barrier against the penetration of water. It serves to seal the pores of the grain layer, while also limiting penetration to the corium below. It also provides a certain measure of mechanical support in examples that have need of it. The use of beeswax, when coupled with water resistance of the lubricating oils, effectively protects conserved leather from further deterioration due to water.\textsuperscript{319}

The compounds reviewed above represent the more common components currently used in leather dressings. While individual elements offer specific benefits to marine leathers, the proportion of these elements within dressings are arranged to produce specific effects. As such, these ratios accurately reflect the focus of the treatment. The four dressing formulae listed below have been chosen from among dozens for their long-term efficacy and popularity within the conservation community. A more comprehensive list of leather baths and
dressings can be found in Geoffrey Smyth's 1986 report, *The Conservation of Historic Leathers*, from University College, Cardiff, United Kingdom.

Examples of Leather Dressings and Baths

British Museum Leather Dressing (BMLD) is composed of 200 grams of lanolin, 15 grams of beeswax, 30 milliliters of cedarwood oil and 350 grams of hexane (solvent).\(^{320}\) This dressing is clearly focused on the lubrication of the collagen fibers. Lanolin and cedarwood oil are present in the highest concentrations, and beeswax is simply used to enhance the sheen of the grain layer and provide limited protection against high humidity levels. Hexane is used because of its high volatility and utility as a universal solvent.

H. Van Soest developed a second leather dressing in 1984 that has been in popular use ever since at the Rijksdienst Oudheidkundig Bodemonderzoek (State Service for Archaeological Investigations, Amsterdam, Holland). It contains 4 grams of neats foot oil, 2 grams of lanolin, 2 grams of imidazole buffer, and 86 grams of white spirits.\(^{321}\) This dressing once again focuses on lubrication with the addition of a buffer for the neutralization of acids. This fusion, however, does not utilize an organic solvent. White spirits are used instead because they are perceived to be gentler than their more volatile organic cousins.

Elize van Diest from the Central Research Laboratory for Objects of Arts and Science in Amsterdam developed a similar mixture that has seen great utility for
archaeological finds. It contains 2.5 grams of castor oil, 1 gram of glycerol, and 8 grams of methylated spirits. This formula seems better suited to the conservation of hydrolyzed leather. It maintains castor oil as an effective lubricant, and glycerol as a lubricant/bulking agent. The use of methylated spirits can also be interpreted as an attempt at a less aggressive treatment.

The father of archaeological leather conservation, Olaf Goubitz, developed in 1964 the most time honored and efficacious of the reviewed treatments. It is a bath that contains 35% castor oil, 15% glycerol and 15% tertiarybutylalcohol. This formula offers excellent lubrication (castor oil), while also providing a significant degree of bulking (glycerol). This treatment consistently results in a dry, well-consolidated product that is not overly hygroscopic, even after thirty years of storage. The proper use of leather dressings and baths is as important as their individual components and composition. The following section will detail the current theories of dressing and bath application.
Dressing and Bath Application

Experiments in the early 1960's with leather dressings and baths have proven that the thoughtless use of these materials will result in poorly conserved, unstable specimens. Since that time, scientific research and trial and error have proven that proper application of leather dressings and baths can result in stable, aesthetically pleasing end products that, if stored in a proper environment, are re-treatable. Employment of dressings and baths differ greatly. Dressing use will be reviewed first because this procedure is more delicate and specimen specific than that for baths.

Leather dressings, when fully emulsified, generally appear as pastes of varying viscosities. Early application procedures encouraged liberal application of dressing, stopping only when the leather no longer absorbed the compounds. This often resulted in darkened leather artifacts that were greasy in texture. Badly hydrolyzed samples also tend to release excess dressing, as they do not have the well-defined fiber structure to hold it. Contemporary procedures advocate using of no more than 5% leather dressing by weight per application. Dressing are applied by hand or with a lint free cloth; extreme care should be taken with badly deteriorated or hydrolyzed samples. This should produce a stable product that is not tacky or distorted. This procedure should then be repeated every two years to replace any dressing components that have sublimated or broken down in the interim.
Baths are much simpler to apply than dressings. Most bath treatments are much less viscous than dressings, and an artifact can simply be submerged into the liquid for a period not to exceed six hours.\textsuperscript{326} Artifacts in poor condition should be submerged with form-fitting supports of wire mesh, while those in a better state can be immersed naked or in a simple wire-framed basket. Once impregnation is complete, the artifact is drained in a curatorial environment until all excess liquid has drained. Follow-up evaluations should be a part of this treatment regimen to determine when and if the procedure should be repeated.\textsuperscript{327}

Extensive use of leather dressings on archaeological materials has produced a body of information regarding the efficacy of the treatment on archaeological examples. The following section represents an evaluation of this data to determine the role of leather dressing methodologies within archaeological conservation.
An Evaluation of Leather Dressings and Baths

Within Archaeological Conservation

Dressings and baths have been used to treat leather assemblages for over three decades. The recent evaluation of specimens by institutions such as the British Museum and State Service for Archaeological Investigations at Amsterdam Holland, has enabled modern conservators to predict the long-term trajectory of leather artifacts treated with traditional dressings and baths. Most critiques of these leather treatments are focused on application procedures, long-term stability and action of various components of the dressings themselves. As such, three basic categories will be considered in this assessment; these include oils, waxes, and dressing application methods.

Oils are the dominant ingredients, by weight, in leather dressings and baths. These substances are required to promote flexibility and reduce water absorption. Despite their utility, certain oils, particularly lanolin and neats-foot oil, maintain variable levels of unsaturated fatty acids. These acids are chemically unstable and lead to oxidative breakdown in the presence of water. This invariably leads to crumbly, stiff leather goods after ten to fifteen years. Furthermore, oils tend to weep with time, resulting in a tacky surface that is frequently stained and discolored. At worst, heavily applied oils can result in chemically unstable specks forming on the surface of the leather.
Waxes are also commonly encountered, particularly in leather dressings. These substances are employed to prevent water uptake and produce a pleasing sheen to the grain layer of the leather. In doing so, however, waxes impede further treatment of an artifact by blocking pores in the grain layer. Waxes also tend to leave a negative polar field on the surface of the leather that attracts dust particles and air pollutants such as sulfur dioxide.  

The most common criticism of leather dressings and baths in particular is the over-zealous application of the medium. Leather dressings, as a matter of course, were applied until the leather no longer absorbed the conservation medium. Baths, by nature, saturate an artifact in the liquid before the excess is removed by draining and blotting. Deleterious effects of the individual components are magnified when they are present in higher quantities, and artifacts that are not carefully monitored after treatment can degrade in a matter of a few years. Judicious application of leather dressings, and the careful draining and blotting of bathed items, more often result in a stable product that is less prone to deterioration. This more cautious treatment regimen, however, is more labor intensive because it must be repeated every one to three years. 

The use of leather dressing and baths, much like freeze-drying, can result in stable, aesthetically pleasing specimens. As with other methodologies that have developed from within fine arts conservation, these dressings and baths work best on artifacts that have not undergone a significant amount hydrolysis or chemical degradation. Leather recovered with the corium structure intact is more likely to
reap the benefits of the above technologies, as it is still possible to improve flexibility and restore color and a healthy chemical balance within the artifact. Therefore, a careful, experienced leather conservator can restore the majority of flexibility and chemical balance to marine artifacts without undue shrinkage or warping.\textsuperscript{332}

Having reviewed the central tenets of modern archaeological leather conservation, it is clear that there are many options from which scientists may choose to treat ancient hide products. A vast majority of the leather assemblages treated by conservators appear both beautiful and stable immediately after conservation. Most problems with treated leather arise one to ten years after conservation. This can be attributed to two separate factors. The first problem, as previously described, is an incomplete or poorly proscribed conservation procedure. The second is due to poor storage facilities and the lack of follow-up evaluations. The final section of this chapter will evaluate current curation procedures, because the conditions in which treated leathers are stored are as vital to their survival as conservation methodology.
Curation of Archaeological Leather

The most salient precept of conservation is an unwavering dedication to the long-term survival of the treated specimen. Because of this, a majority of artifacts are treated with extreme care while in the hands of archaeological conservators. The fate of these objects, however, is often dictated by the curatorial facility in which they are stored. Poorly controlled conditions in such facilities can negate all meticulous conservation efforts in a matter of months. There are four main factors to be considered before a curatorial facility is safe for storage of artifacts. These aspects are humidity, temperature, air purity and curatorial materials. This section will deal with each of these factors independently in order to provide a functional structure for correct storage of archaeological leather assemblages.

An appropriate humidity is vital to safe storage of leather goods. Prior to the 1980’s, most curatorial facilities did not maintain a consistent relative humidity. Most problems afflicting archaeological leathers are born from, or related to, excess water within the matrix of the leather. Both hydrolysis and oxidation require water. Mold growth, constant oozing of hygroscopic bulking agents (PEG and glycerol) and continued alteration of surface color and texture also stem from excess water. As a result, countless leather collections suffered from a series of water-bourn maladies that either destroyed collections or required countless hours to fix and, once again, stabilize them.
Appropriate humidity for the storage of archaeological leather has been determined to be between 52 and 55%. This humidity level does not permit hydrolysis or oxidation of the collagen, while also preventing any damage from molds or hygroscopic conservation chemicals. Humidity levels can be easily regulated by a central air system or with portable humidifiers that can treat single rooms only.

A consistently low temperature is also vital to the stability of marine leathers. Composed almost exclusively of protein, leather can denature and warp irreversibly at temperature that exceeds 20° Celsius. This temperature can fall even lower depending on the condition of the individual proteins at time of conservation. High temperature also accelerates chemical deterioration processes, particularly those associated with hydrolysis. For this reason, the accepted temperature for storage of leather assemblages is between 0 and 16° Celsius. Lower temperatures are preferred as they can slow the rate of chemical deterioration even further.

Unlike most other material types, leather and other hide products are very susceptible to air pollutants. One of the most common air contaminants is sulfur dioxide, which is a metabolite of bacteria and is a component of car exhaust fumes, coal, and petroleum products. This chemical, if allowed to build up in sufficient quantities, frequently leads to the powdering of vegetable-tanned leather in the form of red rot. Red rot is localized oxidation of corium fibers on leather artifacts, and if left untreated, will perpetuate until the entire collagen fiber system
has been consumed. It is therefore imperative that leather goods be stored in facilities that offering some protection from surrounding pollution. This can be achieved with simple air filtration units that remove hazardous chemical from the surrounding air.

Having reviewed the essence of leather conservation, it has become evident that there is no current conservation treatment that has escaped the scrutiny of archaeological conservation community. Although each of the methodologies evaluated in this chapter have produced stable artifacts, each has also yielded a significant proportion of irretrievable failures. It is clear that the field of archaeological leather conservation needs research into alternate treatment plans and new technologies.

Conservators Donny Hamilton and Wayne Smith from the Nautical Archaeology Program at Texas A&M University have attempted to fill this need. Using polymer passivation technologies, Dr. Smith has redefined the tenets of archaeological conservation. This protocol has become a viable treatment option for many organic compounds, including ancient waterlogged wood, bone, and leather. Conservation of the Belle leather assemblage with polymer passivation represents the first practical application of this technology on waterlogged leather items. The following chapter will review the conservation of the Belle leather assemblage in terms of this emerging technology.
7. CONSERVATION OF THE *BELLE*

LEATHERASSEMBLAGE:

SUMMARY OF PROCEDURE AND RESULTS

Conservation of waterlogged leather has been a source of contention within the archaeological conservation community, and little work has been conducted in recent years regarding new technologies. Two basic techniques have dominated leather conservation for three decades. Polyethylene glycol or glycerol infusions used in conjunction with freeze-drying are the most common treatment used in modern laboratories.\(^{341}\) This therapy was developed in the early 1960's in the Netherlands, and few changes have been made since the mid-1970's due in large to the cost effectiveness of the technique.\(^{342}\)

The other method used in leather conservation is the application of dressings to both wet and dry leathers. Over forty different dressings have been used to treat leathers, all of which contain petroleum products and waxes. These treatments were originally designed to replace some of the natural oils or tanning additives that were once present during the objects use life. The most common of these therapies is British Museum Leather Dressing (BMLD).\(^{343}\)

Despite the popularity of these methodologies, both are inherently flawed. They are still in use because many archaeological conservators are reluctant to develop treatments that couple existing wisdom with recent science. Leather conservation, however, is currently undergoing a renaissance regarding
employment of new technologies. Led by conservator C. Wayne Smith from Texas A&M University, introduction of polymer passivation techniques provides archaeological conservators with a new option concerning treatment of leather objects recovered from marine settings. This chapter reviews the use of polymer passivation on archaeological leather, focusing on the chemical components and action of the treatment, a review of the application procedure, and an assessment of the results. As with most new technologies, there are few sources available regarding polymer passivation. Background chemistry was drawn from the work of fellow student and chemist, Ann Miller. The remainder of the data for this chapter emanates from personal experience and observation.

Chemical Components

In theory, polymer passivation treatment represents the infusion of "a linear silicone-polymer cross linked [and cured] with an alkosilane in situ using a tin based catalyst."\textsuperscript{344} Three basic compound are utilized in this process, an alkosilane cross-linker called methyltrimethoxysilane (MTMS), a tin-based catalyst called dibutyltin diacetate (DBDTA), and a linear silicone-polymer known as silanol-terminated polydimethylsiloxane or silicone oil. Although this reaction requires the presence of all three chemical compounds, silicon oil is the central component and will be discussed first.
Silanol-terminated polydimethylsiloxane (Figure 41) is a linear chain-like molecule composed of a tetrahedral silicon molecule that shares single bonds to two methyl functional groups and two oxygen molecules. The oxygens are in turn bonded to other silicon units of the same composition. This silicon chain can continue indefinitely in this manner. Similar units called silanols molecules terminate the structure; these molecules maintain un-bonded alcohol functional groups instead of naked oxygen groups. The repeated, non-branching chain of silicone units define silanol-terminated polydimethylsiloxane as a linear polymer. The compound itself is as a colorless, viscous liquid. Silicone oils exist is many different viscosities, the level of which is defined by the molecular weight of the polymer. Thick, viscous oils maintain long, heavy chains, while the thinner, less dense compounds maintain shorter polymer lengths.

The second component is the cross-linker, methyltrimethoxysilane (Figure 42). Another silicone-based molecule, an individual MTMS molecule is a single silicone atom bonded to three methoxy functional groups and one methyl group. This cross-linker assists the silicone oils to link with each other and the chemical structure of the artifact.

The final compound used during the polymer passivation procedure is the dibutyltin diacetate (Figure 43) catalyst. DBDTA is composed of a tetrahedral tin atom bonded to two butyl functional groups formed from a linear four-carbon chain. The same tin atom is also bound to two acetate functional groups. These groups are composed of a central tetrahedral carbon that is single bonded to a
methyl group, double bonded to an oxygen atom, and single bonded to a second oxygen, which is shared with the tin in a single bond. As a catalyst, DBDTA provides the requisite energy needed to initiate the reaction between silicone oil and MTMS.

Reaction Sequence

Curing or hardening of the oils occurs when a cross-linker and catalyst is mixed with the silicone compound. The chemical reaction in which this occurs takes place in three separate stages. These are the hydrolysis of DBDTA, followed by a reaction between the resultant dibutyltin acetate hydroxide with MTMS, and finally cross-linking of silicone oil with that intermediate compound.

The first stage in the curing process is the transformation of DBDTA into a viable catalyst. In this reaction, DBDTA reacts with ambient water vapor, which results in the cleavage of an acetate group from the tin compound that is summarily replaced with an alcohol functional group. The resultant compounds are a functional catalyst, dibutyltin acetate hydroxide, and an ethanol byproduct.

In the second stage, dibutyltin acetate hydroxide them merges with MTMS. In this reaction, the newly acquired alcohol functional is cleaved from dibutyltin acetate hydroxide and is replaced with the trimethoxy silane from MTMS. The resultant compounds are a polymerization intermediate and a methanol byproduct.
In the third stage, the polymerization intermediate combines with silanol-terminated polydimethylsiloxane. In this reaction, the trimethoxy silane group is cleaved from the polymerization intermediate, and replaces the alcohol functional group on the terminal silanol unit of silanol-terminated polydimethylsiloxane. Resultant compounds are polydimethylsiloxane bonded to methyltrimethoxysilane and dibutyltin acetate hydroxide. Actual cross-linking occurs between the newly acquired methanol bonding sites with the remaining terminal alcohol groups. Note that the dibutyltin acetate hydroxide catalyst is regenerated as a byproduct and helps to carry the reaction to completion.

In general terms, cross-linked silicone oil resembles a clear, plasticized compound that is flexible and impermeable to water. It is very stable chemically and has a half-life that exceeds 2,000 years. Silicone oil is also universally non-reactive, and can be employed on a variety of media without risk. In terms of these qualities, silicone oil is an excellent candidate for use as a consolidant/sealant in archaeological conservation. Despite recent applications to that end, silicone chemistry was created for other purposes. Conservator C. Wayne Smith developed a procedure for the application of the silicone oils to archaeological materials; the following section will review this process as it relates to the waterlogged leather recovered from the Belle shipwreck.
Procedure

The procedure described below encompasses the entire treatment regimen for the waterlogged leather recovered from the seventeenth-century French shipwreck, *Belle*. The figures that accompany this section will detail the conservation of a typical seventeenth century latchet-type shoe, Artifact Record Number 6075 (Figure 44). As defined by the author, the polymer passivation procedure can be divided into five distinct sections. These steps include: 1) post excavation storage and desalinization, 2) dehydration, 3) silicon oil impregnation, 4) draining and cleaning, 5) catalysis and 6) curation.

Post Excavation Storage and Desalinization

All artifacts recovered during excavation were stored in salt water with sediments from the site area in Matagorda Bay. Treatment of all artifacts began after the assemblage had arrived at the Conservation Research Laboratory (CRL) at Texas A&M University. The first priority for the conservation of artifact # 6075 was removal of soluble salts.

Soluble salts can be efficiently removed with a series of water baths. The leather artifacts from *Belle* were subject to the gradual removal of soluble salts with a succession of rinses. These sequential baths prevented structural damage to specimens that cannot withstand a rapid osmotic exchange between the artifact
and the surrounding medium. The bath sequence is as follows: a) 75% seawater/25% fresh water, b) 50% seawater/50% fresh water, c) 25% seawater/75% fresh water and d) 100% fresh water. The rinse in successive baths of 100% fresh water continued until the soluble salt level reached that of the fresh water source. De-ionized water is then substituted for the fresh water until all soluble salts have been removed from the artifacts. All chloride levels were checked using a calibrated conductivity meter.

Dehydration

The polymer passivation procedure requires that the artifact undergoing treatment be free of water for two reasons. First, silicon oil impregnation is based on a solvent/silicone oil exchange. Upon immersion in a silicone oil compound, the solvent trapped in the pores and interstices of the dehydrated leather will rapidly volatilize to a gas. This gas then exits the structure of the leather, which leaves cavities that are filled with the surrounding silicon compound. Higher volatility organic solvents, e.g. acetone, promote a swifter exchange than less volatile solvents such as ethanol. The faster exchange results in less damage to the cellular structure and collagen matrix. Complete dehydration of leather objects is important for a second, unrelated reason. Water trapped within the matrix of the leather consolidated with silicon oil will promote future deterioration of the collagen structure due to hydrolysis.
To avoid damage that can stem from the rapid exchange of organic solvents during the dehydration process, the sequence begins with a series of ten solvent baths that progress from lower to higher volatilities. The succession of baths is as follows: a) 75% de-ionized water and 25% ethanol, b) 50% de-ionized water/50% ethanol, c) 25% de-ionized water/75% ethanol, d) 100% ethanol, followed by e) a second bath of 100% ethanol. Acetone was then introduced to the artifact using a similar sequence: f) 75% ethanol/25% acetone, b) 50% ethanol/50% acetone, c) 25% ethanol/75% acetone, d) 100% acetone, followed by a second immersion in 100% acetone (figure 45). Progress of the dehydration process was charted using successive readings from a specific gravity meter.

Silicone Oil Impregnation

A silicon oil compound containing 65% silicone oil (SDF-1/PR-10) and 35% methyltrimethoxysilane (MTMS) cross linker was mixed by weight to consolidate leather from Belle. SDF-I type silicone oil maintains a middling molecular weight specifically tailored to the conservation of archaeological leather; it offers substantial support for fragile leathers and also imbues treated items with realistic flexibility. Furthermore, the relatively low viscosity of the silicon/cross linker mixture contributes to a rapid solvent/silicone replacement, which reduces the shrinkage and warping that stems from the slow exchange of a more viscous silicon polymer.
Once prepared, the silicon oil/MTMS amalgam was transferred to a non-reactive plastic container. The leather shoe was quickly removed from the final acetone bath and immediately plunged into silicon oil (figure 46). The artifact was held firmly against the base of the container with a friction fitting wooden batten that ensured complete immersion in the conservation medium (Figure 47). There are two vital aspects to the silicon immersion process. First, the leather artifact must be completely saturated with the organic solvent prior to submersion in order to initiate a thorough silicone oil/solvent exchange. Second, the artifact must be completely covered with the silicone compound during the entire process. Exposed surfaces are subject to partial impregnation, which will result in shrinkage, warping and inter-fiber collapse.

The solvent/silicone exchange was evident shortly after the shoe was submerged in the silicone mixture, as thousands of small bubbles composed of gaseous acetone evolved from the surface of the leather. The submerged artifact was allowed to rest in the silicone compound at ambient pressure until the gas evolution had stopped. The artifact was then subjected to a vacuum of 8 Torr for 48 hours to ensure that all acetone had been replaced with the silicone medium.
Draining and Cleaning

The shoe was removed from the conservation medium 24 hours after gas evolution ceased. It was then placed on ¼ inch mesh screen that was mounted above a Pyrex beaker to drain excess silicon oil (Figure 48). The time required to remove the extraneous oil from a leather artifact varies, but a well-drained object should appear dry with no visible evidence of the conservation compound on the surface (Figure 49).

Once drained, the shoe was prepared for mechanical cleaning by separating all unattached pieces from the main body of the artifact. MTMS was then liberally brushed onto all surfaces to loosen adhering sediments. Soil was then mechanically removed using cotton-tipped wooden dowels, lint-free polishing cloths, and an assortment of non-abrasive brushes (Figure 50). Heavily mineralized sediments were removed with dental picks and a 10% solution of hydrochloric acid in de-ionized water. Some concretions were left in situ because their removal would alter diagnostic attributes of the artifact.

Over the course of the deposition process, sediments that surround the artifact will creep into the interstices of footwear or other stitched artifacts. Unwanted soils are typically found between insoles or lifts of a stacked leather heels, and in stitch holes that surround all footwear fragments. It is imperative that these components be separated to facilitate removal of sediments. This will result in a
more accurate form that will not be subject to damage from the effects of hidden acidic soils.

There are also several cleaning procedures that can restore more realistic leather-like qualities to deteriorated archaeological examples. The corium layer of leather will appear matted and waxy after it has been removed from the conservation media. Several applications of MTMS with a non-abrasive brush, followed by repeated agitation with a cotton-tipped dowel, will separate the entwined corium fibers. This results in a suede-like appearance typical of recently tanned leather.

The papillary layer of leather, which is commonly referred to as the outer grain stratum, also requires specific treatment to produce a appropriate exterior. Silicone oils trapped at the base of the corium layer will leak out of the hair follicle sheaths that punctuate the papillary layer. This will lead to a shiny, dappled appearance on the surface of the grain layer that must be removed with a lint-free polishing cloth. Once the leather artifact has been cleaned of all visible sediments and mineralized concretions, it should be placed on lint-free absorbent paper until all residual silicone oils have drained and there is no silicon leakage on the test paper (Figure 51).
Catalysis and Curatorial Storage

Once the shoe was cleaned and thoroughly drained of excess oils, it was arranged in a non-reactive plastic container lined with acid-free paper. Five to 10 milliliters of dibutyltin diacetate was decanted into a small aluminum basin, which was placed in the bottom of the container (Figure 52). The assembly was then sealed with a form fitted lid. The dibutyltin diacetate vaporized over the next hour, covering the artifact with an even layer of catalyst. Several applications were required to ensure a thorough reaction throughout the interior of the object. Catalysis was considered complete when the artifacts were no longer waxy or sticky to the touch.

Conservators must handle dibutyltin diacetate with the utmost care. It should be stored in an airtight environment; failure to do so can lead to oxidation of catalyst and unwanted cross-linking of artifacts in the earlier stages of treatment. Care must also be taken to decant and store the catalyst in a silicone-free, ventilated area.

Once the polymer passivation treatment was complete, the leather was placed in a sealed polyethylene bags with any relevant provenience data. They were then stored with other leather finds in a non-reactive plastic container at 68° Fahrenheit and 55% relative humidity.

On a whole, leathers treated with silicone oil maintained a realistic color and texture. Shrinkage was minimal, and pieces displayed greater flexibility and
tensile strength than before the treatment. The following section will evaluate, in detail, the efficacy of the polymer passivation methodology on the Belle leather assemblage.

Results

The Belle leather assemblage was the first substantial collection of waterlogged leathers to be conserved with polymer passivation treatment. Although earlier experimentation on ancient collagen yielded promising results, it remained unclear as to how the procedure would benefit leathers recovered in different states of preservation. The following evaluation represents a pre- and post-conservation assessment in which leathers are judged on four separate characteristics developed, in part, by the Environment Leather Project and the Leather Conservation Center at the University of Northampton. These include color, flexibility, tensile strength, and shrinkage. The data used in this study was largely qualitative in nature and was gathered at the Conservation Research laboratory at Texas A&M University between January and November of 2002.
Pre-treatment Condition of Belle Leathers

As with most archaeological assemblages, Belle leathers were recovered in a wide range of preservation. Causes of deterioration, however, can be distilled to the hydrolysis of collagen fibers. As previously discussed, hydrolysis arises from a number of factors, including digestive enzymes of microorganisms and acidification and subsequent reaction of metal salts. Hydrolysis is limited, however, to artifacts in constant contact with oxygenated water; most microbes cannot survive in an anaerobic environment, and metal salts trapped within leather require free radicals of hydrogen and oxygen to be reactive. The Belle leathers survived for 320 years because they were quickly covered with protective sediments, which stopped or greatly reduced their exposure to oxygenated seawater. Despite the speed with which they were deposited, many of La Salle’s leather goods suffered extensive damage.

Numerous artifacts were recovered with some degree of ferrous staining or ferric concretions. Aside from marring the appearance of the specimen, they also contribute to continued hydrolysis of the leather, and in some cases obscured surface detail and decreased flexibility. Hydrolysis, not mineralization, was the main conservation problem with Belle leathers.

Beside the presence of soluble salts and oxidized sediments, all of the Belle leathers suffered from some degree of hydrolysis. In the least severe of cases, individual collagen fibers of the corium were shortened, and they sloughed from
the body of the leather if handled roughly. Despite this, the tightly packed papillary layer remained beautifully preserved. Being waterlogged, these examples were swollen and were not extremely flexible, but they retained a great deal of tensile strength because most of the fiber network was intact. Damage was most visible on the edges of leather elements and on areas that maintained fine work such as stitch holes. These areas suffered because the interior body of the corium was exposed to agents of decay immediately after deposition. Colors of these items ranged from Munsell Chart brown (7.5YR 4/3) to very dark brown (7.5YR 2.5/2).³⁵² Thirty percent of the Belle leather assemblage was in such a condition, including all of the intact footwear.

The remaining 70% of the collection ranged from moderate to poor condition. The corium layer of these items was severely hydrolyzed in areas. This was manifested by a complete lack of integrity in the fiber matrix, in which the corium appeared as a solid mass of waxy paste. The papillary layer was visibly frayed and worn, serving largely as a backing to which the degraded corium adhered. These examples seem to be in better condition than they were. They were very flexible, and did not differ in color significantly (7.5YR 3/2 dark brown to very dark brown 7.5YR 2.5/2) from their better-preserved brethren.³⁵³ The enhanced flexibility, however, was due to the lack of fiber structure, and the color did not differ because disassociated collagen does not change color in a noticeable way. The most pointed indicator of condition in these cases was the lack of tensile strength. A deficient fiber structure resulted in a marked loss of stability; these
artifacts were friable and prone to tearing. The papillary layer alone held the form of many artifacts together.

Despite the range of preservation within the Belle leather assemblage, each artifact was conserved using the same basic procedure. The following section will evaluate the efficacy of the polymer passivation procedure on these leathers to ascertain the role of this new technology within leather conservation.

Efficacy of Polymer Passivation on Ancient Waterlogged Leathers

Archaeological conservators are charged with two main tasks. They must preserve material culture for future generations, and they must also ensure that the end product maintains its aesthetic, historic, and archaeological integrity. These two tenets guide this evaluation. Performance of silicone oil technologies was assessed using four categories established by leather conservators to address those fundamental guidelines. These criteria are color, flexibility, tensile strength, and shrinkage.
Color

Seventeenth-century cordwainers used leathers in a variety of colors to manufacture shoes, and modern scholars assert that footwear of European commoners ranged in hue from light to dark brown to black. The color of shoes was therefore very much a function of personal preference. The ocean is also replete with organo-chemicals that affect the color of leathers differently depending on microenvironments from which they were excavated. It is therefore impossible to judge the true pre-deposition color of the Belle footwear.

As previously mentioned, the color of the Belle footwear ranged from brown (7.5YR 4/3) to very dark brown (7.5YR 2.5/2) before treatment. Although this falls within the range of acceptability for shoes of that era, it must be assumed that iron salts from other artifacts seeped into the matrix of the leather and bound with the leather tannins, creating a slightly darker hue than the original. Leather color thusly altered can be lightened by the removal of the iron salts; many employ an immersion in 10% solution of disodium EDTA in de-ionized water. This is not recommended, however, because the sequestering agent removes protective tannins along with iron salts, thus reducing any residual protection from these compounds, while also compromising the historic integrity of the original tanning procedure. Disodium EDTA was not used for this reason, and the resultant color can be attributed to the silicone oil treatment alone.
Belle leathers treated by polymer passivation emerged with a slightly brighter tone than before treatment. This alteration, however, was not appreciably different from the pre-treatment hue; the color designation for the observed examples varied little on the Musell Color Chart. The slight change is likely due to variations in light reflection between fresh water and cured silicone oil. Aesthetically, the conserved leathers were pleasing to look at and the footwear emerged from treatment well within the accepted color range for shoes of their era.

Flexibility

The flexibility of seventeenth-century shoe leather depended on two factors; the portion of the shoe from which the leather came, and the quality of the leather used by the cordwainer. Superior upper leathers were very supple by definition, while excellent sole and heel components were rigid and tough. This trait, however, varied according to the quality of the leather and the degree to which the shoe was worn. It is reasonable to suppose that the Belle leathers were of low to middling quality, and that they had been sufficiently softened with months of hard wear.

The sole and heel leathers recovered from Belle maintained their rigid character. Well preserved uppers, however, were not extremely flexible; seawater had leached most of the tannins and lubricants that had enabled the corium fibers
to slide against one another. The use of acetone during dehydration also altered the chemical structure of the individual collagen proteins, fixing many in position. Conversely, poorly preserved uppers were very flexible because they lacked a coherent fiber structure. These examples were in need of structural support, not enhanced flexibility.

Upon completion of the polymer passivation procedure, well-preserved upper leathers were more flexible than before treatment. Silicone that coated each fiber allowed them to glide against each other with less friction, creating a more pliant material with a more realistic feel and texture. Despite the encouraging results, none of the Belle leathers maintained the flexibility of their modern counterparts. This is due in large to their state of preservation at the time of recovery, and not the chosen conservation treatment.
Tensile Strength

Relative tensile strength of the conserved leathers is an important measuring stick for two reasons. An enhanced strength or toughness indicates that the procedure served an effective consolidant. This implies that the silicone complex coated the leather fibers, and that the plasticized medium provides mechanical support for strands that had been weakened or disjointed by hydrolysis. The improved strength also enables the treated items to behave naturally. Leather was a commonly used because it could be drawn and pulled without deforming, and historic leathers that can approximate their original toughness are more realistic and true to their original form and concept. Despite its utility, tensile strength of hydrolyzed leather is difficult to measure without destroying the tested object. Consistently faced with this problem, archaeological conservators have long relied on touch, smell, sight and common sense to report preliminary results.\textsuperscript{365} The evaluation is based on observations of that type.

As previously mentioned, leather artifacts from \textit{Belle} were friable and easily torn before conservation; despite the care of the conservator, this damage occurred when the objects were moved between solvent baths and during the early stages of silicone impregnation. None of the objects could withstand any torsion or pulling; the application of this type of force resulted in further damage. Upon removal from the silicone mixture, however, many artifacts displayed greater strength and stood without support. The tensile strength of the objects increased
even further after catalysis. Shoes that arrived in pieces were re-assembled without concern, and the most severely hydrolyzed examples were handled without any additional loss. The polymer passivation treatment imbued the Belle leathers with greater tensile strength, and preserved some severely damaged examples that would not have survived freeze-drying or the application of leather dressings.

Shrinkage

As leather deteriorates in a marine environment, the bulking oils and tannins are lost due to bacterial attack and leaching. Resultant voids between collagen fibers are filled with water, sediments and salts from the depositional environment. These substances support the fiber structure, and largely prevent the shrinkage and deformation of the artifact.\(^{366}\) During the conservation process, conservators must remove water from leather goods to prevent further damage from hydrolysis, and in doing so they must ensure that the structure remains as it was upon excavation. To maintain the structure of these leather items and support the voids, a consolidant, or bulking agent, is infused into the object. A popular means of judging the efficacy of a consolidant is to measure the amount of shrinkage that takes place after the conservation treatment has been completed.

In order to determine the amount of shrinkage of the Belle leathers, and the efficacy of silicone oils as a consolidant, the shrinkage percentage was calculated
for five random proveniences within the leather footwear assemblage. This was achieved by subtracting the post-conservation length and width from the same measurements pre-treatment, and then dividing that sum by the pre-treatment measurements (Tables 6 and 7).

The randomly sampled proveniences, numbers 5851, 5954, 6043, 6870, and 11,414, shrank little during the polymer passivation treatment. On average, the artifacts shrank 1.3% in width and 2.3% in length. The loss that did occur can likely be attributed to two factors. The first is a delay in artifact transfer between the acetone bath and the silicone medium; the second possibility is an incomplete silicone exchange caused by partial submersion in the polymer. It is clear that the polymer passivation treatment is a more than adequate consolidant that will, if used properly employed, result in negligible deformation.
Conclusion

Preliminary results of this study indicate that the polymer passivation treatment is a viable option for conservation of waterlogged leather. Silicone oils were successfully applied to leather goods in all states of preservation, and the resultant products were well stabilized while also maintaining aesthetic, archaeological and historical integrity. Despite this early success, the procedure used on the Belle artifacts can be modified to better suit the needs of archaeological leather.

Upon excavation, the Belle leathers were desalinated and stored in large quantities of fresh water for several years. While submerged in water, the leathers continued to hydrolyze and break down, further damaging to structure of already delicate artifacts. Although there is no means to completely eliminate this, archaeological leathers should be stored in very small amounts of de-ionized water in sealed containers. This reduces the amount of ions available to propagate hydrolysis, and does not permit the migration of others into the storage solution.\textsuperscript{367}

After desalination was completed, artifacts were dehydrated in a series of solvent baths that culminated in two successive immersions in acetone. Acetone is not kind to proteins such as collagen. It tends to denature the intact, healthy protein fibers and fix them in place. This can result in warping and a severe
reduction in flexibility, which can make reconstruction difficult or even impossible.

Acetone is used in the final step of dehydration because it is highly volatile and has a low surface tension. This reduces strain on the interior of enclosed cell bodies during solvent-silicone exchange, and therefore limits the damage done to the structure during this exchange. Unlike most organic artifacts, leather items lack enclosed cellular spaces, and are not nearly as susceptible to damage this way. It is therefore recommended that leather goods be dehydrated with several baths of one hundred percent ethanol. This will not damage intact protein bodies, and should be still facilitate a thorough silicone exchange if a sufficient vacuum is applied. If these two recommendations are considered, the future silicone treated leathers should yield results that surpass the excellence of the Belle examples.

The summary of results in this chapter represents a preliminary assessment of the polymer passivation of waterlogged leather. Although very promising, additional quantitative research is required to supplement the qualitative observations supplied above. These should include scanning and transmission electron microscopy, experimentation with different molecular weight silicone oils and different crosslinker percentages, and a detailed, yearly evaluation of the Belle leathers to determine the long-term efficacy of the treatment. As with all conservation procedures, only time will determine the true value of the polymer passivation.
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APPENDIX A

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(Photograph by Amy Bourgens)
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(Photograph by Amy Bourgens)
APPENDIX B

TABLES
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<th>Artifact Record Number</th>
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### Table 2. Construction Elements

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<td>7449</td>
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<td>11,300</td>
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<td>11,398</td>
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<td>1(7)</td>
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<tr>
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<td>1(7)</td>
<td>1(2)</td>
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<td>11,685</td>
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<td>1(8)</td>
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<td>13,959</td>
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<td>1(8)</td>
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<td><strong>Totals</strong></td>
<td><strong>20</strong></td>
<td><strong>10</strong></td>
<td><strong>5</strong></td>
<td><strong>10</strong></td>
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<tr>
<td>Artifact Record Number</td>
<td>Heels</td>
<td>Stacked Leather</td>
<td>Wooden</td>
<td>Seams Per Inch of Sewn Seam</td>
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<td>11,414</td>
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<td>13,959</td>
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Total: 22  6  3  1
Table 4. Sole Length in Centimeters

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<th>Artifact Record Number</th>
<th>Sole Length (cm)</th>
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<td>6075</td>
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<td>26.05</td>
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<td>7012</td>
<td>27.46</td>
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<table>
<thead>
<tr>
<th>Total</th>
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<tbody>
<tr>
<td>Average</td>
<td>25.76 cm</td>
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Table 5. Use-Wear Traits

<table>
<thead>
<tr>
<th>Artifact Record Number</th>
<th>Wear on Latchet Holes</th>
<th>Abrasion on Heels and Soles</th>
<th>Friction Imprints on Uppers</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
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<td>6870</td>
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<td>11,617</td>
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<tr>
<td>11,685</td>
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<td>1</td>
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<td><strong>Totals</strong></td>
<td><strong>3</strong></td>
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<td><strong>6</strong></td>
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Table 6. Percent Shrinkage (Width)

<table>
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<tr>
<th>Artifact Record Number</th>
<th>Identification</th>
<th>Post-Conservation Width (cm)</th>
<th>Pre-Conservation Width (cm)</th>
<th>Percent Shrinkage</th>
</tr>
</thead>
<tbody>
<tr>
<td>5851</td>
<td>Right Quarter</td>
<td>11.9</td>
<td>12.2</td>
<td>-2.5</td>
</tr>
<tr>
<td>5954</td>
<td>Quarter Fragment</td>
<td>3.81</td>
<td>3.90</td>
<td>-2.3</td>
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<tr>
<td>6043</td>
<td>Treadsole Fragment</td>
<td>3.20</td>
<td>3.20</td>
<td>0.0</td>
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<tr>
<td>6870</td>
<td>Toe Cap</td>
<td>4.35</td>
<td>4.41</td>
<td>-1.4</td>
</tr>
<tr>
<td>11,414</td>
<td>Midsole Fragment</td>
<td>5.65</td>
<td>5.67</td>
<td>-0.3</td>
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</table>
Table 7. Shrinkage Percentage (Length)

<table>
<thead>
<tr>
<th>Artifact Record Number</th>
<th>Identification</th>
<th>Post-Conservation Length (cm)</th>
<th>Pre-Conservation Length (cm)</th>
<th>Percent Shrinkage</th>
</tr>
</thead>
<tbody>
<tr>
<td>5851</td>
<td>Right Quarter</td>
<td>10.1</td>
<td>10.3</td>
<td>-1.9</td>
</tr>
<tr>
<td>5954</td>
<td>Quarter Fragment</td>
<td>6.91</td>
<td>7.02</td>
<td>-1.5</td>
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<tr>
<td>6043</td>
<td>Treadsole Fragment</td>
<td>4.85</td>
<td>4.87</td>
<td>-0.4</td>
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<td>6870</td>
<td>Toe Cap</td>
<td>6.86</td>
<td>7.01</td>
<td>-2.2</td>
</tr>
<tr>
<td>11,414</td>
<td>Midsole Fragment</td>
<td>15.5</td>
<td>16.4</td>
<td>-5.5</td>
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APPENDIX C

SELECT CONSERVATION ETHICS
The following list of conservation ethics were selected from the International Institute for Conservation (IIC) guidelines by my mentor, Dr. Donny L. Hamilton. These considerations accurately embody the ethical concerns of the archaeological conservator.

A. *Respect for Integrity of Object*

Regardless of an artifact’s condition or value, its aesthetic, historic, archaeological, and physical integrity should be preserved. After conservation, an object should retain as many diagnostic attributes as possible.

B. *Competence and facilities*

It is the conservator’s responsibility to undertake the investigation or treatment of a historic or artistic work only within the limits of his or her professional competence and facilities.

C. *Single Standard*

With every historic or artistic work he undertakes to conserve, regardless of his opinion of its value or quality, the conservator should adhere to the highest and most exacting standards of treatment. Although circumstances may limit the extent of treatment, the quality of the treatment should never be governed by the quality or value of the object. While special techniques may be required during treatment of large groups of objects, such as archival and natural history material, these procedures should be consistent with the conservator’s respect for the integrity of the objects.
D. Suitability of Treatment

The conservator should not perform or recommend any treatment which is not appropriate to the preservation or best interests of the historic or artistic work. The necessity and quality of the treatment should be more important to the professional than his remuneration.

E. Principle of Reversibility

The conservator is guided by and endeavors to apply the “principle of reversibility” in his treatments. He should avoid the use of materials which may become so intractable that their future removal could endanger the physical safety of the objects. He also should avoid the use of techniques which cannot be undone if that should become undesirable.

F. Limitations on Aesthetic Reintegration

In compensating for damage or loss, a conservator may supply little or much restoration, according to a firm previous understanding with the owner or custodian and the artist, if living. It is equally clear that he cannot ethically carry compensation to a point of modifying the known character of the original.

G. Continued Self-Education

It is the responsibility of every conservator to remain abreast of current knowledge in his field and to continue to develop is skills so that he may give the best treatment circumstances permit.
H. *Auxiliary Personnel*

The conservator has an obligation to protect and preserve the historic and artistic works under his care at all times by supervising and regulating the work of all auxiliary personnel, trainees, and volunteers under his professional direction. A conservator should not contract or engage himself to clients as a supervisor of insufficiently trained personnel unless he can arrange to be present to direct the work.
APPENDIX D

BELLE FOOTWEAR CATALOG
Record Number: 500 (No Provenience)

Identification:

Provenience 500 represents a disassembled square toed, buckled, lachet type shoe.

Components:

Uppers: Includes a vamp, toecap, and the left and right quarter pieces.
Soles: All three soles are present, including the treadsole, midsole and insole. The midsole and treadsole display impressions of bracing thread.
Heel: The heel is of the peche variety. It is fastened to treadsole with six hardwood pegs set in a semicircular pattern (driven up into heel) and eight pegs in the center (driven down into heel). There is also a semicircular split lift set on the rear of the sole. The heel cap of at the base is also in place.
Construction Techniques:

Welt: The shoe is constructed with two types of welts. The welt that surrounded the heel represents the curled tension variety. The welt surrounding the remainder of the shoe resembles the more standard folded welt.
Upper Stitching: The rear seam joining the quarters is whip stitched. The seam at the quarter/vamp junction is also whip stitched.

Fastening:

The chape hole in the left quarter displays use-wear that indicates the employment of an anchor chape buckle.

Materials:

Uppers: Calf leather
Soles: Cow leather
Heel: Calf leather, cow leather, hide glue (peche heel), hardwood pegs
Stitching: Waxed flax cord.
Welt: Cow leather

Tool Marks:

Makers Marks: N/A
Tools Marks: 1) the midsole displays single slash mark used to extend left rear of midsole to edge of the tread sole

Repairs:

The cow leather cap that secures the base of the peche heel has been replaced as evidenced by additional attachment pegs.

Quality of Manufacture:

Average SPI for visible seams: 9
Average SPI for hidden seams: 6.5
Leather Quality: 5

Dimensions:

Width at Toe: 6.09
Width at Center of Heel: 6.51 cm
Length of Treadsole: 25.4 cm
Use Wear:

The attachment hole on the chape of the left quarter shows extensive use wear from the attachment of a chape buckle. The midsole and insole also show the distinct impression of a left foot. The heel cap also displays extensive wear at the rear of the heel.
Identification:

501 represents the partial remains of a square toed, buckle type shoe with overlapping lachets.

Components:

Uppers: A partial vamp and a complete right quarter piece.
Soles: N/A
Heel: N/A

Construction Techniques:

Only the heel welt is present. It represents the curled tension variety.
Upper Stitching: The rear seam joining the quarters is whip stitched. The seam at the quarter/vamp junction is also whip stitched.

Fastening:

Two puncture holes at the base of the tongue extension on the vamp and the short lachet of the right quarter indicate that the shoe was fastened or secured using a tie lace that joined short lachets. There may have been an iron support ring in the lachet to fortify the hole.
Materials:

Uppers: calf leather, Iron corrosion product surrounding the lace hole on the chape of the right quarter could indicate an iron ring support for the lachet hole. Welt: cow leather.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 9
Average SPI for hidden seams: 3
Leather Quality: 6.5 (above average-supple with even, pleasing grain)

Dimensions:

Length of Vamp: 18 cm
Width of Vamp: 12.6 cm
Width of Heel Welt: 5.1 cm

Use Wear:

The attachment hole on the chape of the right quarter displays extreme trauma that suggests torsional stress from numerous tyings.
Record Number: 11,685

Identification:

Provenience 11685 represents a single peche heel.

Components:

Uppers: N/A
Soles: N/A
Heel: A peche heel attached to treadsole with six hardwood pegs set in a semicircular pattern around the edge of the heel (driven up into heel) and eight in the center driven down from the treadsole into the heel. The heel cap is in place.

Construction Techniques:

Welt: N/A
Upper Stitching: N/A

Fastenings:

N/A

Materials:

Heel: Cow leather, calf leather, hardwood pegs, hide glue.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A
Repairs:

No repairs are evident.

Quality of Manufacture:

No visible seam stitching.
No hidden seam stitching.
Leather quality: 3

Dimensions:

Width of Heel: 6.32 cm
Length of Heel: 6.14 cm
Depth of Heel: 2.77 cm

Use Wear:

The leather cap of the heel displays limited wear on the rear of the heel.
Identification:

Provenience 7449 represents the partial remains of a round toed, buckled, lachel type shoe. Photograph displays largest vamp fragments and right quarter fragment.

Components:

Uppers: Eleven vamp fragments, one fragment of the right quarter.
Soles: Complete sock, or insole cover composed of corium only and a portion of the insole from the heel junction.
Heel: Insole maintains pseudomorph from heel attachment.

Construction Techniques:

Welt: N/A
Upper Stitching: The rear seam joining the quarters is whip stitched. The seam at the quarter/vamp junction is also whip stitched.

Fastening:

The chape hole in the left quarter displays use wear that indicates the employment of an anchor chape buckle.

Materials:

Vamp and quarter: Cow leather
Sock: de-grained or stripped cow leather
Insole: Cow leather.
Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 9
Average SPI for hidden seams: 5
Leather quality: 6

Dimensions:

Right Quarter: 8.2 cm high X 9.36 cm wide.
Sock: 16.3 cm long x 6.5 cm wide
Insole: 6.32 cm wide.

Use Wear:

The attachment hole on the chape of the left quarter shows extensive use wear from the attachment of a chape buckle.
Identification:

Provenience 11,300 represents three fragments of a folded welt.

Components:

Uppers: N/A
Soles: N/A
Heel: N/A

Construction Techniques:

Welt: The uppers were fastened to the sole structure with a folded welt.
Upper Stitching: N/A

Fastening:

N/A

Materials:

Welt: Calf leather

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A
Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 8
Average SPI for hidden seams: 6
Leather quality: 6

Dimensions:

Welt fragments: 1.92 cm long X .92 cm wide (reconstructed)

Use Wear:

N/A
Identification:

Provenience 11736 represents four vamp fragments from the right corner attachment of the vamp/cap junction and one curled tension welt. The shoe was square toed.

Components:

Uppers: Five vamp fragments from the right corner attachment of the vamp/cap junction.
Soles: N/A
Heel: N/A

Construction Techniques:

Welt: The uppers were fastened to the sole structure with a curled tension welt.
Upper Stitching: N/A

Fastening:

N/A

Materials:

Vamp: Cow leather.
Welt: Cow leather.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A
Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 8
Average SPI for hidden seams: 5.
Leather Quality: 6

Dimensions:

Welt Fragment: 5.91 cm long X 1.82 cm wide
Upper Fragments: 1) 2.69 cm long X 1.32 cm wide, 2) 2.9 cm long X .75 cm wide, 3) 3.1 cm long X 2.09 cm wide, 4) 3.1 cm long X 2.2 cm long X 1.1 cm wide

Use Wear:

N/A
Identification:

Provenience 5954 represents a quarter fragment from a lachet type shoe.

Components:

Uppers: One quarter fragment that maintains a portion of the rear seam.
Soles: N/A
Heel: N/A

Construction Techniques:

Welt: N/A
Seam Stitching: The rear seam joining the quarters is whip stitched.

Fastening:

N/A

Materials:

Quarter: Calf Leather.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A
Repairs:
No repairs are evident.

Quality of Manufacture:
Average SPI for visible seams: 9
No hidden seam stitching.
Leather Quality: 7

Dimensions:
Quarter Fragment: 6.91 cm long X 3.81 cm wide.

Use Wear:
N/A
Identification:

Provenience 6870 represents a toecap fragment from a square-toed shoe.

Components:
Uppers: One toecap fragment.
Soles: N/A
Heel: N/A

Construction Techniques:
Welt: N/A
Seam Stitching: N/A

Materials:
Toe Cap: Cow Leather.

Tool Marks:
Makers Marks: N/A
Tool Marks: N/A

Repairs:
No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
Average SPI for hidden seams: 4
Leather Quality: 6.5

Dimensions:

Toe Cap: 6.86 cm long X 4.35 cm wide.

Use Wear:

The interior of the toecap displays wear marks left by the first (big) and second toes of the wearer.
Identification:

Provenience 5447 represents a reverse curl welt fragment and a vamp fragment from the left corner attachment of the vamp/toe cap junction.

Components:

Uppers: Vamp fragment from the left corner attachment of the vamp/toe cap junction.
Soles: N/A
Heel: N/A

Construction Techniques:

Welt: The uppers were fastened to the sole structure with a folded welt.
Upper Stitching: N/A

Fastening:

N/A

Materials:

Welt Fragment: Calf leather.
Vamp Fragment: Cow leather.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A
Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 7
Average SPI for hidden seams: 4
Leather Quality: 5.5

Dimensions:

Welt Fragment: 10.8 cm long X .77 cm wide.
Vamp Fragment: 4.5 cm long X 2.0 cm wide.

Use Wear:

N/A
Identification:

Provenience 5851 represents the complete right quarter of a lachet type shoe.

Components:

Uppers: A complete right quarter piece.
Soles: N/A
Heel: N/A

Construction Techniques:

Welt: N/A
Upper stitching: The rear seam joining the quarters is whip stitched. The seam at the quarter/vamp junction is also whip stitched.

Fastening:

N/A

Materials:

Right Quarter: Cow leather.
Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 9
No hidden seam stitching.
Leather Quality: 6.5

Dimensions:

Quarter: 10.1 cm long X 11.9 cm wide.

Use Wear:

N/A
Identification:

Provenience 6043 represents a treadsole fragment.

Components:

Uppers: N/A
Soles: One treadsole fragment
Heel: N/A

Construction Techniques:

Welt: N/A
Seam Stitching: N/A

Fastening:

N/A

Materials:

Treadsole Fragment: Cow Leather
Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.

Quality of Manufacture:

No visible seam stitching.
Average SPI for hidden seams: 5
Leather quality: 7 (Leather was thicker and harder than other soles from Belle assemblage)

Dimensions:

Treadsole Fragment: 4.85 cm long X 3.2 cm wide.

Use Wear:

N/A
Identification:

Provenience 6059 represents a folded welt fragment.

Components:
Uppers: N/A
Soles: N/A
Heel: N/A

Construction Techniques:

Welt: The uppers were fastened to the sole structure with a folded welt.
Upper Stitching: N/A

Fastening:

N/A

Materials:

Welt Fragment: Cow Leather.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.
Quality of Manufacture:

Average SPI for visible seams: 7
Average SPI for hidden seams: 3
Leather Quality: 6

Dimensions:

Welt Fragment: 3.2 cm long X 1.1 cm wide

Use Wear:

Stitching holes display a significant amount of tension deformation from stress and heavy use.
Identification:

Provenience 10,263 represents a folded welt fragment.

Components:

Uppers: N/A
Soles: N/A
Heel: N/A

Construction Techniques:

Welt: The uppers were fastened to the sole structure with a folded welt.
Upper Stitching: N/A

Fastening:

N/A

Materials:

Welt Fragment: Cow Leather.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.
Quality of Manufacture:

Average SPI for visible seams: 5
Average SPI for hidden seams: 4
Leather Quality: 5

Dimensions:

Welt Fragment: 2.9 cm long X .9 cm wide

Use Wear:

Several stitching holes in the welt are exploded, indicating heavy use.
Identification:

Provenience 11,617 represents a single peche heel.

Components:

Uppers: N/A
Soles: N/A
Heel: A peche heel attached to treadsole with seven hardwood pegs set in a semicircular pattern around the edge of the heel (driven up into heel) and two pegs in the center driven down from the treadsole into the heel. Fragments of the heel cap are in place.

Construction Techniques:

Welt: N/A
Upper Stitching: N/A

Fastening:

N/A

Materials:

Heel: Cow leather, calf leather, hardwood pegs, hide glue.

Tool Marks:

Makers Marks: N/A
Tool Marks: There is a split lift on the top of the heel.

Repairs:

No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
No hidden seam stitching.
Leather Quality: 2

Dimensions:

Width of Heel: 7 cm
Length of Heel: 6.85 cm
Depth of Heel: 1.75 cm

Use Wear:

The heel cap display significant wear in all areas, which suggests heavy, prolonged use.
Identification:

Provenience 11,414 represents a midsole fragment.

Components:

Uppers: N/A
Soles: One midsole fragment with impressions or bracing thread.
Heel: N/A

Construction Technique:

Welt: N/A
Upper Stitching: N/A

Fastening:

N/A

Materials:

Midsole Fragment: Cow Leather

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
No hidden seam stitching.
Leather Quality: 5

Dimensions:

Midsole Fragment: 15.5 cm long X 5.65 cm wide.

Use Wear:

The top of the midsole displays a distinct impression from the ball of the foot.
Identification:

Provenience 11,251 represents an oak peg for the attachment of a stacked leather or peach heel.

Components:

Uppers: N/A
Soles: One oak peg.
Heel: N/A

Construction Techniques:

Welt: N/A
Upper Stitching: N/A

Fastening:

N/A

Materials:
Hardwood Peg: Oak.

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
No hidden seam stitching.

Dimensions:

Hardwood Peg: 2.7 cm long X .7 cm wide at the head.

Use Wear:

N/A
Identification:

Provenience 11,398 represents a stacked leather heel.

Components:

Uppers: N/A
Soles: N/A
Heel: A stacked leather heel attached to treadsole with eight hardwood pegs set in a semicircular pattern around the edge of the heel (driven up into heel) and seven pegs in the center driven down from the treadsole into the heel. The heel was also sewn onto the treadsole as evidenced by a line of stitching hole aligned along the outer edge of the artifact. Fragments of the heel cap are in place.

Construction Techniques:

Welt: N/A
Upper Stitching: N/A

Fastening:

N/A

Materials:

Stacked Leather Heel: Cow leather, hardwood pegs.

Tool marks:

Makers Marks: N/A
Tool Marks: N/A
Repairs:

No repairs are evident.

Quality of Manufacture:

No visible seam stitching.
Average SPI for hidden seams: 3
Leather Quality: 7.5

Dimensions:

Width of Heel: 7 cm
Length of Heel: 6.9 cm
Depth of Heel: 2.45 cm

Use Wear:

The heel cap displays limited scuffing at the rear of the heel.
Identification:

Provenience 13,959 represents a leather covered wooden heel.

Components:

Uppers: N/A
Soles: N/A
Heel: A leather covered heel attached to treadsole with eight brass fastener's set in a circular pattern in the center of the heel (driven down from the treadsole into the heel).

Construction Techniques:

Welt: N/A
Upper Stitching: N/A

Fastening:

N/A

Materials:

Wooden Heel: Oak wood, leather, brass tacks (only corrosion remains).

Makers Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
No hidden seam stitching.
Leather Quality: 6

Dimensions:

Width of Heel: 6.7 cm
Length of Heel: 8.5 cm
Depth of Heel: 4 cm

Use Wear:

N/A
Identification:

Provenience 6060 represents the partial remains of a round toed, tie laced, open sided lachet type shoe.

Components:

Uppers: Includes partial vamp, and toecap, and left and right quarters
Soles: All soles are present, to include insole, midsole and fragments of the treadsole.
Heel: A single split lift remains from the heel. Attachment was by six hardwood pegs (driven up into sole) arranged haphazardly around the center of the lift.

Construction Techniques:

Welt: The uppers were attached to the soles using a folded welt in the body of the shoe and a curled tension welt at the heel.
Upper Stitching: The seam at the quarter/vamp junction is also whip stitched.

Fastening:

Two puncture holes at the base of the tongue extension on the vamp and the short lachet of the right quarter indicate that the shoe was fastened or secured using a tie lace that joined short lachets.

Materials:

Uppers: Calf leather
Soles: Cow leather
Heel: Cow leather
Welt: Cow leather
Tool Marks:

Makers Marks: N/A
Tool Marks: Treadsole displays a beveled cut mark around the entire base of the sole that lays approximately 1.2 from the exterior edge.

Repairs:

The center portion of the treadsole has been replaced. The interior was removed by cutting and a second treadsole interior was fixed to the shoe structure using broad-headed iron tacks evenly spaced every .3 cm. The use of iron tacks is evidenced by the pattern of iron oxidation pseudomorphs on the edge of the original treadsole and the fragment of the replacement.

Quality of Manufacture:

Average SPI for visible seams: 7
Average SPI for hidden seams: 5
Leather Quality: 7

Dimensions:

Width at Toe: 5.84 cm
Width at Center of Heel: 5.6 cm
Length of Treadsole: 25.76 cm

Use Wear:

The insole and midsole both display the same use wear in the form of a foot impression. The treadsole also displays significant abrasion on the grain layer.
Record Number: 5854

Identification:

Provenience 5854 represents the partial remains of a square-toed shoe. All remains were conserved in situ and some stitching is visible. No photograph is available.

Components:
Uppers: Includes partial vamp and toecap.
Soles: All sole are present, to include the insole, midsole and treadsole. The treadsole is a composite piece with a separate lift attached at the rear of the sole, 2.78 cm to the rear of the heel seat.
Heel: N/A

Construction Techniques:

Welt: The uppers were attached to the soles using a folded welt in the body of the shoe and a curled tension welt at the heel.
Upper Stitching: N/A

Fastening:

N/A

Materials:

Uppers: Calf leather
Soles: Cow leather
Welt: Cow leather

Tool marks:

Makers Marks: N/A
Tool Marks: There are several slash marks on the underside of the treadsole that may be intended to indicate the forward edge of the heel.

Repairs:

No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
Average SPI for hidden seams: 6
Leather Quality: 6

Dimensions:

Width at Toe: 4.7 cm
Width at Center of Heel: 6.56 cm
Length of Treadsole: 26.05 cm

Use Wear:

The insole displays use wear in the form of a foot impression. The distal portion of the treadsole also displays significant wear.
Identification: Provenience 7012 represents the partial remains of a square-toed shoe.

Components:
Uppers: N/A
Soles: All sole are present, to include the insole, midsole and two thin tread soles.
Heel: A peche heel attached to treadsole with eight hardwood pegs set in a semicircular pattern around the edge of the heel (driven up into heel) and one peg in the center driven down from the treadsole into the heel. The complete heel cap is in place.

Construction Techniques:
Welt: The upper are attached to the sole assembly with a folded welt.
Upper Stitching: N/A

Fastening:
N/A

Materials:
Uppers: Calf leather
Soles: Cow leather

Tool Marks:
Makers Marks: N/A
Tool Marks: N/A

Repairs:
No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
Average SPI for hidden seams: 6
Leather Quality: 6

Dimensions:

Width at Toe: 5.65 cm
Width at Center of Heel: 6.91 cm
Length of Treadsole: 24.35 cm

Use Wear:
The insole displays use wear in the form of a foot impression.
Identification:

Provenience 5811 represents the partial remains of a round-toed, buckled lachet type shoe. The sole structure is pictured above.

Components:

Uppers: Includes 16 upper fragments, to include 13 vamp fragments, 2 quarter fragments and 1 toecap fragment.
Soles: All sole are present, to include a complete insole and treadsole and 8 midsole fragments.
Heel: A peche heel attached to treadsole with eight hardwood pegs set in a semicircular pattern around the edge of the heel (driven up into heel) and one peg in the center driven down from the treadsole into the heel. The complete heel cap and rear lift are in place.

Construction Techniques:

Welt: The upper are attached to the sole assembly with a folded welt.
Upper Stitching: The rear seam joining the quarters is whip stitched. The seam at the quarter/vamp junction is also whip stitched.
Fastening:

A fragment of the lachet from the right quarter maintains a small hole that would only be suited to a tie-laced shoe.

Materials:

Uppers: Calf leather
Soles: Cow leather
Heel: Calf leather, cow leather, hide glue (peche heel), hardwood pegs
Welt: Cow leather

Tool Marks:
Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 9
Average SPI for hidden seams: 6
Leather Quality: 6

Dimensions:

Width at Toe: 5.15 cm
Width at Center of Heel: 5.81 cm
Length of Treadsole: 25.50 cm

Use Wear:

The insole displays use wear in the form of a foot impression.
Identification:

Provenience 6075 represents the partial remains of a round-toed, tie-laced lachet type shoe.

Components:

Uppers: Includes 13 upper fragments, to include 10 vamp fragments, and 3 quarter fragments.
Soles: All sole are present, to include 1 insole fragment, 4 midsole fragments and two complete treadsoles.
Heel: A peche heel attached to treadsole with nine hardwood pegs set in a semicircular pattern around the edge of the heel (driven up into heel) and one peg in the center driven down from the treadsole into the heel. The complete heel cap and rear lift are in place.

Construction Technique:

Welt: The upper are attached to the sole assembly with a folded welt.
Upper Stitching: The rear seam joining the quarters is whip stitched. The seam at the quarter/vamp junction is also whip stitched.

Fastening:

A fragment of the lachet from the right quarter maintains a small hole that would only be suited to a tie-laced shoe.
Materials:

Uppers: Calf leather  
Soles: Cow leather  
Heel: Calf leather, cow leather, hide glue (peche heel), hardwood pegs  
Welt: Cow leather

Tool Marks:

Makers Marks: The interior of the right quarter displays a single circular strike mark that forms the work *Eslect*. A second etched mark is beneath that, forming the letters *RP*.
Tool Marks: The uppermost treadsole displays single slash mark used to extend left rear of midsole to edge of the lower treadsole.

Repairs:

No repairs are evident.

Quality of Manufacture:

Average SPI for visible seams: 8  
Average SPI for hidden seams: 5  
Leather Quality: 6.5 Width at Toe: 6.01 cm

Dimensions:

Width at Center of Heel: 7.24 cm  
Length of Treadsole: 27.46 cm

Use Wear:

N/A
Identification:

Provenience 6050 represents the partial remains of a square-toed shoe. The heel and largest two insole fragments are pictured above.

Components:

Uppers: N/A
Soles: Portions of the treadsole and the insole are present, to include 7 treadsole fragments and three insole fragments.
Heel: A partially preserved stacked leather heel attached to treadsole with seven hardwood pegs set in a semicircular pattern around the edge of the heel (driven up into heel) and three pegs in the center driven down from the treadsole into the heel.

Construction Techniques:

Welt: N/A
Upper Stitching: N/A

Materials:

Soles: Cow leather
Heel: Cow leather, hardwood pegs

Tool Marks:

Makers Marks: N/A
Tool Marks: N/A

Repairs:

No repairs are evident.
Quality of Manufacture:

No visible seam stitching.
No hidden seam stitching.
Leather Quality: 5

Dimensions:

Width at Toe: 4.9 cm
Width at Center of Heel: 6.45 cm

Use Wear:

N/A
VITA

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Work Experience

Mariners Museum, Newport News, VA
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Conservator/Conservation Assistant (University Assistantship)
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R.C. Goodwin and Associates, Frederick, MD
Archaeologist I, Conservator, Translator, Analyst
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Chef Tournan
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